Consumers Energy
Count on Us®

July 13, 2021

Tim Unseld
Materials Management Division
Department of Environment, Great Lakes, and Energy
Grand Rapids District Office
350 Ottawa Avenue NW, Unit 10
Grand Rapids, Michigan 49503

Mr. Unseld,

This correspondence has been prepared to submit for Michigan Department of Environment, Great Lakes and Energy (EGLE) approval a Construction Permit Application (CPA) for a lateral and vertical expansion of the JH Campbell (JHC) Dry Ash Landfill. The JHC Dry Ash Landfill is a currently permitted Type III landfill owned and operated by Consumers Energy Company (CEC). The CPA has been prepared by Golder Associates.

The CPA includes a lateral expansion of 27.2 acres and vertical expansion over approximately 42.9 acres of constructed and unconstructed areas. The expansion includes an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill footprint. As part of the construction permit modification that was approved by EGLE in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. The expansion is proposed to regain that lost airspace and to provide a lateral expansion for Cells 6-9 as discussed in email correspondence from EGLE on January 22, 2021.

This CPA was prepared to permit sufficient airspace in the Dry Ash Landfill to service the JHC generating plant until its closure in 2040, as currently approved by the Michigan Public Service Commission via CEC's Integrated Resource Plan (IRP). In June 2021 CEC announced an updated IRP which proposes to close the JHC generating plant in 2025. Given the schedule for regulatory review and approval of the new proposed IRP, CEC is submitting this CPA as prepared under the current approved IRP. If approved, closure of the plant in 2025 will reduce the total airspace needed to reach final closure.

Please contact the undersigned with any questions regarding this submittal.

Sincerely,
Consumers Energy Company

Bethany Swanberg

Bethany Swanberg, PE
Bethany.Swanberg@cmsenergy.com
(517) 788-0282

REPORT

Landfill Expansion Construction Permit Application

J.H. Campbell Generating Facility – Dry Ash Landfill, Type III Expansion, Facility ID 395496, West Olive, Michigan

Section A – Introduction
Section B – Environmental Assessment
Section C – Hydrogeologic Investigation Report, Prepared by TRC
Section D – Hydrogeologic Monitoring Plan, Prepared by TRC
Section E – Topographic Map Report
Section F – Engineering Report
Section G – Operations Reports
Section H – Construction Quality Assurance Plan
Engineering Drawings (Stamped and not Stamped)

Submitted to:

J.H. Campbell Generating Facility

Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.

15851 South US 27, Suite 50
Lansing, Michigan 48906

and

TRC

1540 Eisenhower Place
Ann Arbor, Michigan 48108

PN 19132873

Original Electronic Submittal to EGLE – July 13, 2021

GOLDER
MEMBER OF WSP

REPORT

Section A - Introduction

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion Facility ID 395496

Submitted to:

J.H. Campbell Generating Facility
Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50 Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

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FIGURES

APPENDICES

1.0 SECTION A - GENERAL INFORMATION AND INTRODUCTION

1.1 Name and Location of the Facility

J.H. Campbell Generating Facility Dry Ash Landfill
17000 Croswell Street
West Olive, MI 49460-9748
Contact: Caleb Batts, P.E.
Phone: 989-891-3019

1.2 Name and Address of the Operator

Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

1.3 Name and Address of the Property Owner(s)

Consumers Energy Company
1 Energy Plaza
Jackson, Michigan, USA 49201
Contact: Bethany Swanberg, P.E.
Phone: 517-788-0282

1.4 Name and Address of any Mineral Rights Owner(s)

Consumers Energy Company
1 Energy Plaza
Jackson, Michigan, USA 49201
Contact: Bethany Swanberg, P.E.
Phone: 517-788-0282

1.5 Type of Disposal Area Proposed

The J.H. Campbell (JHC) Dry Ash Landfill is a licensed and captive Type III Low Hazard Industrial Landfill owned by the Consumers Energy Company (CEC). Only coal combustion residuals (CCR) generated by CEC's J.H. Campbell Generating Facility will be disposed in the landfill. The currently permitted airspace volume for the JHC Dry Ash Landfill is 9,500,000 cubic yards.

CEC is proposing an expansion of the currently permitted J.H. Campbell Generating Facility Dry Ash Landfill which will include an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill. As such, the lateral extent of the landfill boundary will remain unchanged. As part of the construction permit modification that was approved by the Michigan Department of Environment, Great Lakes and Energy (EGLE) in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. A vertical expansion within the currently permitted solid waste boundary is proposed to regain the lost airspace and to provide sufficient capacity for the remaining life of the generating facility. A cut/fill drawing has been included as Appendix E to show the approximate airspace lost due to the re-design of the floor grades in Cells 5 through 9. A lateral expansion is required for the unconstructed

Cells 6 through 9, per the Part 115 rules. The proposed vertical expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area. The proposed increase in airspace will provide an estimated additional 2 years of site life with a total remaining site life of approximately 20 years.

This expansion updated design will be consistent with current rules developed under Part 115 of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, as amended (Part 115).

The proposed Type III expansion is consistent with Section 111.16.5 of the April 2000 Ottawa County Solid Waste Management Plan (and approved Plan amendment) as documented in Appendix B.

1.6 Type of Application Being Submitted

CEC is submitting an Application for Permit to Construct a Solid Waste Disposal Area to EGLE for an expansion of the J.H. Campbell Type III Low Hazard Industrial Landfill. The EGLE's Administratively Complete Checklist has been customized for this application and is included in Appendix C.

1.7 Type of Waste Proposed for Disposal

Usage of the JHC Landfill is solely for the disposal of coal combustion residuals (CCR) and other CCR containing materials generated by the JHC Generating Facility. Conditioned fly ash is the main solid waste disposed of in the JHC Landfill. Fly ash is conveyed from the JHC Generating Facility through pipes into the three silos adjacent to the JHC Landfill. Bottom ash is disposed less frequently in the JHC landfill only when an excess is stockpiled on site and it cannot be sold. Bottom ash is conveyed through pipes from the JHC Generating Facility into a concrete bottom ash tank system managed by JHC personnel. Disposal of waste other than CCR or other CCR containing materials shall receive authorization by the Consumers Energy Environmental Services Landfill Compliance group prior to disposal.

1.8 The Number of Acres Applied For

- Currently Permitted Type III Low Hazard Industrial Waste Landfill solid waste boundary is 104 acres, this area will remain unchanged.
- A lateral expansion is required for Cells 6, 7, 8, and 9 for a total of 27.2 acres
- A 42.9-acre vertical expansion extent is proposed within the currently permitted solid waste boundary.

Table 1 includes a summary of the JHC Landfill existing permitted and proposed facility information.

Table 1: JHC Landfill Facility Summary

Landfill Item	Area (acres)
Total Facility Boundary (solid waste boundary plus ancillary areas)	410
Ancillary Areas (power generation, storm water, leachate transfer, operations, etc.)	306
Solid Waste Boundary (Cells 1 through 9)	104

Landfill Item	Area (acres)
Cells 1 through 5 (active areas)	43.4
Cells 1 through 4 (partially closed areas)	33.5
Cells 6 through 9 (unconstructed) Lateral Expansion	27.2
Proposed Vertical Expansion within currently permitted solid waste boundary	42.9

1.9 The Design Capacity of the Landfill

The proposed expansion and redesign is expected to provide approximately 532,000 cubic yards of additional airspace to the facility. This will provide an estimated total facility design of approximately 10,032,000 cubic yards when combined with the existing permitted disposal capacity.

The J.H. Campbell Generating Facility Dry Ash Landfill currently places approximately 265,200 cubic yards of solid waste per year, which is subject to change based on power usage. Based on the remaining permitted airspace and proposed vertical expansion increase of approximately 532,000 cubic yards, the proposed expansion will increase the life expectancy of the existing facility by approximately 2 years (total remaining would be 20 years) at current disposal rates. The only anticipated source of waste is the J.H. Campbell Generating Facility. The existing facility does not accept other forms or origins of waste.

1.10 Signature of Owner and Operator

J.H. Campbell Type III Low Hazard Industrial Landfill

Authorized Signature:

Mr. Caleb Batts, P.E.
Generation CCR Operations Lead
Consumers Energy Company

Date: 7-2-2021.

See Appendix A, Application For Solid Waste Disposal Area Construction Permit.

1.11 Facility Map

See Figure 1, Facility Map.

1.12 Facility Legal Description

A PARCEL OF LAND IN THE SOUTHEAST 1/4 OF SECTION 10, THE SOUTHWEST 1/4 OF SECTION 11, THE NORTHWEST 1/4 OF SECTION 14 AND IN THE NORTHEAST 1/4 SECTION 15,T6N,R16W, PORT SHELDON TOWNSHIP, OTTAWA COUNTY, MICHIGAN, DESCRIBED AS

FOLLOWS:

TO FIND THE POINT OF BEGINNING OF THIS DESCRIPTION, COMMENCE AT THE NORTHWEST CORNER OF SAID SECTION 15; RUN THENCE EASTERLY ALONG THE NORTH LINE OF SAID SECTION 15 APPROXIMATELY 1525 FEET; THENCE SOUTHERLY APPROXIMATELY 195 FEET TO THE NORTHWEST CORNER OF THE EXISTING ASH STORAGE AREA THENCE ALONG THE NORTHERLY LINE OF SAID EXISTING AREA EASTERLY 1505 FEET; THENCE CONTINUING ALONG SAID NORTHERLY LINE SOUTHEASTERLY 135 FEET; THENCE CONTINUING ALONG SAID NORTHERLY LINE EASTERLY 140 FEET TO THE POINT OF BEGINNING OF THIS DESCRIPTION; THENCE NORTHERLY 1985 FEET; THENCE EASTERLY 1265 FEET; THENCE SOUTHEASTERLY 690 FEET; THENCE EASTERLY 1095 FEET; THENCE SOUTHEASTERLY 540 FEET; THENCE SOUTHERLY 1460 FEET; THENCE WESTERLY 430 FEET; THENCE NORTHWESTERLY 300 FEET TO THE INSIDE CREST OF THE EXISTING ASH STORAGE AREA DIKE; THENCE ALONG SAID INSIDE CREST WESTERLY 2535 FEET; THENCE NORTHERLY 195 FEET TO THE POINT OF BEGINNING.

CONTAINING 143 ACRES MORE OR LESS.

A restrictive covenant for the site has been entered, a copy is included in Appendix B.

1.13 Application Fee

See Appendix D, for a photocopy of the check payable to the “State of Michigan” for $750.00.

FIGURES

Figure 1 - Facility Map

LEGEND

- EXISTING ACTIVE AREA
- EXISTING CLOSED AREA
- EXISTING PERMITTED SOLID WASTE BOUNDARY
- PROPOSED LATERAL EXPANSION AREA
- PROPOSED VERTICAL EXPANSION AREA
- EXISTING CELL BOUNDARY
- MONITORING WELL
- PROPERTY LINE

SITE LEGAL DESCRIPTION

A PARCEL OF LAND IN THE SOUTHEAST 1/4 OF SECTION 10, THE SOUTHWEST 1/4 OF SECTION 11, THE NORTHWEST 1/4 OF SECTION 14 AND IN THE NORTHEAST 1/4 SECTION 15,T6N,R16W, PORT SHELDON TOWNSHIP, OTTAWA COUNTY, MICHIGAN, DESCRIBED AS FOLLOWS:

TO FIND THE POINT OF BEGINNING OF THIS DESCRIPTION, COMMENCE AT THE NORTHWEST CORNER OF SAID SECTION 15; RUN THENCE EASTERLY ALONG THE NORTH LINE OF SAID SECTION 15 APPROXIMATELY 1525 FEET; THENCE SOUTHERLY APPROXIMATELY 195 FEET TO THE NORTHWEST CORNER OF THE EXISTING ASH STORAGE AREA THENCE ALONG THE NORTHERLY LINE OF SAID EXISTING AREA EASTERLY 1505 FEET; THENCE CONTINUING ALONG SAID NORTHERLY LINE SOUTHEASTERLY 135 FEET; THENCE CONTINUING ALONG SAID NORTHERLY LINE EASTERLY 140 FEET TO THE POINT OF BEGINNING OF THIS DESCRIPTION; THENCE NORTHERLY 1985 FEET; THENCE EASTERLY 1265 FEET; THENCE SOUTHEASTERLY 690 FEET; THENCE EASTERLY 1095 FEET; THENCE SOUTHEASTERLY 540 FEET; THENCE SOUTHERLY 1460 FEET; THENCE WESTERLY 430 FEET; THENCE NORTHWESTERLY 300 FEET TO THE INSIDE CREST OF THE EXISTING ASH STORAGE AREA DIKE; THENCE ALONG SAID INSIDE CREST WESTERLY 2535 FEET; THENCE NORTHERLY 195 FEET TO THE POINT OF BEGINNING.

CONTAINING 143 ACRES MORE OR LESS.

REFERENCE(S)

1. SOLID WASTE BOUNDARY SHOWN IS PROVIDED FROM THE ORIGINAL CONSTRUCTION PERMIT APPLICATION, DATED DECEMBER 15,1993, PERMIT NO. 0299, ATTACHMENT A. ALSO FROM THE CURRENT OPERATING LICENSE, DATED JANUARY 23, 2019, NUMBER 9542, ATTACHMENT A.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
0	2021-TBD	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA

SIGNATURE
NAME
TIFFANY D. JOHNSON
MICHIGAN P.E. No.
6201049160

Consumers Energy
J.H. CAMPBELL PLANT
WEST OLIVE, MI

EXISTING PROPERTY SITE PLAN AND LEGAL DESCRIPTION

SCALE: 1" = 300'
JOB: PT-02661
DRAWING NO. ---
SHEET 200-1
REV. 0

APPENDIX A

Construction Permit Application Form

EGLE Michigan Department of Environment, Great Lakes, and Energy
Materials Management Division

APPLICATION IS HEREBY MADE TO THE DIRECTOR, MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY, FOR A PERMIT TO CONSTRUCT A SOLID WASTE DISPOSAL AREA, AS REQUIRED UNDER THE PROVISIONS OF PART 115, SOLID WASTE MANAGEMENT, OF THE NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION ACT, 1994 PA 451, AS AMENDED. COMPLETION OF THIS FORM IS REQUIRED TO OBTAIN A PERMIT. PROVIDING FALSE INFORMATION MAY RESULT IN CIVIL OR CRIMINAL PENALTIES.

APPLICATION FOR PERMIT TO CONSTRUCT A SOLID WASTE DISPOSAL AREA

APPLICANT: PLEASE COMPLETE ALL SECTIONS.

I. FACILITY NAME AND PHYSICAL LOCATION

NAME OF FACILITY				
J.H. Campbell Dry Ash Landfill				
ADDRESS (STREET): 17000 Croswell Street			TOWNSHIP: Port Sheldon	COUNTY: Ottawa
CITY: West Olive	STATE: MI	ZIP CODE: 49460	TELEPHONE: 616-738-3241	

II. FACILITY OWNER / APPLICANT

LEGAL NAME OF FACILITY OWNER / APPLICANT: Consumers Energy Company		MICHIGAN CORPORATE ID NUMBER:	TELEPHONE:	
ADDRESS (MAILING): 1945 Parnall Road		CITY: Jackson	STATE: MI	ZIP CODE: 49201
REPRESENTATIVE OF FACILITY OWNER: Caleb Batts	TITLE: CCR Operations Lead		TELEPHONE: 989-225-9890	
PERSON PREPARING APPLICATION: Caleb Batts	TITLE: CCR Operations Lead		TELEPHONE: 989-225-9890	

III. PROPERTY OWNER(S) and MINERAL RIGHTS OWNER(S) (List all entities that own a portion of either the property and/or mineral rights)

NAME OF OWNER(S) Attach separate sheet if necessary: Consumer Energy Company		CONTACT PERSON(S) Attach separate sheet if necessary: Caleb Batts		
TELEPHONE: 989-225-9890	ADDRESS: 1945 Parnall Road	CITY: Jackson	STATE: MI	ZIP CODE: 49201

IV. APPLICATION TYPE

☐ Lateral Expansion ☒ Vertical Expansion ☐ Change in Disposal Type ☐ New Disposal Area
☐ New Application ☐ Renewal Application ☐ Re-submittal ☐ Modification

V. TYPE OF DISPOSAL AREA (Check all that apply)

TYPE OF DISPOSAL AREA	PERMITTED	PROPOSED
☐ Municipal Solid Waste Landfill	☐	☐
☐ Municipal Solid Waste Incinerator Ash Landfill	☐	☐
☒ Type III Landfill		
☐ Industrial	☐	☐
☒ Low Hazard Industrial	☒	☒
☐ Construction and Demolition	☐	☐
☐ Solid Waste Transfer Facility	☐	☐
☐ Solid Waste Processing Plant	☐	☐
☐ Other	☐	☐

VI. FACILITY AREA (Check all that apply)

Facility Area .... 410 acres

LANDFILLS LAND USE:

☒ Lateral Expansion .... 27.2 acres
☒ Vertical Expansion .... 42.9 acres
☐ New Disposal Area .... acres
☒ Isolation and Ancillary Area .... 306 acres
☒ Current Solid Waste Units(s) or Portion of Unit(s) on site
- ☒ Active Fill Area .... 43.4 acres
- ☒ Closed Area .... 33.5 acres
- ☐ Unclosed Area .... acres
- ☒ Unconstructed Area .... 27.2 acres

VII. DESIGN CAPACITY

Landfill:

Current filled 5,299,800 cu. yds.
Current Remaining 4,200,200 cu. yds. 20.5 years remaining (estimate)
Proposed New 4,200,200 (Cells 6-9) + 532,000 vert. exp. cu. yds. 22.5 years projected (estimate)

VIII. FEE and APPLICATION DOCUMENTS

☒ *Copy* of Application Fee is attached: Amount $750
☒ *Copy* of Application Fee Checklist is attached.
☒ Administrative Completeness Worksheet is attached. ☐ N/A
☒ Facility Map is attached.
☒ Facility Legal Description is attached.
☒ Description of waste type(s) is attached. ☐ N/A

I HEREBY CERTIFY THAT THIS INFORMATION AND ALL ATTACHED PAGES ARE CORRECT AND COMPLETE.

FACILITY OWNER'S SIGNATURE ☒ **Signing as AGENT for the Facility Owner** [signature] *NAME TYPED or PRINTED* Caleb Batts	TITLE: CCR Operations Lead	DATE: 7-2-2021
PROPERTY OWNER'S SIGNATURE ☒ **Signing as AGENT for the Property Owner** [signature] *NAME TYPED or PRINTED* Caleb Batts	TITLE: CCR Operations Lead	DATE: 7-2-2021

CONSTRUCTION PERMIT APPLICATION FEE WORKSHEET

LEGAL NAME OF FACILITY	FACILITY ID NUMBER
J.H. Campbell Dry Ash Landfill	395496
LEGAL NAME OF FACILITY OWNER / APPLICANT: Consumers Energy Company	

		TYPE OF FACILITY / Section of Act	NEW [1] 11509(2)(a)	LAT EXP [1] 11509(2)(b)	VERT EXP [1] 11509(2)(c)	RTF/PP [2] 11509(3)	MODIFY 11509(5)
1.	☐	**Municipal Solid Waste (MSW) Landfill** (Includes MSW Ash)	☐ $1500	☐ $1000	☐ $750		
2.	☒	Type III Industrial Waste Landfill					
	☐	Industrial	☐ $1000	☐ $750	☐ $500		
	☒	Low Hazard Industrial	☐ $750	☒ $500	☒ $250		
	☐	Construction and Demolition	☐ $750	☐ $500	☐ $250		
	☐	Other Non-Industrial	☐ $750	☐ $500	☐ $250		
3.	☐	Transfer/Processing/Other[3]/Combinatio					
	☐	Municipal Solid Waste, et al.				☐ $1000	
	☐	Industrial Waste or Construction and Demolition				☐ $500	
	☐	Other ______			☐	☐ $500	
	☐	Expansion				☐ $250	
4.	☐	**Modification or Renewal**					☐ $250
		SUBTOTAL	$	$ 500	$ 250	$	$
		APPLICATION FEE TOTAL (NEW + LAT EXP + VERT + RTS/PP + MODIFY)					$ 750

Preparer's Signature: [signature] Title: 7-2-2021 Date:

NAME TYPED or PRINTED Caleb Batts

NOTE: If the application is for any combination of disposal area types, the applicant shall pay the sum of the individual fees [Section 11509(6)]. However, the application fee under Section 11509(3) is not accumulative, whereas the fees under Section 11509(2) are accumulative.

1. The subtotal of this column is the sum of all of the applicable fees.
2. Only one fee box in this column is to be checked. Select the largest fee within line 3.
3. This category of "other" includes both Surface Impoundments and Waste Piles.

Make check or money order payable to:	REMIT TO:
STATE OF MICHIGAN	**MICHIGAN DEPT. OF ENVIRONMENT, GREAT LAKES, AND ENERGY** **CASHIER'S OFFICE** **PO BOX 30657** **LANSING, MI 48909-8157**

Return this completed and signed Worksheet and the application fee to the Cashiers Office.

If the proposed disposal area is located in Wayne County, return the remainder of the application documents and a *copy* of this Worksheet and a *copy* of the application fee and any attachments to Wayne County, Department of Environment.

All other facilities return the remainder of the application documents and a *copy* of this Worksheet and a *copy* of the application fee and any attachments directly to the Department of Environment, Great Lakes, and Energy through the Materials Management Division District Office.

FOR DEPARTMENT USE ONLY	FOR DEPT. CASHIER'S OFFICE ONLY
APPLICATION AMOUNT RECEIVED: $________	
SIGNATURE ________ DATE ________ 20__	

APPENDIX B

Letter of Ottawa County Consistency, Advisory Analysis Letter, and Restrictive Convenant Information

miOttawa Department of
Public Health

Lisa Stefanovsky, M.Ed.
Health Officer

Paul Heidel, M.D., M.P.H.
Medical Director

October 6, 2020

Bradley T. Runkel
Senior Engineer Lead (Landfill Operations Compliance)
Consumers Energy
1945 W. Parnall
Jackson, MI 49201

Dear Mr. Runkel P.E.:

The Summary & Consistency Report for J.H. Campbell Coal Ash Lanfilled owned by Consumers Energy was received by this office on September 15, 2020. After reviewing the report this office found that it is administratively complete.

To outline the process from this point forward, the Solid Waste Planning Committee will meet and designate a Facility Review Subcommittee to review the summary report and issue a recommendation. The recommendation will be one of three options:

1. The Facility Review Subcommittee may recommend that the Solid Waste Planning Committee find that the expansion is not consistent with the County Solid Waste Management Plan.
2. The Facility Review Subcommittee may recommend that the Solid Waste Planning Committee find that the expansion is consistent with the County Solid Waste Management Plan;
3. The Facility Review Subcommittee may recommend that the Solid Waste Planning Committee find that the expansion is consistent with the County Solid Waste Management Plan subject to certain conditions and/or agreements.

If the Solid Waste Planning Committee finds the proposed expansion to be consistent with the County Solid Waste Management Plan, a Letter of Consistency will be issued. The Letter of Consistency is valid for one year from the date of issuance. If the construction permit is not issued by the Michigan Department of Environmental Quality within this one (1) year period, the letter of consistency becomes null and void.

If you have any questions feel free to call me directly.

Kimberly Wolters, REHS

Kimberly Wolters, REHS
Environmental Sustainability Supervisor
616-494-5569

Cc: Ottawa County Solid Waste Planning Committee
Ottawa County Board of Commissioners
Port Sheldon Township

STATE OF MICHIGAN
DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY
GRAND RAPIDS DISTRICT OFFICE

EGLE

GRETCHEN WHITMER
GOVERNOR

LIESL EICHLER CLARK
DIRECTOR

February 17, 2021

Ms. Bethany Swanberg
Consumers Energy Company
1945 West Parnall Road
Jackson, Michigan 49201

Dear Ms. Swanberg:

SUBJECT: Advisory Analysis, JH Campbell Solid Waste Disposal Area; Waste Data System Number 395496

On February 10, 2021, an advisory analysis was held for the JH Campbell Solid Waste Disposal Area Dry Ash Landfill pursuant to Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 115). The advisory analysis consisted of an online meeting and discussion of the proposed Vertical and Lateral expansion of the dry ash landfill.

The following main items were discussed during the office meeting:

1. The landfill area shall be consistent with and contained in the approved Ottawa County Solid Waste Management Plan (County Plan). A determination of consistency with the plan must be submitted with a Solid Waste Disposal Area Construction Permit application.
2. Because the expansion will include both a vertical expansion and a lateral expansion (even though the permitted footprint of the landfill will not be changed beyond previously permitted boundaries), building future Cells 6–9 will not require a new solid waste disposal area construction permit. Those future cells will not meet the definition of a lateral expansion for a coal ash landfill because there would be a permit issued after December 28, 2018 and Solid Waste Disposal Area Operating License #9542 previously authorized Consumers Energy to build Cells 6-9 and accept waste in them for disposal once acceptable certification was made to Michigan Department of Environment, Great Lakes and Energy (EGLE).
3. The plans and specifications shall be sealed and signed by a professional engineer licensed in the State of Michigan.
4. All requirements of Part 115 and the Part 115 Rules shall be met.
5. The public notice and public hearing procedures were previously discussed and EGLE recommends asking for a public hearing on the proposal to help educate any local residents and/or groups that are interested in this proposal.
6. The application needs to be for the entire solid waste disposal unit. The intent will be to replace all existing permits with a new permit provided that a comprehensive, approvable application is provided.
7. The landfill must maintain adequate horizontal and vertical isolation distances as prescribed in the Part 115 Rules. The horizontal isolation distance from a domicile existing at the time of an advisory analysis is based on February 10, 2021. All other isolation distances referenced are evaluated at the time of permit application.
8. Rule 902 of the Part 115 administrative rules discusses the required elements of an administratively complete construction permit application. The application shall include, but

is not limited to, a completed construction permit application form, construction permit application fees as specified in Part 115, an environmental assessment that contains the information contained in Rule 903, a hydrogeological report that is in compliance with Rule 904, a hydrogeologic monitoring plan in compliance with Rule 905, topographic maps that are in compliance with Rule 909, engineering plans and reports as specified by Rules 910 and 911, and a construction quality assurance plan as specified by Rule 916.

9. Many portions of the required items listed in Item 8 have already been submitted and approved. However, EGLE still recommends that you look at these items and ensure that they are still relevant and would apply to the vertical and lateral expansion of the ash landfill.
10. Rule 902(3) requires that any site that has been determined to be the source of groundwater contamination must include an approved RAP in their construction permit application. For the dryash landfill portion of the site, a Part 201 restrictive covenant is required on the portion of the property which includes the landfill footprint and the leachate ponds. This restrictive covenant would include language which prohibits the installation and use of domestic water wells without prior approval of EGLE.
11. EGLE understands that Consumers Energy is working on a RAP for the complete site to be submitted in October 2021. That RAP could contain the Part 201 Deed Restrictions as part of the remedy to be utilized to address the site conditions.

Should you require further information, please contact me, at 616-490-8097 or at unseldt@michigan.gov.

Sincerely,

Timothy J. Unseld

Timothy J. Unseld, Environmental Engineer
Grand Rapids District Office
Materials Management Division

cc: Mr. Brad Runkel, Consumers Energy Company
Mr. Caleb Batts, Consumers Energy Company
Ms. Tiffany Johnson, Golder Environmental Services
Ms. Margie Ring, EGLE (via email)
Mr. Fred Sellers, EGLE (via email)
Mr. Jim Arduin, EGLE (via email)
Mr. Kent Walters, EGLE (via email)

DECLARATION OF RESTRICTIVE COVENANT

This Declaration of Restrictive Covenant (Restrictive Covenant) has been recorded with the Ottawa County Register of Deeds for the purpose of protecting public health, safety, and welfare, and the environment by prohibiting or restricting activities that could result in unacceptable exposure to environmental contamination present at the property located at 17000 Croswell Street, Ottawa County and legally described in Exhibit 1 attached hereto (Property).

The Property is associated with Consumers Energy's JH Campbell Dry Ash Landfill, for which response activitites were conducted pursuant to Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), MCL 324.20101 *et seq*. The Property described contains hazardous substances in excess of the concentrations developed as the unrestricted residential criteria under Section 20120a(1)(a) or (17) of the NREPA.

The restrictions contained in this Restrictive Covenant are based upon information available at the time the response activities were implemented. Failure of the response activities to achieve and maintain the criteria, exposure controls, and any requirements specified by the response activities; future changes in the environmental condition of the Property or changes in the cleanup criteria as defined in the NREPA; the discovery of environmental conditions at the Property that were not accounted for during implementation of the response activities; or use of the Property in a manner inconsistent with the restrictions described herein, may result in this Restrictive Covenant not being protective of public health, safety, and welfare, and the environment.

Land-use restrictions have been imposed on the property in the form of the Part 115 Restrictive Covenant recorded on February 12, 1999, in Liber 2601, Page 25, Ottawa County. This Restrictive covenant is is in addition to those already imposed and will serve to prevent the potential for unacceptable exposure to hazardous substances as a result of the conditions created by the presence of groundwater contaminant concentrations that exceed the unrestricted residential cleanup criteria under Section 20120a(1)(a) of the NREPA.

<u>Definitions</u>

For the purposes of this Restrictive Covenant, the following definitions shall apply:

"EGLE" means the Michigan Department of Environment, Great Lakes, and Energy, its successor entities, and those persons or entities acting on its behalf.

"Owner" means at any given time the then current title holder of the Property or any portion thereof.

All other terms used in this document which are defined in Part 3, Definitions, of the NREPA; Part 201 of the NREPA; or the Part 201 Administrative Rules, Michigan Administrative Code, 2013 AACS R 299.1 – R 299.50, shall have the same meaning in this document as in Parts 3 and 201 of the NREPA and the Part 201 Administrative Rules, as of the date of filing of this Restrictive Covenant.

Summary of Response Activities and Environmental Contamination

Boron and selenium have been historically detected above Part 201 unrestricted residential cleanup criteria for drinking water in the Dry Ash Landfill perimeter groundwater monitoring network. The monitoring network is situated around the Dry Ash Landfill solid waste boundary. Institutional controls exist on the property in the form of a Part 115 restrictive covenant that limits property use to a sanitary landfill and prohibits filling, grading, excavation, drilling, or mining of the land without authorization from EGLE. Response activities have been completed as documented in previously submitted response activity plans for the Dry Ash Landfill and other existing or completed remedies are described in the EGLE-approved Remedial Action Plan, J.H. Campbell Solid Waste Disposal Area, Ash Impoundment Cells A-K, originally prepared on August 9, 1999 by Natural Resource Technology, Inc. and the Remedial Action Plan Addendum, JH Campbell Solid Waste Disposal Area (Cell 1), dated January 31, 2008 and prepared by Consumers Energy, which revised the Remedial Action Plan to include the Dry Ash Landfill.

NOW THEREFORE,

1. Declaration of Land Use or Resource Use Restrictions

Consumers Energy, the Owner of the Property, hereby declares and covenants that the Property shall be subject to the following restrictions and conditions:

a. Activity and Use Limitations. The use of the Property is restricted to use as a sanitary landfill and specific restrictions memorialized in the previously recorded restrictive covenant shall apply.

b. Restriction for Use of Groundwater. The Owner shall prohibit the consturction and use of wells or other devices on the Property to extract groundwater for consumption, irrigation, or any other purpose, except as provided below:

(i) Wells and other devices constructed as part of a response activity for the purpose of evaluating groundwater quality or to remediate subsurface contamination associated with a release of hazardoous substances into the environment are permitted provided the construction of the wells or devices complies with all applicable local, state, and federal laws and regulations and does not cause or result in a new release, exacerbation of existing contamination, or any other violation of local, state, or federal laws or regulations.

(ii) Short-term dewatering for construction purposes is permitted provided the dewatering, including management and disposal of the perched groundwater, is conducted in accordacne with all applicable local, state, and federal laws and regulations and does not cause or result in a new release, exacertation of existing contamination, or any other violation of local, state, and federal environmental laws and regulations.

c. Contaminated Soil Management The Owner shall manage all soils, media and/or debris located in accordance with the applicable requirements of Section 20120c of the NREPA; Part 111, Hazardous Waste Management, of the NREPA; Toxic Substances Control Act (TSCA), 15 USC 2601 *et seq.*; Subtitle C of the Resource Conservation and Recovery Act, 42 U.S.C. Section 6901 *et seq*.; the administrative rules promulgated thereunder; and all other relevant state and federal laws.

2. Running with the Land. This Restrictive Covenant shall run with the Property and shall be binding on the Owner; future owners; and their successors and assigns, lessees, easement holders, and any authorized agents, employees, or persons acting under their direction and control. Pursuant to Section 20121(5)(b) of the NREPA, the duration of this Restrictive Convent is perpetual. Improper modification or rescission of any restriction necessary to prevent unacceptable exposure to regulated substances may result in the need to perform additional response activities by those parties responsible for performing response activity at the Property or to comply with Section 20107a of the NREPA.

3. Enforcement of Restrictive Covenant. The State of Michigan, through EGLE, and Consumers Energy may individually enforce the restrictions set forth in this Restrictive Covenant by legal action in a court of competent jurisdiction.

4. Severability. If any provision of this Restrictive Covenant is held to be invalid by any court of competent jurisdiction, the invalidity of such provision shall not affect the validity of any other provisions hereof, and all such other provisions shall continue unimpaired and in full force and effect.

5. Authority to Execute Restrictive Covenant. The undersigned person executing this Restrictive Covenant is the Owner and represents and certifies that he or she is duly authorized and has been empowered to execute and record this Restrictive Covenant.

(Signature Page to Follow)

IN WITNESS WHEREOF, I, Consumers Energy, the current and legal Owner of the Property, has caused this Restrictive Covenant to be executed on this 5th day of May, 2021.

Consumers Energy Company,
a Michigan corporation

By: Julie C. Guinn
Julie C. Guinn

Its: Senior Real Estate Analyst
Title

STATE OF **Michigan**
COUNTY OF **Ottawa**

The foregoing instrument was acknowledged before me this 5th day of May, 2021, by Julie C. Guinn, Senior Real Estate Analyst of Consumers Energy Corporation, a Michigan corporation, on behalf of the corporation.

AISLING WARREN
NOTARY PUBLIC - STATE OF MICHIGAN
COUNTY OF HILLSDALE
My Commission Expires 1/11/2022
Acting in the County of Jackson

Aisling Warren
Notary Public, State of Michigan
County of Jackson
My Commission Expires: Jackson
Acting in the County of Jackson

Prepared by and when recorded return to:

Bethany Swanberg
Consumers Energy
1945 W. Parnall Road (P22-119)
Jackson, Michigan 49201

EXHIBIT 1

Attachment A

Campbell Plant Part 201
Restrictive Covenant

Legal Description: Restrictive Covenant Area (Per Liber 2601 Pages 25-26)

A parcel of land in the Southeast 1/4 of Section 10, the Southwest 1/4 of Section 11, the Northwest 1/4 of Section 14, and the Northeast 1/4 of Section 15, Town 6 North, Range 16 West, described as follows: To find the place of beginning of this description, commence at the Northwest corner of said Section 15 and run thence Easterly, along the North line of said Section 15, approximately 1525 feet; thence Southerly approximately 195 feet to the Northwest corner of the existing ash storage area; thence Easterly, along the Northerly line of said existing ash storage area, 1505 feet; thence Southeasterly, continuing along said Northerly line, 135 feet; thence Easterly, continuing along said Northerly line, 140 feet to the **PLACE OF BEGINNING OF THIS DESCRIPTION**; thence Northerly 1985 feet; thence Easterly 1265 feet; thence Southeasterly 690 feet; thence Easterly 1095 feet, thence Southeasterly 540 feet; thence Southerly 1460 feet, thence Westerly 430 feet, thence Northwesterly 300 feet to the inside crest of the existing ash storage area dike; thence Westerly, along said inside crest, 2535 feet; thence Northerly 195 feet to the **Place of Beginning.**

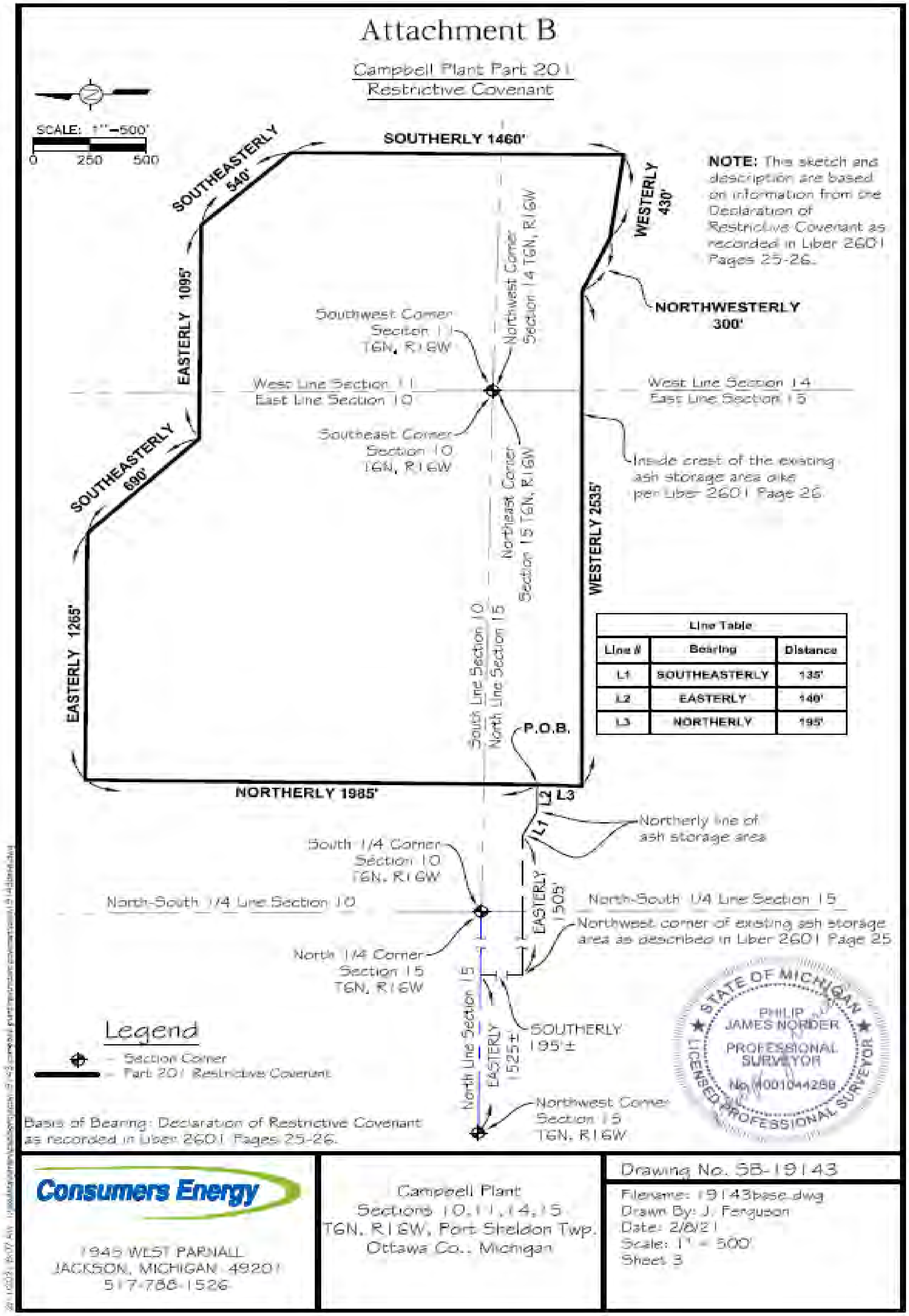
Containing 143 acres, more or less.

STATE OF MICHIGAN
PHILIP JAMES NORDER
PROFESSIONAL SURVEYOR
No. 4001044286
LICENSED PROFESSIONAL SURVEYOR

Basis of Bearing: Declaration of Restrictive Covenant as recorded in Liber 2601 Pages 25-26.

Consumers Energy 1945 WEST PARNALL JACKSON, MICHIGAN 49201 517-788-1526	Campbell Plant Sections 10,11,14,15 T6N, R16W, Port Sheldon Twp. Ottawa Co., Michigan	Drawing No. SB-19143 Filename: 19143base.dwg Drawn By: J. Ferguson Date: 2/8/21 Scale: N/A Sheet 2

EXHIBIT 2


Attachment B
Campbell Plant Part 201
Restrictive Covenant
SCALE: 1"=500'
0 250 500
SOUTHERLY 1460'
SOUTHEASTERLY 540'
WESTERLY 430'
NOTE: This sketch and description are based on information from the Declaration of Restrictive Covenant as recorded in Liber 2601 Pages 25-26.
EASTERLY 1095'
NORTHWESTERLY 300'
Southwest Corner Section 11 T6N, R16W
Northwest Corner Section 14 T6N, R16W
West Line Section 11
East Line Section 10
West Line Section 14
East Line Section 15
Southeast Corner Section 10 T6N, R16W
SOUTHEASTERLY 690'
Inside crest of the existing ash storage area dike per Liber 2601 Page 26
Northeast Corner Section 15 T6N, R16W
WESTERLY 2535'
EASTERLY 1265'
South Line Section 10
North Line Section 15
Line Table
Line # | Bearing | Distance
L1 | SOUTHEASTERLY | 135'
L2 | EASTERLY | 140'
L3 | NORTHERLY | 195'
P.O.B.
NORTHERLY 1985'
L2 L3
L1
Northerly line of ash storage area
South 1/4 Corner Section 10 T6N, R16W
North-South 1/4 Line Section 10
EASTERLY 1505'
North-South 1/4 Line Section 15
Northwest corner of existing ash storage area as described in Liber 2601 Page 25
North 1/4 Corner Section 15 T6N, R16W
SOUTHERLY 195'±
North Line Section 15
EASTERLY 1525±'
STATE OF MICHIGAN
PHILIP JAMES NORDER
PROFESSIONAL SURVEYOR
No. 4001044288
LICENSED PROFESSIONAL SURVEYOR
Legend
Section Corner
Part 201 Restrictive Covenant
Northwest Corner Section 15 T6N, R16W
Basis of Bearing: Declaration of Restrictive Covenant as recorded in Liber 2601 Pages 25-26.
Consumers Energy
1945 WEST PARNALL
JACKSON, MICHIGAN 49201
517-788-1526
Campbell Plant
Sections 10, 11, 14, 15
T6N, R16W, Port Sheldon Twp.
Ottawa Co., Michigan
Drawing No. SB-19143
Filename: 19143base.dwg
Drawn By: J. Ferguson
Date: 2/8/21
Scale: 1" = 500'
Sheet 3

APPENDIX C

Administratively Complete Checklist

EGLE

Michigan Department of Environment, Great Lakes, and Energy
Materials Management Division

CHECKLIST FOR ADMINISTRATIVE COMPLETENESS SOLID WASTE LANDFILL CONSTRUCTION PERMIT PACKET

This information is authorized under Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Failure to submit will result in the return of the application as administratively incomplete.

The information indicated on this checklist is necessary for a solid waste landfill construction permit application to be administratively complete pursuant to the administrative rules for Part 115.

Please complete and submit this "Checklist for Administrative Completeness" with the construction permit application. For Part A 1 - 12 - General Information, please indicate by checking in allotted space that you have included the information and in A - 13 indicate amount of enclosed check. For Parts B through J, please record in the allotted space the location of the documents in the construction permit packet where the required information can be found. To facilitate our review of the construction permit application, please complete this administrative completeness checklist in its entirety and enclose all of the requisite information.

All 'non-shaded' boxes (☐) require a response; 'dark-shaded' boxes (■) do not.

'Light-shaded' boxes (☐) may be used to record information but does not necessarily require a response.

Refer to Section A - Introduction	**A. General information required to be submitted on the construction permit application provided. Rule 902(1)(a).**
Section 1.1 of Section A	1. Name and location of the facility.
Section 1.2 of Section A	2. Name and address of the operation.
Section 1.3 of Section A	3. Name and address of the property owner(s).
Section 1.4 of Section A	4. Name and address of any mineral rights owner(s).
Section 1.5 of Section A	5. The type of disposal area proposed.
Section 1.6 of Section A	6. The type of application being submitted.
Section 1.7 of Section A	7. A description of the type of waste proposed for disposal attached to application form.
Section 1.8 of Section A	8. The number of acres applied for.
Section 1.9 of Section A	9. The design capacity of the landfill.
Section 1.10 of Section A	10. The signature of the owner and proposed operator.
Section 1.11 of Section A	11. Facility map included with application form.

Location of Documents	Description of Item
Section 1.12 of Section A	12. Facility's legal description attached to application form.
$750.00	13. Indicate the amount of the application fee **Rule 902(1)(b)**
Appendix D of Section A	14. Verification of receipt of application fee from Cashier's Office.

Description of Item	Location of Documents
B. An environmental assessment must contain the following information. Rule 902(1)(c)	**Refer to Section B – Environmental Assessment**
1. Documentation of consistency with the county solid waste management plan through either of the methods allowed. **Rule 902(2)** and **Rule 903(1)(a)**	Refer to Section A, Appendix B and Section B.1
a. Letter, resolution, or other document from designated planning agency that the proposed disposal area is consistent.	Refer to Section A, Appendix B and Section B.1
b. Statement from applicant saying why they believe the proposed disposal area is consistent based on the requirements of the plan, if the designating planning agency refuses to provide the original documentation.	Not Applicable (NA)
2. A list of required governmental permits/licenses required for the disposal area. **Rule 903(1)(b)** and **903(2)(c)**	Refer to Section B.2
3. Documentation of compliance with location standards specified in Rules 411-419 (for Type II) or Rules 305 and 310 (for Type III). **Rule 903(1)(c)**	Refer to Section B.3
a. Rule 411 Groundwater Isolation	Refer to Section B.3.a
b. Rule 412 Horizontal isolation	Refer to Section B.3.b
c. Rule 413 Sensitive areas	Refer to Section B.6.e, f, g, h
d. Rule 414 Airport safety	Refer to Section B.3.b and B.6.i and Figure 3
e. Rule 415 Floodplains	Refer to Section B.6.d
f. Rule 416 Wetlands	Refer to Section B.6.h.a and B.7.h.a
g. Rule 417 Fault areas and impact zones	Refer to Section B.3.b and Attachment B-2
h. Rule 418 Unstable areas	Refer to Section B.3.b and Attachment B-2
i. Rule 419 Vertical expansions	Refer to Section B.3.b
4. Demonstration of compliance with performance standards for surface water, groundwater, and air; specified in Rule 306 (for Type III) and Rule 436 (for Type II). **Rule 903(1)(d)**	Refer to Section B.4
(a) surface water,	Refer to Section B.4.a
(b) groundwater, and	Refer to Section B.4.b
(c) air	Refer to Section B.4.c

Description of Item	Location of Documents
5. A description of the proposed facility which includes “a. - e.” as follows: **Rule 903(2)(a)**	Refer to Section B.5
a. Type and size of the disposal area.	Refer to Section B.5.a
b. Public roads to be used to access the facility.	Refer to Section B.5.b
c. Anticipated volume waste to be received per day.	Refer to Section B.5.c
d. Anticipated counties to be served.	Refer to Section B.5.d
e. Anticipated useful life of the facility.	Refer to Section B.5.e
6. A description of the existing environment including **Rule 903(2)(b)**	
a. Maps showing the existing topography, land use, and residences surrounding the facility.	Refer to Section B.6.a
b. Existing air quality including a wind rose from the closest available station.	Refer to Section B.6.b
c. Hydrology including the following from the nearest available station:	Refer to Section B.6.c
(1) Magnitude of the 24-hour, 25-year	Refer to Section B.6.c(1)
(2) Average annual rainfall.	Refer to Section B.6.c(2)
d. Maximum floodplain elevation of surface waters proximate to the facility.	Refer to Section B.6.d
e. List of all endangered or threatened species whose range falls within the property boundaries of the facility.	Refer to Section B.6.e
f. List of historic or archaeological sites proximate to the property boundary.	Refer to Section B.6.f
g. List of any known sites of environmental contamination.	Refer to Section B.6.g
h. Identification of any significant public resources within or adjacent to the proposed facility.	Refer to Section B.6.h
i. Identification of any airport within 10,000 feet of the facility.	Refer to Section B.6.i
7. Statement of the anticipated environmental impacts in relation to each component of the existing environment (as described in B.6). **Rule 903(2)(d)**	Refer to Section B.7

Description of Item	Location of Documents
8. A listing of alternative actions for waste disposal in the country or region, including alternatives considered positive and negative, economic, and environmental impacts of the alternatives, and the alternative of no action. **Rule 903(2)(e)**	Refer to Section B.8
9. A summary statement of the unavoidable adverse impacts. **Rule 903(2)(f)**	Refer to Section B.9
10. A statement of the protective and corrective measures that will be taken to reduce and mitigate adverse impacts to acceptable levels. **Rule 903(2)(g)**	Refer to Section B.10
11. Graphic displays and references as follows: **Rule 903(3)**	
a. Maps that show the location of the proposed action, if applicable, with respect to communities or features that readily identifiable as locations in the state.	Refer to Section B.11.a and Section B - Figures 1 through 14 and Engineering Drawings Sheets 200-1 through 200-6
b. Maps, diagrams, or photographs that illustrate the relationships of the disposal area to the environmental element being impacted.	Refer to Section B.11.b and Section B - Figures 1 through 14 and Engineering Drawings Sheets 200-1 through 200-6
c. References to the literature or other sources of information from which data in the environmental impact statement is taken and upon which conclusions are based.	Refer to Section B.11.c
C. A hydrogeological report that includes the following: Rule 902(1)(d)	**Refer to Section C for the following subsections.**
1. A determination of existing groundwater quality, including the area and vertical extent of any groundwater contamination. **Rule 904(1)(a)**	Refer to Sections 4.1 and 4.2
2. Definition of the following aquifer: **Rule 904(1)(e)(i)-(iii)**	
a. The uppermost aquifer and aquifers that are hydraulically inter-connected to the uppermost aquifer beneath the facility property.	Refer to Section 2.2
b. Any aquifer that is utilized by Type I and Type II and public water supplies, as defined in R 325.10502, within 1,000 feet of the proposed active work area.	Refer to Sections 2.2 and Section 5.2
c. Any aquifer that is utilized by Type IIb and Type III public water supplies, as define in R 325.10502, within 1,000 feet of the proposed active work area.	Refer to Sections 2.2 and Section 5.1

Description of Item	Location of Documents
3. A determination of the background groundwater quality. **Rule 904(1)(b)** and **Rule 904(4)(a)**	Refer to Section 4.1
4. A map of the site and surrounding area, drawn to scale and showing "a. - g.": **Rule 904(4)(b)**	Refer to the Engineering Drawings, Sheet 200-2 and Figure 2
a. Distance to existing wells and properties with the potential for groundwater supplies showing all soil borings within one-half mile, including all domestic municipal, industrial, oil, and gas wells for which copies of logs area available.	Refer to Engineering Drawings, Sheet 200-2 and Appendix A in Section C.
b. Existing lakes or ponds.	Figure 2 (Site Features Map)
c. Streams, springs, or wetlands.	Figure 2
d. Direction of surface drainage and groundwater movement in the area.	Figures 4 and 5 (GW Contour Map)
e. Locations of borings, observation wells, and other well data used in the report.	Figure 2, Figure 4
f. Topography, including predominant topographic features.	Figure 2 and the Engineering Drawings, Sheet 200-2
g. Location of any known or potential sources of groundwater contaminants.	Figures 6 and 7 (DW and GSI Exceedances)
5. Observation well records or soil borings to locate and identify aquifers beneath the property aquifers beneath the property identifying: **Rule 904(4)(c)**	Appendix A
a. Depth to groundwater.	Table 2, Figure 2, Appendix A
b. Aquifer thickness.	Appendix B
c. Vertical and horizontal groundwater flow directions.	Figure 4, Section 2.2
d. Vertical and horizontal flow rates.	Refer to Section 2.2
6. A groundwater elevation map, based on stabilized water level readings, contoured at not more than one foot, referenced to U.S. Geological Survey datum and including: **Rule 904(4)(d)**	Refer to the Figures
a. Groundwater flow directions and possible variations in groundwater flow directions.	Figure 4, Section 2.2
b. Depth of groundwater.	Table 2, Figure 4, Section 2.2

Description of Item	Location of Documents
7. An evaluation of site earth materials, including bedrock characteristics, if bedrock exists within 50 feet of the proposed base of fill, based on boring logs including: **Rule 904(4)(e)**	Section 2.0
a. Soil and rock descriptions.	Refer to Section 2.1
b. Methods of sampling.	Appendix A (Boring Logs)
c. Sample depths.	Appendix A (Boring Logs)
d. Data of boring.	Appendix A (Boring Logs)
e. Water level measurements at the time of the boring.	Appendix A (Boring Logs)
f. Soil tests data.	Section 2.1 includes the results and references 1996 HMP. Soils geotechnical laboratory test data for can also be found in Section F, Appendix B.
g. Boring locations.	Figure 2
8. A series of geologic cross sections or fence diagrams that pass through representative borings, referenced to a site map that shows all wells and borings, and illustrating the following: **Rule 904(4)(f)**.	Refer to the Figures and the Engineering Drawings (Sheets 500-1 and 500-2)
a. Existing topography.	Figure 3 (Cross-Section), Figure 2 (Site Features Map)
b. Soil borings.	Figure 3, Appendix A
c. Soil classification.	Figure 3, Appendix A
d. Stratigraphy.	Figure 3, Appendix A
e. Bedrock.	Appendix B
f. Wells.	Figure 3
g. Stabilized water level readings.	Figure 3
h. Proposed site grades.	See Engineering Drawings, Sheets 400-1 and 400-3
9. The nature, extent and consequence of any mounding that results from diversion of infiltration and surface runoff during operation and post-closure. **Rule 904(4)(g)**	Refer to Section 3.3 and 3.4
10. A description of any proposed engineering modifications intended to modify groundwater level. **Rule 904(4)(h)**	Refer to Section 2.2.3

Description of Item	Location of Documents
11. A determination of the horizontal and vertical flow system, and diagrams that illustrate horizontal and vertical flow directions of groundwater. **Rule 904(4)(i)**	Figure 3, Table 2
12. A compilation and interpretation of data, maps, and charts based on site conditions to support the conclusions and recommendations of the hydrogeological report. **Rule 904(4)(k)**	See Figures

D. The hydrogeological plan as required by R 299.4905. Rule 902(1)(e)	**Refer to Section D - HMP**
1. A plan that includes monitoring of the following: **Rule 905(1)**	
a. The monitoring well system which is in compliance with R 299.4906.	Refer to Section 2.1
b. The leachate and secondary collection system of the landfill, as specified in R 299.4432.	Refer to Section 4.4
c. Any surface water that may receive runoff from the active work area.	Refer to Sections 3 and 4.3
2. The following specific information: **Rule 905(2)**	
a. The location to be sampled.	Refer to Section 3.3.1
b. A list of constituents to be sampled and the frequency of sampling.	Refer to Table 2
c. Identification of the sampling and analysis procedures to be used for each constituent or parameter proposed including:	
(1) Sample collection.	Refer to Section 4.4
(2) Sample preservation and shipment.	Refer to Section 4.5
(3) Analytical procedures including the method detection limit for the procedure specified.	Refer to Sections 5 and 6
(4) Chain of custody control.	Refer to Section 4.5
(5) Laboratory and field Quality Assurance/Quality Control.	Refer to Section 4.6
(6) Procedures for preventing cross-contamination during well installation, purging, and sampling.	Refer to Section 4.7
d. Statistical procedures for evaluating data in compliance with R299.4908.	Refer to Section 6.0
E. Topographic maps that meet the following requirements: Rule 902(1)(f)	**Refer to Section E - Topographic Maps**
1. Maps referenced to U.S. Geological Survey.	Refer to Section E.1, and the Engineering

Description of Item	Location of Documents
datum at a scale of not more than 200 feet to the inch with contour intervals that clearly show the character of the land and land uses within 1,500 feet of the solid waste disposal unit(s). **Rule 909(1)**	Drawings
2. The following specific information: **Rule 909(2)**	
a. A legal description of the property included in the application.	Refer to Section E.2.1
b. Proposed solid waste disposal units.	Refer to Section E.2.2
c. Structures on the site.	Refer to Section E.2.3
d. Existing and proposed utilities.	Refer to Section E.2.4
e. Borrow areas.	Refer to Section E.2.5
f. Surface waters, wetland, or floodplains.	Refer to Section E.2.6
g. Special drainage devices, if necessary.	Refer to Section E.2.7
h. On-site roads.	Refer to Section E.2.7
i. Public access roads.	Refer to Section E.2.8
j. Fencing and other means of controlling access.	Refer to Section E.2.10
k. The location of all residences.	Refer to Section E.2.11
F. Engineering plans and engineering reports for a landfill that meet the following requirements: Rule 902(1)(g) and Rule 910	**Refer to Section F – Engineering Report and the Engineering Drawings**
1. Details of the following: **Rule 910(1)(a)**	
a. Soils underlying each liner system including information on: **Rule 910(1)(a)** and **Rule 910(2)**	
(1) A settlement analysis estimating total and differential settlement including immediate settlement, primary consolidation, and secondary consolidation based on maximum loading. **Rule 910(2)(a)**	Refer to Section F, Subsection F.1.a.(1)
(2) A slope stability study. **Rule 910(2)(b)**	Refer to Section F, Subsection F.1.a.(2)
(3) A performance analysis under varying groundwater conditions. **Rule 910(2)(c)**	Refer to Section F, Subsection F.1.a.(3)
(4) Calculations that show the potential for bottom heave or blowout. **Rule 910(2)(d)**	NA (Double Composite Sand Site)
b. Compacted soil liners or natural soil that is used in place of a compacted liner including information on: **Rule 910(1)(b)** and **Rule 910(3)**	NA (Double Composite Sand Site)
(1) The location and thickness of soils to be	NA (Double Composite Sand Site)

Description of Item	Location of Documents
used for the compacted or natural soil liner.	
(2) Copies of well boring logs documenting soil deposits.	Refer to Section C and Section F, Subsection F.1.b
(3) Data documenting soil source classification, and permeability's including the locations of the tests performed (horizontal and vertical).	Refer to Section C and Section F – Appendix B
(4) For compacted liners, calculations which show the volume of the source.	NA (Double Composite Sand Site)
c. Bentonite geocomposites or flexible membrane liners that includes the following information: **Rule 910(1)(c)** and **Rule 910(4)**	Refer to Section F, Subsection F.1.c
(1) The methods of storage, handling, and installation including any written instructions from the manufacturer, and quality control procedures.	Refer to Section F, Subsection F.1.c.(1)
(2) The physical specifications of the liner material.	Refer to Section F, Subsection F.1.c.(2)
(3) The ability of the liner material and scrim material, where application, to maintain physical properties under varying conditions of temperature, pH, ultraviolet radiation, biological attack, and prolong leachate throughout the operating and post-closure life of the landfill.	Refer to Section F, Subsection F.1.c.(3)
d. Primary leachate collection and removal systems that includes the following information: **Rule 910(1)(d)** and **Rule 910(5)**	Refer to Section F, Subsection F.1.d
(1) Specifications for the material to be used for the leachate collection system. **Rule 910(5)(a)**	Refer to Section F, Subsection F.1.d.(1)
(2) The design of the collection pipe including the following: **Rule 910(5)(a)**	
(a) Diameter.	Refer to Section F, Subsection F.1.d.(2)(a)
(b) Perforations.	Refer to Section F, Subsection F.1.d.(2)(b)
(c) Slope.	Refer to Section F, Subsection F.1.d.(2)(c)
(d) Spacing.	Refer to Section F, Subsection F.1.d.(2)(d)
(e) Leachate compatibility.	Refer to Section F, Subsection F.1.d.(2)(e)
(f) Structural integrity under static and dynamic loading.	Refer to Section F, Subsection F.1.d.(2)(f)
(3) Design features that allow cleaning of	Refer to Section F, Subsection F.1.d.(3)

Description of Item	Location of Documents
drainage pipes. **Rule 910(5)(c)**	
(4) Procedures to prevent clogging during construction and operation. **Rule 910(5)(d)**	Refer to Section F, Subsection F.1.d.(4)
(5) Calculations to show that the leachate head will be one foot or less above the liner at any point in the system except the sump. **Rule 910(5)(e)**	Refer to Section F, Subsection F.1.d.(5)
(6) Provisions to remove obstructions from the system. **Rule 910(5)(f)**	Refer to Section F, Subsection F.1.d.(6)
(7) Calculations to determine the anticipated volume of the leachate collected. **Rule 910(5)(g)**	Refer to Section F, Subsection F.1.d.(7)
(8) Information on the proposed methods of disposal for the leachate collected. **Rule 910(5)(h)**	Refer to Section F, Subsection F.1.d.(8)
e. Secondary leachate collection or leak detection systems that includes the following information: **Rule 910(1)(e)** and **Rule 910(6)**	Refer to Section F, Subsection F.1.e
(1) The design of the secondary collection system shall include the information required under **Rule 910(5):**	
(a) Specifications for the material to be used for the leachate collection system. **Rule 910(6)(a)** and **Rule 910(5)(a)**	Refer to Section F, Subsection F.1.e.
(b) The design of the collection pipe including the following: **Rule 910(5)(a)**	
(i) Diameter.	Refer to Section F, Subsection F.1.e.
(ii) Perforations.	Refer to Section F, Subsection F.1.e.
(iii) Slope.	Refer to Section F, Subsection F.1.e.
(iv) Spacing.	Refer to Section F, Subsection F.1.e.
(v) Leachate compatibility.	Refer to Section F, Subsection F.1.e.
(vi) Structural integrity under static and dynamic loading.	Refer to Section F, Subsection F.1.e.
(c) Design features that allow cleaning of drainage pipes. **Rule 910(5)(c)**	Refer to Section F, Subsection F.1.e.
(d) Procedures to prevent clogging during construction and operation. **Rule 910(5)(d)**	Refer to Section F, Subsection F.1.e.

Description of Item	Location of Documents
(e) Calculations to show that the leachate head will be one foot or less above the liner at any point in the system except the sump. **Rule 910(5)(e)**	Refer to Section F, Subsection F.1.e.
(f) Provisions to remove obstructions from the system. **Rule 910(5)(f)**	Refer to Section F, Subsection F.1.e.
(g) Calculations to determine the anticipated volume of the leachate collected. **Rule 910(5)(g)**	Refer to Section F, Subsection F.1.e.
(h) Information on the proposed methods of disposal for the leachate collected. **Rule 910(5)(h)**	Refer to Section F, Subsection F.1.e.
(2) The method of detecting, removing, and analyzing leaks that are detected in the system. **Rule 910(6)(a)**	Refer to Section F, Subsection F.1.e.
f. Dewatering systems that includes the following information: **Rule 910(1)(f)** and **Rule 910(7)**	NA
(1) Design calculations for the drain pipe diameter.	NA
(2) Design features that allow cleaning.	NA
(3) Procedures to prevent clogging during construction and operation.	NA
(4) An evaluation of the structural suitability of underdrain pipe under both static and dynamic loadings.	NA
g. Information on the control of the following: **Rule 910(1)(g)** and **Rule 910(8)**	Refer to Section F, Subsection F.1.g
(1) Run-on.	Refer to Section F, Subsection F.1.g.(1)
(2) Run-off.	Refer to Section F, Subsection F.1.g.(2)
(3) Wind dispersal of particulate matter.	Refer to Section F, Subsection F.1.g.(3)
(4) Gas that is generated within the landfill	NA
(i) A description of a landfill gas monitoring plan that complies with R 299.4433.	NA
h. The final cover as specified in a closure plan that is in compliance with the provisions of R 299.4446 and includes the following: **Rule 910(1)(h)**	Refer to Section F, Subsection F.1.h.

Description of Item	Location of Documents
(1) An overall description of the methods, procedures, and processes that will be used to close each unit of the landfill in accordance with R 299.4446.	Refer to Section F, Subsection F.1.h.(1)
(2) An estimate of the maximum extent of operation that will be open at any time during the active life of the landfill.	Refer to Section F, Subsection F.1.h.(2)
(3) An estimate of the maximum inventory of waste ever on-site over the active life of the landfill.	Refer to Section F, Subsection F.1.h.(3)
(4) A description of the final cover, including engineering plans and specifications.	Refer to Section F, Subsection F.1.h.(4)
(5) A schedule for completing all activities that are necessary to satisfy the final cover requirements of these rules.	Refer to Section F, Subsection F.1.h.(5)
i. Post-closure maintenance and monitoring, as specified in a plan that is in compliance with provisions of R 299.4447 and including the following: **Rule 910(1)(i)**	Refer to Section F, Subsection F.1.i
(1) A description of the monitoring and maintenance activities that are required for each unit, and the frequency at which these activities will be performed.	Refer to Section F, Subsection F.1.i.(1)
(2) Name, address, and telephone number of the person or office to contact about the facility during the post-closure period.	Refer to Section F, Subsection F.1.i.(2)
(3) A description of the planned uses of the property during the post-closure period.	Refer to Section F, Subsection F.1.i.(3)
2. Engineering plans prepared and sealed by a professional engineer. **Rule 910(9)**	Refer to Section F, Subsection F.2 and the Engineering Drawings
G. Operation plans which meet the requirements of R 299.4911 by including the following: Rule 902(1)(h)	**Refer to Section G – Operations Plan**
1. The following plans that describe how the facility will be operated: **Rule 911(1)**	
a. A fill progression plan over the active life of the landfill including final slopes and elevations and including the location and description of the permanent survey benchmark to be used for elevation control.	Refer to Section G, Subsection 1.3 and the Engineering Drawings Sheets 400-4 through 400-8
b. A landscape plan that identifies and locates existing vegetation to be retained and proposed vegetation to be used for cover, screening, and other purposes.	Section G, Subsection 1.3 and the Engineering Drawings Sheet 800-1
c. Engineering plans that detail leachate	Section G, Subsection 1.3 and the Engineering

Description of Item	Location of Documents
collection and removal facilities and, if applicable, that show any systems to be used for leachate recirculation.	Drawings Sheets 400-2 and 600-1
d. An engineering plan that shows gas management systems, if applicable. (If not applicable, indicate "NA").	NA, the site is CCR
2. Engineering reports that describe: **Rule 911(2)**	
a. All equipment to be used at the landfill for construction and operation.	Refer to Section G, Subsection 2.1
b. The landfill's personnel requirements, including the duties, training, and authority of the responsible individual who is to direct landfill operations.	Refer to Section G, Subsection 2.2
c. Access controls to be used including:	
(1) Signs.	Refer to Section G, Subsection 2.3.1
(2) Hours of operation.	Refer to Section G, Subsection 2.3.2
(3) Usage rules.	Refer to Section G, Subsection 2.3.3
(4) Natural and artificial barriers.	Refer to Section G, Subsection 2.3.4
(5) Traffic control.	Refer to Section G, Subsection 2.3.5
d. The methods to be used to control dust and blowing papers from the active fill area.	Refer to Section G, Subsection 2.4
e. The methods for disposal of large or bulky items.	Refer to Section G, Subsection 2.5
f. The on-site road design and method of controlling fugitive dust.	Refer to Section G, Subsection 2.4
g. The methods to control salvaging, if allowed.	Refer to Section G, Subsection 2.8
h. The storage locations of, and the design for, white goods and other recyclable materials.	Refer to Section G, Subsection 2.15
i. The procedures for separating recyclable materials from general refuse, if applicable.	Refer to Section G, Subsection 2.15
j. The type of daily cover to be used and the source, quantity, and method of placement of the cover.	Refer to Section G, Subsection 2.17
k. The process for receiving and unloading solid waste including the procedures for inspecting loads for hazardous waste.	Refer to Section G, Subsection 2.19
(i) A description of a program for detecting and preventing the disposal of wastes that are prohibited by R 299.4430.	Refer to Section G, Subsection 2
(ii) The program meets all the	Refer to Section G, Subsection 2

Description of Item	Location of Documents
requirements of R299.4430(3)	
l. The procedures for the receipt and disposal of asbestos waste.	Refer to Section G, Subsection 2.16
H. Construction Quality Assurance Plans that meet the requirements of R 299.4916 by including the following: Rule 902(1)(i)	**Refer to Section H – Construction Quality Assurance Plan**
1. Method for addressing the following physical components where applicable: **Rule 916(2)**	
a. Foundations.	Refer to Section H, Subsections 6 and 7
b. Dikes.	Refer to Section H, Subsections 6 and 7
c. Low-permeability soil liners.	Refer to Section H, Subsection 9 (GCLs)
d. Flexible membrane liners.	Refer to Section H, Subsection 10
e. Leachate collection and removal systems and secondary collection systems.	Refer to Section H, Subsections 11, 12, 13, and 14
f. Final cover systems.	Refer to Section H, Subsection 15, 16, and 17
2. Observations, inspections, tests, and measurements that will be used to ensure: **Rule 916(4)**	
a. Structural stability and integrity of the features listed in "H.1.".	Refer to Section H, Subsections, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17
b. Proper construction of all components of the liners, primary and secondary collection and removal system(s), and final cover system.	Refer to Section H, Subsections, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17
c. Conformity of all materials used with design and other material specifications.	Refer to Section H, Subsections, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17
I. Include Remedial Action Plan in compliance with Part 201 and Part 115 Rules, if landfill facility has been determined to be a source of probable source of groundwater contamination. Rule 902(3)	**Refer to Section I – Copy of Remedial Action Plan**

APPENDIX D

Copy of Application Fee Check

CONSUMERS ENERGY COMPANY
ONE ENERGY PLAZA
JACKSON, MI 49201

000003

Consumers Energy
Count on Us

06/07/2021

Page 1

STATE OF MICHIGAN DEPT OF
EVIRONMENTAL QUALITY
PO BOX 30657
LANSING, MI 48909-8157

PAYMENT INQUIRIES (517) 788-0741

PO NUMBER	INVOICE NO.	EXTENDED INVOICE NO.	INVOICE DATE	GROSS AMOUNT	DISCOUNT AMOUNT	RETAINER AMT HELD	NET AMOUNT
0000380460	N/A		06/04/2021	750.00	0.00	0.00	750.00

ADDITIONAL MEMO

PERMIT APPLICATION FEE

Total $750.00

DETACH AND RETAIN THIS STUB FOR YOUR RECORDS CHECK # 1201732127 ATTACHED BELOW

THE FACE OF THIS CHECK IS PRINTED BLUE - THE BACK CONTAINS A SIMULATED WATERMARK

Consumers Energy
Count on Us

CONSUMERS ENERGY COMPANY
ONE ENERGY PLAZA
JACKSON, MI 49201

56-1544
441

JPMorgan Chase Bank, N.A.
Columbus, OH

No. 1201732127

06/07/2021

SEVEN HUNDRED FIFTY and 0/100 DOLLARS

$750.00

PAY TO THE ORDER OF

STATE OF MICHIGAN DEPT OF
EVIRONMENTAL QUALITY
PO BOX 30657
LANSING, MI 48909-8157

AUTHORIZED SIGNATORY

⑈1201732127⑈ ⑆044115443⑆ 937271963⑈

APPENDIX E

Airspace Lost Figure

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	-5	0	
2	0	5	
3	5	10	
4	10	15	
5	15	20	
6	20	25	
7	25	27	

Cut/Fill Summary

SURFACE NAME	Cut	Fill	Net
REGRADED CELL SUBGRADE VOLUME LOST	450 Cu. Yd.	509,530 Cu. Yd.	509,080 Cu. Yd.<Fill>

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

AIRSPACE LOST

SCALE: 1" = 100'

JOB: PT-01891

DRAWING NO.

FIGURE A-1

REV. A

GOLDER

MEMBER OF WSP

golder.com

REPORT

Section B - Environmental Assessment

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion Facility ID 395496

Submitted to:

Consumers Energy Company
J.H. Campbell Generating Facility
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50 Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

Executive Summary

Golder Associates Inc. has prepared an Environmental Assessment (EA) for the proposed Type III Landfill lateral and vertical expansion of the Consumers Energy Company (CEC) J.H. Campbell (JHC) Generating Facility Dry Ash Landfill (JHC Landfill) located at 17000 Croswell Street, West Olive, Michigan. The JHC Landfill is currently permitted and licensed as a Type III Low Hazard Industrial Landfill and is used only for the disposal of coal combustion residuals (CCR, ash) generated by CEC. The currently permitted airspace volume for the JHC Dry Ash Landfill is 9,500,000 cubic yards.

As defined by the Michigan Department of Environment, Great Lakes, and Energy (EGLE), a Type III landfill is any landfill that is not a municipal solid waste landfill or hazardous waste landfill and includes:

- Industrial waste landfills;
- Landfills which accept waste other than household waste, municipal solid waste incinerator ash, or hazardous waste from conditionally exempt small quantity generators;
- Construction and demolition (C&D) waste landfills; but not included in this application as a facility to receive these materials: and
- CCR landfills and existing surface impoundments closed as landfills

JHC Landfill retains Solid Waste Disposal Area Operating License Number (9542) issued by the Michigan Department of Environment, Great Lakes and Energy (EGLE)) dated January 23, 2019 and expiring January 23, 2023, in accordance with the provisions of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act (NREPA), Public Act (PA) 451 of 1994, as amended and any regulations promulgated pursuant to this act (Part 115 Rules). In addition to Part 115, the facility complies with the requirements of 40 CFR Part 257, Hazardous and Solid Waste Management System: Disposal of CCR.

CEC is submitting a Solid Waste Disposal Area Construction Permit Application (CPA) for proposed lateral and vertical expansion of the facility to provide additional Type III solid waste capacity. The lateral expansion area includes 27.2 acres and vertical expansion is over approximately 42,9 acres of constructed and unconstructed areas. The expansion is to include an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill. As such, the lateral extent of the landfill boundary will remain unchanged. As part of the construction permit modification that was approved by EGLE in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. A lateral expansion is required for the unconstructed Cells 6 through 9 per the revisions to Part 115. A lateral and vertical expansion within the currently permitted solid waste boundary is proposed to regain the lost airspace and to provide sufficient capacity for the remaining life of the generating facility. The proposed expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area. The proposed increase in airspace will provide an estimated additional 2 years of site life with a total remaining site life of approximately 20 years.

Part 115 requires the submittal of an environmental assessment with the CPA. This EA for JHC Landfill has been prepared in accordance with the requirements of Rules 299.4902 and 299.4903.

Table of Contents

FIGURES

ATTACHMENTS

Attachment B-1 Ottawa County Consistency Documentation

Attachment B-2 Location Restrictions (Wetland, fault areas and seismic zones, and unstable areas)

Attachment B-3 Sensitive Areas (Flood Plains, Endangered Species, Historical and Archeological Areas, Soil Types)

Attachment B-4 Contaminated Sites

SECTION B - ENVIRONMENTAL ASSESSMENT

This Construction Permit Application (CPA) is proposing a lateral and vertical expansion of the currently permitted Type III JHC Landfill to includes lateral expansion of 27.2 acres and vertical expansion over approximately 42,9 acres of constructed and unconstructed areas. The expansion includes an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill footprint. As part of the construction permit modification that was approved by Michigan Department of Environment, Great Lakes, and Energy (EGLE) in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. The expansion is proposed to regain the lost airspace and to provide sufficient capacity for the remaining life of the generating facility. The proposed expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area. The proposed increase in airspace will provide an estimated additional 2 years of site life with a total remaining site life of approximately 20 years.

As defined by EGLE, a Type III landfill is any landfill that is not a municipal solid waste landfill or hazardous waste landfill and includes:

- Industrial waste landfills
- Landfills which accept waste other than household waste, municipal solid waste incinerator ash, or hazardous waste from conditionally exempt small quantity generators.
- Construction and demolition (C&D) waste landfills; but not included in this application as a facility to receive these materials.
- CCR landfills and existing surface impoundments closed as landfills.

This application for the Type III Landfill expansion is being submitted to add capacity to the JHC Landfill for disposal of coal combustion residuals (CCR). The proposed Type III expansion will be designed and operated to meet or exceed criteria established by local, state, and federal regulatory agencies. Expansions of Type III landfills will not be issued an operating license unless the construction permit process specified in the act and Part 115 Rules Rule 299.4902 to Rule 299.4920 has been complied with and they achieve the standards contained in Part 3 of the Part 115 rules. In addition to the Part 115 requirements, the facility complies with the requirements of 40 CFR Part 257, Hazardous and Solid Waste Management System: Disposal of CCR.

The following sections of this Environmental Assessment (EA) address the environmental assessment requirements of 299.4903 of Part 115.

B.1 - DOCUMENTATION CONSISTENCY

The proposed Type III expansion is consistent with the Ottawa County Solid Waste Management Plan (April 2000) and Plan Amendment Proposal approved by EGLE (December 2015) (County Plan). This is documented by the Consistency Letter, dated December 8, 2020, Attachment B-1, that confirms the Type III expansion resulting in a total disposal volume of 10,032,000 cubic yards (9,500,00 cubic yards (original permit) + 532,000 cubic yards (expansion)) is approved for disposal of CCR solid waste (Rule 299.4903(a)).

B.2 - REQUIRED PERMITS/LICENSES

The state and federal permits and/or licenses that are required for the construction and operation of the site include (Rule 299.4903 (b):

- Solid Waste Disposal Area Operating License Number 9542 issued January 23, 2019 and expiring January 23, 2024, in accordance with the provisions of Part 115, Solid Waste Management, of the Natural

Resources and Environmental Protection Act (NREPA), Public Act (PA) 451 of 1994, as amended and any regulations promulgated pursuant to this act (Part 115 Rules);

- Renewable Operating Permit Number B2835 in accordance with Part 55 of NREPA as amended and any regulations promulgated pursuant to this act effective February 4, 2020, revised September 3, 2020 and expiring February 4, 2025;
- National Pollution Discharge Elimination System Permit Number MI0001422 effective June 1, 2018 and Expiring October 1, 2022.

B.3 - COMPLIANCE WITH LOCATION STANDARDS FOR TYPE III LANDFILL

Since the facility exists and is operating under an approved construction permit and operating license, the location standards were reviewed with respect to the existing Type III boundary, which will not change. The latera l expansion will remain within the landfill boundary originally permitted in the initial Construction Permit Application originally approved. This assessment adheres to the Rule 299.4903(c). These rules establish standards under the act for Type III landfill units. The standards ensure the protection of human health and the environment.

This application for the Type III expansion is being submitted to add capacity to the JHC Landfill for large volumes of inert Type III material, consisting of CCR and CCR containing materials. The Type III unit proposed will NOT accept construction and demolition materials. Under Part 115 Rule 299.4305 'Type III Landfill Location Restrictions', Type III landfills that are not construction and demolition debris landfills are subject to the following active work area requirements:

- Shall not be located closer than 100 feet to adjacent property lines, road rights-of-way, or lakes, and perennial streams;
- Shall not be located closer than 300 feet to domiciles that exist at the time of issuance of a construction permit; and
- In addition, approval of less than 200 feet of isolation distance requires either a berm which is not less than 8 feet high with a 4-foot fence on top and which is constructed around the perimeter of the active work area or natural screening that offers equivalent protection.

Greater isolation distances may be required in any of the following situations:

- Geological conditions require it.
- The site is adjacent to special quiet zones, as designated by local or state government.
- The site is near an airport.
- Federal or state regulations apply.
- Dewatering will adversely affect adjacent aquifers.

The site also must meet the location restrictions of the Ottawa County Siting requirements in the County Plan. No dewatering will be required for this Type III expansion. Rule 299.4310 applies for this Type III expansion for groundwater isolation.

B.3.a Part 115 Rule 299.4310 Groundwater Isolation

Rule 299.4310

(1) Type III landfills that do not have a liner or leachate collection system shall have a permanent minimum clearance of 4 feet from the bottom of the waste to the groundwater level unless the director authorizes a variance from this requirement under Rule 299.4108. The JHC Landfill Type III expansion includes the use of a liner and leachate collection system as shown in the Engineering Drawings, sheets 400-2, 500-6, and 500-7, and 500-8 so this rule is not applicable.

(2) Type III landfills that have a liner shall have a permanent minimum clearance of 4 feet from the top of the liner to the groundwater level unless the director authorizes a variance from this requirement under Rule299.4108. This Type III expansion includes the use of a liner and leachate collection system as shown in the Engineering Drawings, sheets 400-2, 500-6, and 500-7, and 500-8. The permanent minimum clearance from the bottom of waste (including at the sump locations) to the groundwater level is greater than 5 feet, as required by the Federal CCR Rule (40 CFR 257), see Sheets 400-1 and 500-5 in the Engineering Drawings.

(3) Gravity interception of groundwater to maintain the minimum clearance to groundwater level specified by this rule may be utilized. The pumping of groundwater to control groundwater level is not considered permanent and shall not be utilized. Neither gravity interception nor pumping of groundwater is required for this proposed Type III unit design to maintain groundwater separation.

B.3.b. Part 115 Rule 299.4305 Horizontal Isolations (replaces Rule 4412 per Type III)

Rule 299.4305(1) See also Section G – Operations Plan.

Rule 299.4305(2)(a)

(i) Noise: See Rule 299.4305(5)

(ii) and (iii) Blowing papers and dust: The JHC Landfill only accepts CCR for disposal from the JHC Generating Facility, therefore blowing papers is not an issue. The proposed horizontal isolation distances meet or exceed the regulatory criteria and are believed to be more than adequate to prevent off-site nuisance conditions due to dust. However, additional operational measures have been incorporated into the daily operation of the landfill. Dust control measures include moisture conditioning of the CCR in the silos prior to placement to reduce dust. A water tanker is on site to provide additional dust control in the CCR active area and on unpaved roads as needed. Other potential procedures for dust control are detailed in Section G - Operations Plan and the Fugitive Dust Control Plan (see Operations Plan Section G - Appendix C), which meets the State and Federal requirements.

(iv) Odor: Odors are to be controlled by way of source control, dispersion, and odor control agents. The Type III wastes designated for the expansion area (ash) are not expected to generate odors.

(v) and (vi) Vectors and pest animals: The Type III CCR waste is not expected to generate vectors or attract pest animals.

(vii) Equipment vibration: The operation of the landfill is not expected to involve any machinery that would generate significant vibration beyond the isolation distances described by Rule 299.4305(2)(b) or required by the County Plan.

Rule 299.4305(2)(b)

The JHC Landfill has prepared a series of drawings which demonstrate that the facility meets the appropriate setback restrictions as listed in the Part 115 Rules, refer to the Engineering Drawings.

The proposed expansion meets the 100- foot setback requirement for adjacent property lines, rights-of-way, inland lakes or perennial streams (400 feet from lakes and streams per the County Plan). No occupied domiciles exist within 300 feet of the landfill footprint (1,000 feet from the active work area per the County Plan). No public wells exist within 800 feet of the footprint. The relative location of these features to active area and solid waste boundaries are shown by Engineering Drawings Sheets 200-2 through 200-6.

The site does require greater isolation distances due to any of the items listed in this rule.

(i) Geological Conditions: The proposed expansion area is not located in a critical dune area nor is it located in a high-risk erosion or environmental area. See Figure 2, Soils Map (note that sand dunes shown by the soils map within the proposed expansion no longer due to historical activities prior to the dry ash facility construction).

A review of information currently developed by the United States Geological Survey (USGS) Earthquake Hazards Program and the National Earthquake Information Center (NEIC) indicates that there are no faults which were active in the Holocene period located within 200 feet of the JHC Landfill. It is estimated the JHC Landfill site will have an approximate 0.42-percent chance of a 0.10g horizontal acceleration in 50 years in lithified materials (see Attachment B-2). This is less than a 10-percent chance of exceeding a horizontal acceleration of 0.1g in 250 years, which is equivalent to exceeding a 2-percent chance over 50 years, Figure 7 and Figure 8, Michigan Seismicity Map, include the appropriate documentation developed by the USGS Earthquake Hazards Program Design Maps Tool, 2009 NEHRP.

Attachment B-2 provides documentation that there are no known forces that would make the structural components of the site susceptible to foreseeable natural or human-induced events or forces impacting the stability of the natural geologic formations at the site. These include localized ground subsidence or slope failures from karst formations, oil production activities, or groundwater removal.

Additional information on the geological conditions at the site are provided in the Section C – Hydrogeological Investigation Report.

(ii) Designated Quiet Zone: There are no state or local government designated quite zones in the vicinity of the site.

(iii) Airports: The closest airport, the Grand Haven Memorial Airpark, is approximately 8 miles north of the proposed expansion. There are no airports servicing jet or piston aircraft within 10,000 feet of the property boundary as indicated on Figure 3, Airport Location Map.

(iv) Applicable Federal and State Regulations: See paragraph B2.

(v) Dewatering: No dewatering is required for the proposed expansion.

Rule 299.4305(3)

The solid waste boundary for the proposed expansion of the JHC Landfill is not located within a 100-year floodplain. Figure 4 shows the location of 100-year floodplains at the site.

This satisfies or addresses Rule 299.4305(3).

Rule 299.4305(4)

The solid waste boundary for the proposed expansion of the JHC Landfill will not be located within a designated wetland area. The Ottawa County Wetlands Inventory Map (Figure 5) and United States Fish and Wildlife Service National Wetland Inventory Map (Figure 6) illustrates the location of nearby wetlands. There were no wetlands shown within the proposed solid waste boundary of the expansions and the proposed landfill expansion meets the siting requirements of this rule. Attachment B-2 includes more information on wetlands for the site.

This satisfies or addresses Rule and 299.4305(4).

Rule 299.4305(5)

Sound levels at the property line of a Type III landfill facility are restricted based on neighbouring land use. For instance, should the adjacent land use at a common property line be residential in character, the maximum sound level allowed is 75 dBA. Likewise, commercial use is 85 dBA and all other uses, including industrial, should not be exposed to any sound level higher than 90 dBA. Property lines adjacent to residential areas in proximity to the site are greater than 400 feet. The Act requires an isolation distance of 200 feet to a property line (300 feet from a domicile and 1,000 feet per the County Plan) from the active work area, or in this example the sound source. The greater isolation distances (400 feet vs. 200 feet) would be expected to attenuate sound levels such that the Act's level of 75 dBA at 200 feet from the source would reduce to approximately 69 dBA with an additional 400 feet of isolation distance, using the basic rule of a 6 dBA reduction for every doubling of distance. The operation of the proposed landfill is intended to not create a noise level exceeding 69 decibels for specified adjacent land uses as measured at the solid waste facility property line nearest the active work area. It is recognized that the control measures will not reduce all sound levels to a degree of consistency such that any associated sound will never be heard. Atmospheric conditions alone can alter sound propagation such that typically unnoticed sound can, under unusual conditions, be detected miles away. CEC proposes to utilize reasonable measures, to minimize sound disturbance to adjacent properties. It should also be noted that based on the intended use of the expansion area, its operation is not expected to be continuous through the day's operating hours. Ancillary operations of the future development of the Type III unit would be addressed on a case-by-case basis.

This satisfies or addresses Rule 299.4305(5).

B.4 - COMPLIANCE WITH PERFORMANCE STANDARDS

B.4.a. Surface Water

An EGLE watershed map for Ottawa county has been included as Figure 9. According to the Michigan Watershed Map, the JHC Landfill Site is located within the Macatawa Watershed.

Storm water runoff is managed within the JHC Landfill site. Non-contact surface water run-off at the JHC Landfill is routed via perimeter ditches, pipes, and berms designed to be freely draining (open channel flow conditions). The surface water is directed to perimeter ditches outside of the solid waste boundary where it than infiltrates back into the soil on site or is discharged via the ditching to the NPDES outfall.

Surface water monitoring is conducted in accordance with the site NPDES permit. Monitoring of groundwater, that could include infiltrated storm water runoff, will be conducted in accordance with JHC's updated Hydrogeologic Monitoring Plan, which is included as Section D of this CPA, which was prepared by TRC. The non-contact water is managed to control erosion and sedimentation using controls such as engineered ditches, and diversion berms. Existing vegetation is maintained to minimize adverse aesthetic and erosion effects. Soil erosion and sedimentation control measures are implemented at JHC. This satisfies Rule 299.4903(1)(d).

Contact water is prevented from leaving the lined disposal area and is managed as leachate. Leachate is collected and controlled by the leachate collection system detailed in the Engineering Design Report that is included in this CPA which addresses Rule 299.4903(2)(a).

B.4.b Ground Water

Consistent with the requirements of Rule 299.4904, a Hydrogeological Investigation Report is provided in Section C of this CPA, prepared by TRC, that details hydrogeologic information summarized in the following paragraphs.

The expansion site is underlain by unlithified lacustrine deposits, principally sand and silt with varying amount of gravel. The lacustrine deposits are principally coarse-grained materials with moderate to high permeabilities, but varying amounts of silt and clay occur within the sand, and silt and clay layers of varying thickness and lateral continuity may also occur in some areas. Beneath the surficial lacustrine deposits (can exceed 100 feet) is till deposited during the Wisconsin glacial epoch of the Pleistocene. Till is predominately clay and silt with varying amounts of sand, gravel, and boulders. The till (typically less than 100 feet in thickness) is underlain by the Coldwater Shale from the early Mississippian Period which is a major confining unit in the Michigan Basin that ranges in thickness from 500 to 1,300 feet.

The subsurface materials encountered at the site generally consist of approximately 40 to 60 ft of poorly graded, fine-grained lacustrine sand, which makes up the uppermost aquifer encountered in the vicinity of the Landfill. Groundwater in this aquifer is unconfined and typically encountered at depths ranging from 7 to 35 feet below ground surface (ft bgs), varying based on elevation. The lacustrine sand is underlain by a low permeability till layer that prevents downward migration of groundwater. The till is generally encountered within approximately 40 to 60 ft bgs across the Landfill based on soil boring data.

Generalized groundwater flow direction in the uppermost aquifer is presented in Engineering Drawings Sheet 300-9, as required by Rule 299.4904(4)(d). Section C contains supplemental groundwater elevation maps. Based on the groundwater elevation data, the general flow direction of the groundwater in the upper most aquifer is to the south-southwest across the site, with a south-westerly groundwater flow component on the west edge of the site.

The average horizontal groundwater flow velocity was calculated to be 0.43 ft/day based on the most recent static water level data as detailed in the Hydrogeological Investigation Report included as Section C of this CPA, and hydraulic conductivity as required by Rule 299.4904(4)(c)(iv). The uppermost aquifer is hydraulically bounded by the underlying till; therefore, groundwater flow is limited to within the lacustrine sand that makes up the uppermost aquifer. Monitoring well data from 2017 to 2020 showed that the vertical flow potential is consistently upward.

The existing and background water quality was determined and discussed based on Rule 306, 904(1)(a) and (b) and Rule 904(4)(a) within the Hydrogeological Report. Per Rule 904(1)(c), water level elevations have been collected from the site monitoring wells during the most recent groundwater monitoring event.

JHC currently performs quarterly groundwater monitoring in accordance with the existing Hydrogeological Monitoring Plan. An updated Hydrogeological Monitoring Plan prepared by TRC has been included with this application (see Section D of this CPA). This plan will be implemented upon approval by EGLE.

This satisfies or addresses Rules 299.4306, 299.4903(1)(d) and 299.4904.

B.4.c. Air

Type III CCR waste specified to be received at the expansion area is not expected to generate methane or carbon dioxide. Control of wind-borne particulate matter is provided by implementation of the control measures including moisture conditioning of the CCR in the silos prior to placement and watering material and roads as needed. Dust controls are detailed in Section G - Operations Plan and the Fugitive Dust Control Plan (Section G, Appendix C).

This satisfies or addresses Rule 299.4903(1)(d).

B.5 - PROPOSED FACILITY DESCRIPTION

B.5.a Type and Size

The JHC Landfill is currently permitted as a Type III Low Hazard Industrial Landfill located in Sections 15 and 16 Port Sheldon Township, Ottawa County, Michigan. The existing JHC Landfill solid waste boundary and proposed expansion is in Section 15, Township 06N, Range 16W, Port Sheldon Township, Ottawa County, Michigan. A Site Location Map is presented as Figure 1 and illustrates the limits of the expansion area.

The JHC facility boundary is approximately 410 acres with approximately 104 acres permitted for solid waste disposal. The remaining 306 acres includes power generation, stormwater management, leachate ponds buffer zones and ancillary operational areas Including the historical closed surface impoundments adjacent to the landfill. The buffer zones include operations that support the landfill, such as office and maintenance buildings. The undeveloped areas are vegetated with grasses and wooded areas.

The expansion is a expansion wholly contained within the existing facility Solid Waste Boundary (see Figure 1). It is anticipated that the final elevations will be increased by approximately 17 feet. The expansion will include updated final grading in Cells 1, 2, and 4 through 9 for areas without final cover.

The proposed cell liner system will be consistent with the engineering design contained in the current construction permit, as modified in 2018, which includes (from bottom to top) a 60 mil high-density polyethylene (HDPE) geomembrane liner overlain by a single sided composite layer with heat bonded geotextile (double-sided on the side slopes), a geosynthetic clay liner, an additional 60 mil HDPE geomembrane liner and single sided composite layer with head bonded geotextile (geotextile on the side slopes), all of which will be overlain by a 12 inch thick soil layer.

The proposed expansion final cover will be consistent with the engineering design contained in the current construction permit, as modified in 2018, which includes a flexible membrane liner consisting of a 40 mil textured linear low density polyethylene (LLDPE) overlaid by a two foot thick soil layer and 6 inches of topsoil with vegetation.

A leachate collection and removal system are included with each cell construction. Leachate in the existing landfill is collected and pumped to the leachate retention ponds located north of the existing solid waste boundary where it is routed to the combined discharge channel according to the site NPDES permit.

Upon reaching final waste grades, the landfill will be capped by a composite cover system consisting of the layers mentioned above. The cover system is designed to prevent storm water infiltration into the waste. The liners will be overlain by soil to provide drainage, protect the liner against erosion, and sustain vegetative growth.

This satisfies or addresses Rule 299.4903(2)(a)(i).

B.5.b Site Access

The site is accessed from Lakeshore Avenue and bordered by Lakeshore Avenue to the west, Croswell Street and residential properties to the north, and 156th Avenue to the east. A map showing roadways and access is presented on Figure 10. Ash is transferred to the silos on the east side of Lakeshore Drive from the JHC Generating Facility on the west side of Lakeshore drive using pneumatically pumped piping. Off-road haul trucks are used to dispose of the ash in the landfill. JHC only accepts and disposes of CCR and CCR containing waste from Consumers Energy. The main entrance for personnel and deliveries to the facility is from Lakeshore Drive (Figure 10).

This satisfies or addresses Rule 299.4903(2)(a)(ii).

B.5.c Solid Waste Volume

The JHC Landfill's permitted airspace volume is 9,500,000 cubic yards. The vertical component of the expansion will raise the final grades by approximately 17 feet and would contribute an additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the landfill. The proposed expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area and the Cells 6 through 9 unconstructed cells lateral expansion.

This satisfies or addresses Rule 299.4903(2)(a)(iii).

B.5.d Counties Served

The only anticipated source of waste is CCR from Consumers Energy. The existing landfill does not accept other forms or origins of waste.

This satisfies or addresses Rule 299.4903(2)(a)(iv).

B.5.e Anticipated Useful Life of Facility

Type III Landfill

The JHC Landfill currently places approximately 265,200 cubic yards of solid waste per year, which is subject to change based on power generation. Based on the remaining permitted airspace and proposed expansion increase of approximately 532,000 cubic yards; the proposed expansion will increase the life expectancy of the existing facility by approximately 2 years (total remaining would be approximately 20 years) at current disposal rates.

This satisfies or addresses Rule 299.4903(2)(a)(v).

B.6 - DESCRIPTION OF THE EXISTING ENVIRONMENT

The existing JHC Landfill is operated as a Type III Low Hazardous Industrial Landfill. Preceding that activity, the property was used for agriculture and residential purposes.

B.6.a. Topography, Land Use, and Surrounding Residents

B.6.a.a Topography

The expansion area is generally flat surrounded by existing and licensed Landfill Cells 1 through 5, perimeter ditches, berms, and other surface features associated with the management of the solid waste and storm water at the site. Historic, closed ash ponds are located adjacent to the facility, immediately to the south average about 630 ft AMSL. From the southern perimeter of the landfill and historic ash ponds, the topographic surface slopes downward to the south, from approximately 630 ft AMSL to below 580 ft AMSL near the Pigeon River. Refer to Figure 11, Topographic Map, and Sheet 200-1 of the Engineering Drawings for the most recently available topographic conditions.

This satisfies or addresses Rule 299.4903(2)(b)(i).

B.6.a.b Land Use

The proposed expansion is located within Port Sheldon Township. The land in Port Sheldon Township surrounding JHC Landfill is currently zoned as rural residential and light industrial, Figure 12. The expansion is located within the existing landfill solid waste boundary.

The proposed end use for JHC Landfill is anticipated to be green space, however, the ultimate end use will be determined when the site is decommissioned. . Further, space has been allocated for other potential operations that would be ancillary and in support of the overall site's waste management functions.

This satisfies or addresses Rule 299.4903(2)(b)(i).

B.6.a.c. Surrounding Residents

There are rural residential areas located north, east and to the south of the JHC Landfill property, Figure 12.

This satisfies or addresses Rule 299.4903(2)(b)(i).

B.6.b Air Quality

Ottawa County is in the western part of the lower peninsula of Michigan. The prevailing winds are primarily out of the west/southwest with an average speed of 10 knots. The most recent wind rose depicting the average wind conditions observed in Grand Rapids, Michigan between 1973 and 2007 and is provided as Figure 13. The City of Grand Rapids is located approximately 33.2-miles east of the JHC Landfill.

According to EGLE, state-wide annual carbon monoxide levels over the last 10 years have generally remained at one-third of the state standard. A peak in the state-wide average level occurring in 1994 was due to two exceedances of the standard at one air monitoring site in Detroit. Neither 1-hour nor 8-hour carbon monoxide standard exceedances have occurred in the last decade. All areas in Michigan have been in attainment with the 1-hour and 8hour standards since August 30, 1999.

Fugitive dust emissions from landfill activity are normally attributed to truck traffic from roadways, wind erosion from open areas, and storage piles. Ongoing practices at JHC Landfill to control dust and to maintain grassy areas have been sufficient to maintain low emissions at the Site.

Michigan rules require a yearly estimate of the PM-10 and non-methane organic carbons (NMOC) emissions rate for annual state emissions fees. JHC Landfill performs emission estimates and currently operates in compliance with the facility’s ROP.

This satisfies or addresses Rule 299.4903(2)(b)(ii).

B.6.c Hydrology

B.6.c.(1) and (2).Magnitude of 24-hour, 25-year storm and Average Annual Rainfall

The average annual precipitation, derived from climatology data from the US Department of Agriculture – National Resources Conservation Service, is approximately 36.10 inches. Annual precipitation information has been included in Figure 14, Michigan Precipitation Map. The magnitude of a 24-hour, 25-year storm event for Ottawa County is approximately 4.97 inches.

This satisfies or addresses Rule 299.4903(2)(b)(iii).

B.6.d Floodplain Elevations

The solid waste boundary for the proposed expansion of JHC Landfill is not located within a 100-year floodplain, as noted in Panel 190 of the Flood Insurance Rate Map for Ottawa County (FEMA December 16, 2011). The elevation of the 100-year floodplain for Pigeon Lake is 584 feet above mean sea level (ft-amsl) along the south boundary of the expansion site. Figure 4 shows the location of 100-year floodplains at the site based upon the FEMA map. The proposed expansion will not encroach into the 100-year floodplain and meets the siting requirements of this rule.

The Site surface water drainage system and onsite leachate retention basins are adequately designed to maintain flood elevations in the vicinity.

This satisfies or addresses Rule 299.4903(2)(b)(iv).

B.6.e Endangered or Threatened Species

Overview

According to the Michigan State University (MSU) Extension – Michigan Natural Features Inventory (MNFI) natural heritage database, several legally protected species have been documented within 1.5 miles of the project site (see Attachment B-3). These documented records are considered historical (>50 years), and it is not likely that negative impacts will occur. Table 1 provides a list of legally protected species near the JHC Landfill, as provided by the MNFI. Table 2 further identifies special concern species that may be located on or in the vicinity of the project site. These species do not have regulatory protection but may receive protections in the future. Additionally, a US Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) review was completed online on April 19, 2020 to identify federally listed species which may be present within or in the vicinity of the site and may potentially be affected by activities at the project site. Table 3 provides a list of these species.

MNFI's review indicated there were no concerns for the species in Tables 1 and 2 with regards to project activities.

Table 1: Legally Protected Species within 1.5 miles of the JHC Landfill

Scientific Name	Common Name	First Observation	Last Observation	Federal Listing	State - listing	Category
Acris blanchardi	Blanchard's cricket frog	1968	1968	n/a	Threatened	Animal
Falco peregrinus	Peregrine falcon	2004	2018	n/a	Endangered	Animal
Panax quinquefolius	Ginseng	1979	1980	n/a	Threatened	Plant
Zizania aquatica	Wild rice	1940	1940	n/a	Threatened	Plant

Table 2: Special Concern Species and other Rare Natural Features within 1.5 miles of the JHC Landfill

Scientific Name	Common Name	First Observation	Last Observation	Federal Listing	Category
Lithobates palustris	Pickerel frog	2013	2018	n/a	Animal
Strophostyles helvula	Trailing wild bean	*Non listed*	1918	n/a	Animal

Table 3: Federally Protected Species Identified by the USFWS as Potentially Affected by Activities at the Site

Scientific Name	Common Name	Federal Listing	Critical Habitat Defined (Yes/No)	Defined Critical Habitat Present at Site (Yes/No)
Myotis sodalis	Indiana bat	Endangered	Yes	No
Myotis septentrionalis	Northern long-eared bat	Threatened	No	No
Charadrius melodus	Piping plover	Endangered	Yes	No
Calidris canutus rufa	Red knot	Threatened	No	No
Grus americana	Whooping crane	EXPN[1]	No	No
Sistrurus catenatus	Eastern massasauga	Threatened	No	No[2]

[1]EXPN = Experimental population
[2]Project site is within range of Eastern massasauga

This satisfies or addresses Rule 299.4903(2)(b)(v).

B.6.f Historical or Archaeological Sites

An intensive desktop-level cultural resources review of the JHC Landfill Type III expansion in West Olive, Michigan was completed. The goal of the desktop-level review was to locate previously identified prehistoric and historic archeological sites and historic structures within the Area of Potential Effects (APE, i.e., the expansion area). For this study, the direct APE was limited to the area of ground disturbance associated with the proposed expansion and the indirect APE was limited to ½ mile radius surrounding the proposed expansion boundary. Work was performed in accordance with the standards and guidelines of the Michigan State Historic Preservation Office (SHPO), Register of Professional Archaeologists, and the National Historic Preservation Act (NHPA). The overall approach ensured that the Subject Property and the ½-mile buffer was investigated thoroughly to assess the effect of the proposed expansion on known cultural resources.

Golder contacted the Michigan SHPO Michigan Site File (MSF) SHPO Research team to conduct a preliminary review of cultural resources on and in the vicinity of the Site. Golder obtained a review by the MSF-SHPO Research team on December 18, 2020. Files reviewed in the database included archaeology, architecture, cultural resource survey information and National Register data. Aerial photographs, USGS topographic maps, and the National Register of Historic Places (NRHP) database, were also examined. These sources provided information on the nature and location of previously conducted archaeological surveys and known cultural resource sites.

The background literature review indicates that one cultural resource investigation has occurred within the direct APE in 1993. There are no archaeological sites associated with this investigation. In addition, one investigation has occurred west of the Subject Property within the ½ mile APE. There are two archaeological sites recorded within the ½-mile APE southeast of the Subject Property. One site is eligible for listing on the NRHP and one site is not eligible for listing. These archaeological sites will not be affected by the proposed landfill expansion. Due to the sensitive nature of archaeological resources, we are unable to provide a map of the recorded sites. No historic structures are recorded within the direct and indirect APEs. There are no cultural resource sites listed on the NRHP and no National Historic Landmarks within the vicinity of the proposed project.

In addition to the background literature review through the Michigan SHPO, Golder was made aware that a prehistoric burial ground is present nearly ½ mile southwest of the expansion area. This was not present in the research; however, the area has been fenced and is clearly marked. No disturbance of this area will occur. Further investigation to the area will be warranted if construction activities should expand from the planned footprint.

This satisfies or addresses Rule 299.4903(2)(b)(vi).

B.6.g Sites of Environmental Contamination

To identify any known sites of environmental contamination within one half-mile radius of the Site, available information from federal and state records was obtained through the Environmental Mapper on EGLE website on April 21, 2020. The Part 201-site database, on EGLE's web page was also searched to identify any known sites of environmental contamination. The complete result of the records search is contained in Attachment B-4.

There are known groundwater impacts in the expansion area from the historical ash disposal practices resulting in the facility being in assessment monitoring. The existing and background water quality was determined, and existing impacts discussed based on Rule 306, 904(1)(a) and (b) and Rule 904(4)(a) within the Hydrogeological

Report, Hydrogeological Monitoring Plan, and Remedial Action Plan (Sections C and D of this CPA), prepared by TRC.

This satisfies or addresses Rule 299.4903(2)(b)(vii).

B.6.h Significant Public Resources

B.6.h.a Wetlands

The solid waste boundary for the proposed expansion Type III unit footprint of the JHC Landfill will not be located within a designated wetland. The United States Fish and Wildlife Service Wetland Map indicating the current location of the designated wetlands surrounding the JHC Landfill is included in Figure 5 and Figure 6. There are no wetlands within the solid waste boundary of the proposed landfill expansion areas and therefore, the proposed expansion meets the siting requirements of this rule.

B.6.h.b Surficial Soils

Undisturbed surface soils at the site are described by the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) Web Soils Survey. The proposed expansion area is not located in a critical dune area nor is it located in a high-risk erosion or environmental area. See Figure 2, Soils Map.

Regional geology is characterized by various glacial deposits overlying the sandstone of the Marshall Formation. Parts of Ottawa County are characterized by glacial deposits overlying the Michigan Formation or the Coldwater Shale. The nearest body of water is Pigeon River which flows into Pigeon Lake which continues to flow into Lake Michigan. The general flow direction of the groundwater in the upper most aquifer is to the south-southwest across the site, with a south-westerly groundwater flow component on the west edge of the site.

The subsurface materials encountered at the JHC site generally consist of approximately 40 to 60 feet of poorly graded, fine-grained lacustrine sand, which makes up the uppermost aquifer encountered in the vicinity of the Landfill. Groundwater in this aquifer is unconfined and typically encountered at depths ranging from 7 to 35 feet below ground surface (ft bgs), varying based on elevation, and generally flows to the south-southeast across the Landfill toward Pigeon River.

The aquifer is underlain by a laterally extensive clay-rich till, which serves as the confining base of the aquifer and prevents vertical groundwater flow. The till is generally encountered within approximately 40 to 60 ft bgs across the Landfill based on soil boring data.

Further description of the surficial soils and site geology can be found in Section C, prepared by TRC, of this CPA.

This satisfies or addresses Rule 299.4903(2)(b)(viii).

B.6.i. Airports

Isolation distances per Part 115 Rules 299.4412 thru Rule 299.4418 are demonstrated in this application to address the Rule 299.4305 criteria, however since the Type III expansion proposed will not accept construction and demolition debris waste, the Airport notification requirement in Rule 299.4414 is not applicable. The closest public airport to the Site is the Grand Haven Memorial Airpark located approximately 8 miles north of the Site. No airports were found within 10,000 feet of the expansion area as indicated on Figure 3, Airport Location Map.

This satisfies or addresses the isolation distance criteria of Rule 299.4903(2)(b)(ix) and Rule 299.4305.

B.7 - STATEMENT OF ANTICIPATED ENVIRONMENTAL IMPACTS

The existing JHC Type III Low Hazard Industrial Landfill has been operating as a licensed landfill since 1994.

The intent of the proposed Type III unit expansion at JHC Landfill is to maximize the airspace capacity of the facility for Type III, CCR waste. The proposed landfill expansion will occur within CEC's property boundary and the recommended isolation distances will be maintained.

The following sections will address long and short-term effects on the area's environmental resources surrounding the facility due to the proposed landfill expansion. These sections address the requirements of Rule 299.4903(2)(d).

B.7.a Topography, Land Use, and Surrounding Residents

B.7.a.a Topography

Construction of the JHC Landfill Type III expansion would result in a change in the topography in the area over which it is built. The finished Type III Landfill development would produce a single grassed and terraced hill with slopes of minimum 2-percent to a maximum of 25-percent and a final height of approximately 707.5 feet above mean sea level (ft AMSL)

The finished Type III Landfill development would produce a single grassed and terraced hill with slopes of minimum 2-percent to a maximum of 25-percent and a final height of approximately 17 feet over the existing approved final height.

These changes in the site topography could impact the visual aesthetics of the surrounding area during the construction phase. The expansion area is generally surrounded by existing Landfill Cells 1 through 5, perimeter ditches, berms, wooded areas and other surface features associated with the management of the solid waste and storm water at the site. These areas effectively screen the view of the landfill mitigating impacts to the visual aesthetics of the surrounding area.

This satisfies or addresses Rule 299.4903(2)(b)(i).

B.7.a.b Land Use

General landfill operations and support activities will remain the same as those currently used within the proposed expansion. The proposed expansion is not expected to result in significant changes to the current land use of the area outside the proposed solid waste boundary. No impacts to adjacent land use, property values or demographics are anticipated.

The proposed end use for JHC Landfill is anticipated to be green space, however, the ultimate end use will be determined when the site is decommissioned. .

B.7.a.c Surrounding Residents

There are rural residential areas located north and northeast of the JHC Landfill as shown on Figure 12. The increased height of the landfill may present a minor impact to the visual aesthetic appeal during site operations and following closure of the facility. The local economy may have a positive impact in the form of increased economic opportunities for local contractors, suppliers and other vendors. Transportation and health and safety issues should not differ from those that currently exist.

B.7.b. Air

Air impacts will be similar as the existing facility but will continue for an additional duration of approximately two years. The proposed Type III expansion is not expected to increase annual NMOC emission levels since the CCR materials are already accepted in the currently licensed Type III cells, and the materials to be placed in the expansion area will remain the same. The emissions, such as particulates, carbon monoxide, nitrogen oxides, sulphur dioxides, and lead, emitted by fugitive dust and contained in the exhaust from onsite vehicles is not expected to increase or to cause adverse air quality impacts beyond those of the current facility.

Construction equipment and trucks in route to the JHC Landfill as shown in Figure 10, will account for an insignificant amount of the total mobile source emissions in Ottawa County and the surrounding counties. Based on current equipment operations and maximum traffic volumes, projected exhaust from trucks and machinery because of the expansion should remain below the National Ambience Air Quality Standard Concentration for eight hours and one-hour levels of carbon monoxide.

Dust control measures include moisture conditioning the ash prior to placement, and regular application of water or dust-retardant sprays on internal roads within the property. This is accomplished using a water truck equipped with sprayers as well as use of dust suppressants. Additional measures to control dust include covering interim slopes to control erosion until final cover can be placed.

The Type III wastes proposed to be accepted (CCRs) are not expected to create odor or generate gas.

B.7.c. Hydrology

The proposed expansion is not expected to alter surface water drainage or groundwater flow patterns near the site. The proposed liner system and leachate collection system have been designed to prevent releases of leachate to the groundwater. Leachate from the proposed Type III Landfill will be pumped from the leachate collection system sumps and directed to the leachate retention ponds. Along with these protective features, JHC Landfill provides monitoring of groundwater around the facility to provide additional protection from impact (refer to Section D – Hydrogeological Monitoring Plan, prepared by TRC, of this construction permit application).

B.7.d. Floodplain Elevations

The solid waste boundary for the proposed expansion of JHC Landfill is not located within a 100-year floodplain and will not impact flood levels.

B.7.e. Endangered or Threatened Species

Several endangered or threatened species were identified to potentially be impacted by the development of the site as currently permitted, however, the proposed expansion does not increase the potential impact on these species. Based upon review of the site, Golder does not believe that appropriate habitat is present within the project area for most of the state and federally listed species in Tables 1 and 3 in Section B.6.e above. MNFI identified seven federally listed species within Ottawa County. Using the online IPaC assessment tool and review of on-site habitat, Golder further narrowed down the species that may potentially be affected by activities at the Site to the following three species.

- Indiana bat,
- Northern long-eared bat (NLEB), and
- Eastern massasauga rattlesnake (EMR).

Small, forested areas are present within the project area, and could provide habitat for Indiana bat and northern long-eared bat during portions of the year. The project also falls within the range of the EMR. These species are further discussed below.

<u>Indiana Bat</u>

The Indiana bat occurs only in the eastern United States and is typically confined to the southern three tiers of counties in Michigan. This species summers in Michigan and winters in caves in Indiana and Kentucky. Indiana bats form colonies and forage in riparian and mature floodplain habitats. Their nursery roost sites are commonly located under loose bark or in hollows of trees near riparian habitat. These bats usually avoid houses and other artificial structures and roost under loose bark of dead elm, maple, and ash trees. Other dead trees used include oak, hickory, and cottonwood. Foraging typically occurs over slow-moving, wooded streams and rivers and in the canopy of mature trees. A summer colony's foraging area may encompass a stretch of stream over a half-mile in length. Upland areas isolated from floodplains and non-wooded streams are usually avoided.

Recommended best management practices/conservation strategy - The suggested seasonal tree cutting period is between October 1 and March 31.

Northern long-eared bat

The MNFI identified suitable habitat for the NLEB within the project site; however, there are no known maternity roost trees or hibernacula occurring within a 1.5-mile radius of the project area.

Recommended best management practices/conservation strategy - It is recommended to conduct necessary tree-cutting activities and prescribed burns in forested areas between October 1 and March 31, when possible. When not possible, it is encouraged to remove trees prior to June 1 or after July 31, to protect young bats that may be in forested areas.

Eastern massasauga rattlesnake

With regards to the EMR, the project area falls outside of the USFWS federally designated habitat; however, the site is within EMR range, and relatively near to areas of potential habitat along the Pigeon River. Any sightings of EMR should be reported to the Michigan Department of Natural Resources, Wildlife Division.

Recommended best management practices/conservation strategy - Where the potential exists for this species to occur, the USFWS recommends the following best management practices in order to limit possible impacts:

- Use wildlife-safe materials for erosion control and site restoration.
- To increase human safety and awareness of EMR, those implementing the project should first watch MDNR's "60-Second Snakes: The Eastern Massasauga Rattlesnake" video (available at https://youtu.be/-PFnXe_e02w) or review the EMR factsheet (available at https://www.fws.gov/midwest/endangered/reptiles/eama/pdf/EMRfactsheetSept2016.pdf or by calling 517-351-2555.
- Report any EMR observations, or observation of any other listed threatened or endangered species, during project implementation to the Service within 24 hours.

Migratory Birds

The IPaC report also discusses migratory birds. If tree clearing occurs during the periods recommended for Indiana Bat, the project is unlikely to impact potentially nesting migratory birds.

B.7.f. Historical or Archaeological Sites

No historical or archaeological sites were identified within the proposed expansion area while 3 archaeological sites were identified within ½-mile of the expansion area. The proposed expansion is sufficiently isolated from and does not impact these sites. If any archaeological artifacts or historical remnants are discovered during construction, work will be paused, and the State Historical Preservation Office will be notified.

B.7.g. Sites of Environmental Contamination

The proposed expansion is not anticipated to impact or exacerbate any areas of known environmental contamination. Complete details of the impact and remedial action of known groundwater contamination on site are included in Section I of the CPA.

B.7.h. Significant Public Resources

B.7.h.a Wetlands

The solid waste boundary for the proposed expansion Type III unit footprint of the JHC Landfill will not be located within a designated wetland and the expansion area is sufficiently isolated from known wetlands. Therefore, the proposed will not impact wetlands.

B.7.h.b Surficial Soils

Surface soils within the expansion area will be regraded as part of the approved landfill construction. The proposed expansion will have no additional impact on the surficial soils.

B.8 - ALTERNATIVE ACTIONS FOR WASTE DISPOSAL

The existing JHC Type III Low Hazard Industrial Landfill has been operating as a licensed landfill since 1994.

The intent of the proposed Type III expansion at JHC Landfill is to maximize the airspace capacity of the facility for Type III waste. The proposed landfill expansion will occur within the JHC Landfill currently permitted solid waste boundary and the recommended isolation distances will be maintained.

Alternatives to the proposed expansion include taking no action, other disposal methods, and proposing a new greenfield site for landfill development. Alternatives and their potential impacts are discussed below.

B.8.a. No Action

The proposed vertical expansion increases the permitted airspace volume by 532,000 cubic yards. The total disposal volume is approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area and the unconstructed Cells 6 through 9 for the lateral expansion. The proposed expansion will increase the life expectancy of the existing facility by approximately 2 years (total remaining would be 20 years) at current disposal rates.

B.8.a.a Positive Impacts

Positive impacts of the no action would be the avoidance of potential aesthetic visual impacts and traffic in the neighbouring areas. These impacts are minimal and are offset by the negative impacts of no action.

B.8.a.b Negative Impacts

An alternative to waste disposal at JHC Landfill would have to be identified sooner than anticipated if the Type III expansion were not permitted. The type of waste materials to be received at the Type III expansion area are unlikely to be recycled or reused. Siting of a new “greenfield” landfill would be less desirable than expanding an existing site. This option would require trucking of waste greater distances increasing fuel consumption and greenhouse gas emissions. The potential environmental impacts related to constructing a new landfill are typically considered greater than the potential environmental impacts related to expanding an existing facility.

B.8.b Solid Waste Reduction/Recycling Alternative

This alternative considers resource recovery through recycling and reuses of the waste materials.

B.8.b.a Positive Impacts

The waste disposal airspace at JHC Landfill would not be increased. The landfill would be developed as currently permitted.

B.8.b.b Negative Impacts

This option presumes that a significant quantity of recyclable materials currently remains in the CCR waste stream and can be practically separated for recycling. The types of materials expected to be placed in the Type III area are not easily recycled or reused, and sufficient, viable recycling alternatives do not exist at this time.

B.8.c Construction of a New Landfill Facility Alternative

This option implies that the expansion at JHC Landfill would not occur, and site life would not be increased. Waste would be accepted at the facility until the facility reaches currently permitted capacity. Waste would then be directed to a newly constructed facility after JHC Landfill closes. The newly constructed facility would presumably be located at a site not currently used for waste disposal.

B.8.c.a Positive Impacts

A new facility could potentially be sited in an area with an optimum combination of favourable hydrogeologic conditions and minimal environmental impacts.

B.8.c.b Negative Impacts

A new facility would require a site with favourable hydrogeologic and environmental conditions within reasonable proximity to the site. A site with such conditions may not exist or be available.

Constructing a new landfill would increase the number of landfill developments in Ottawa County or surrounding Counties. This would require obtaining consistency determinations from the host County, including the possibility of modifying the host County's Solid Waste Management Plan to allow the development.

The potential environmental impacts related to constructing a new landfill are typically considered greater than the potential environmental impacts related to expanding an existing landfill. This option would require trucking of waste greater distances increasing fuel consumption and greenhouse gas emissions.

The new site may represent an additional environmental risk if the hydrogeologic conditions are less favourable, or if the design and operation of the landfill were less effective than having an existing Type III operation already in place.

B.8.d Alternate Disposal Methods

Hauling to and disposal of the material CCR materials at an existing commercial Type II landfill facility is the most viable alternate disposal method considered.

B.8.d.a Positive Impacts

Disposal at an existing commercial Type II facility would eliminate the need for the expansion and related social and environmental impacts.

B.8.d.b Negative Impacts

This option would require trucking of waste greater distances increasing fuel consumption and greenhouse gas emissions. Additionally, it would decrease the available Type II airspace requiring earlier development of replacement facilities. At this time it is difficult to obtain approval for disposal of large quantities of CCR materials in local commercial Type II landfills due to material compatibility concerns of placing CCR materials potentially resulting in operational issues and additional environmental impacts. These concerns result in this option being unreliable and subject to service interruptions.

B.9 - SUMMARY STATEMENT OF UNAVOIDABLE ADVERSE IMPACTS

This section describes the impacts from the proposed actions (the JHC Landfill expansion) that are unavoidable. Although these impacts cannot be avoided, the cumulative effect of these impacts is not considered significant. Mitigative measures have been developed and approved for the expansion to minimize the potential short-term and long-term impacts to, wetlands, streams, topography, soils, land use, and aesthetics. These impacts that would occur under the "No Action" alternative are minimal since the solid waste boundary is not changing from the permitted landfill. Costs can be minimized for design and construction as many of the structures and support features currently used for the existing facility will be utilized during operation of the expansion. Suitable transportation routes already exist, and the land planned for the expansion is already owned by CEC, making solid waste management consolidated in one location, utilizing the same infrastructure, personnel, and equipment.

Construction of the expansion will result in a change in the topography. The depositing of wastes in the expansion will result in the topographic grades increasing to approximate final elevations of those approved for the closed portions of the existing landfill site by approximately 17 feet. Proposed impacts to the topography are minimized since the expansion is located within an existing landfill operation and although the elevation is increasing the solid waste boundary will remain the same. Final elevations for the expansion will be blended into the existing facility. Following closure, the final cover will be grass-covered to blend with the local landscape, except for developing a solar or wind energy project. The expansion area is well screened from adjacent properties by existing wooded areas.

Surface water on the site drains to perimeter ditches around the landfill that allow the for infiltration on the site. Monitoring of the surface storm water discharge is governed under the site NPDES permit. Monitoring of storm water which infiltrates into groundwater is integrated into the Hydrogeological Monitoring Plan, prepared by TRC (Section D of this CPA) for the site to accommodate the additional lifespan.

Currently the expansion, as well as the existing facility, is zoned agricultural, rural residential and light industrial. Construction of the expansion will not change the existing land use but will eventually change to an open green space at closure. The change in aesthetics is also not expected to be significant since the expansion will be directly adjacent to an existing landfill operation, the area will be vegetated following closure and suitable screen from surrounding properties exists in the form of woodlands.

B.10 - SUMMARY STATEMENT PROTECTIVE AND CORRECTIVE MEASURES TO REDUCE AND MITIGATE ADVERSE IMPACTS

Engineered methods of reducing adverse impacts to acceptable levels include:

- Isolation distances that exceed the requirements of the Act;
- Maintaining wooded areas surrounding the facility to the extent feasible to limit visibility;
- Designing berms and ditches to divert surface water away from the active waste face, thereby decreasing leachate generation and protecting surface water; and
- Designing the final cover system to satisfy the requirements of Act 451 Part 115, and potentially for use for renewable energy projects.

Operational methods of reducing adverse impacts to acceptable levels are identified in Section G (Facility Operations Plan) of this CPA. These methods include:

- Maintaining the active solid waste fill face at a minimum practical size to reduce dust generation and the attraction of vectors;
- Use of dust control measures include moisture conditioning the ash prior to placement, and regular application of water or dust-retardant sprays on internal roads within the property to minimize fugitive dust.
- Effective use of interim cover and erosion control matting covering interim slopes to prevent fugitive dust, and erosion;
- Staged construction of excavations, lined areas, and final cover systems to reduce the magnitude of construction-related impacts;
- Maintenance of the leachate collection system; and
- Maintaining limited access to the site and effective traffic control.

B.11 - GRAPHIC DISPLAYS

B.11.a.Maps Showing the Location of the Proposed Action

See the Figures and the Engineering Drawings.

B.11.b. Maps, Diagrams, Photographs Illustrating the Relationship of the Disposal Area to the Environmental Element Being Impacted.

See the Figures and the Engineering Drawings.

B.11.c. Reference

Michigan Department of Environment, Great Lakes, and Energy (EGLE), https://www.mcgi.state.mi.us/wetlands/mcgiMap.html

Michigan EGLE Contaminated Sites, https://www.mcgi.state.mi.us/environmentalmapper/#

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EGLE, GeoWebFace, Internet Web Page: http://ww2.deq.state.mi.us/GeoWebFace/#DefaultZoom

EGLE's Part 201-site database, https://www.egle.state.mi.us/FacilitiesInventoryQueries

EGLE Redevelopment and Remediation Division, Internet Web Page: http://www.deq.state.mi.us/erd/sites/misites.html

Michigan Historic Sites Online, State Historic Preservation Office, Internet Web Page: http://www.michigan.gov/mshda/0,1607,7-141-54317---,00.html

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National Weather Service, National Oceanic and Atmospheric Administration (NOAA), https://www.weather.gov/grr/jxninfo

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Solid Waste Management Administrative Rules, Part 115, of NREPA.

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U.S. Geological Survey, Michigan Water Science Center, http://mi.water.usgs.gov/index.php

U.S. Geological Survey, National Seismic Hazard Mapping Project, http://earthquake.usgs.gov/research/hazmaps/

U.S. Geological Survey, Topographical Map

Western Michigan University, 1981, Hydrogeologic Atlas of Michigan, Kalamazoo, Michigan.

Western Michigan University, 1981, Hydrogeology for Underground Injection Control in Michigan, Part 1, Kalamazoo, Michigan.

Figures

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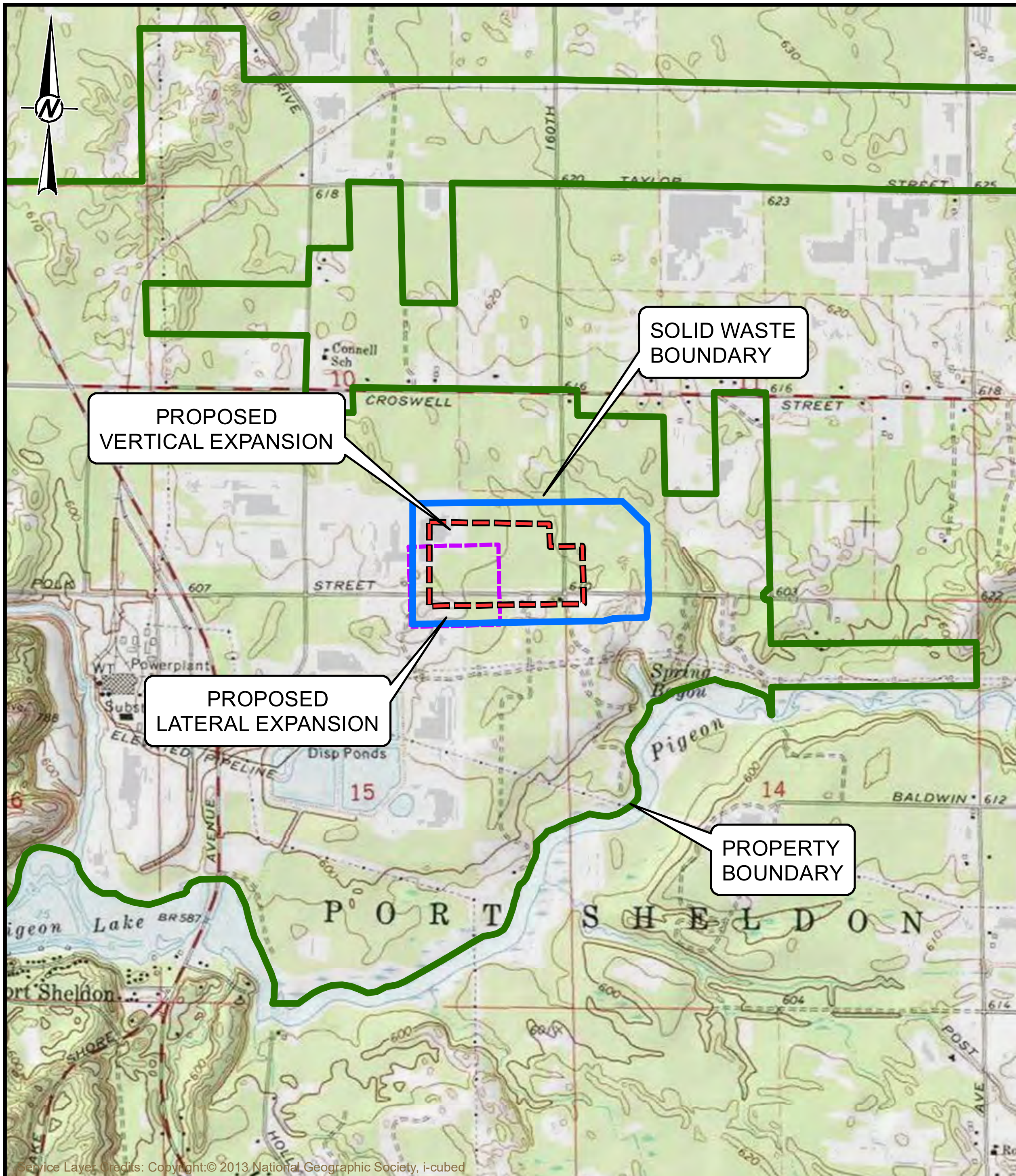

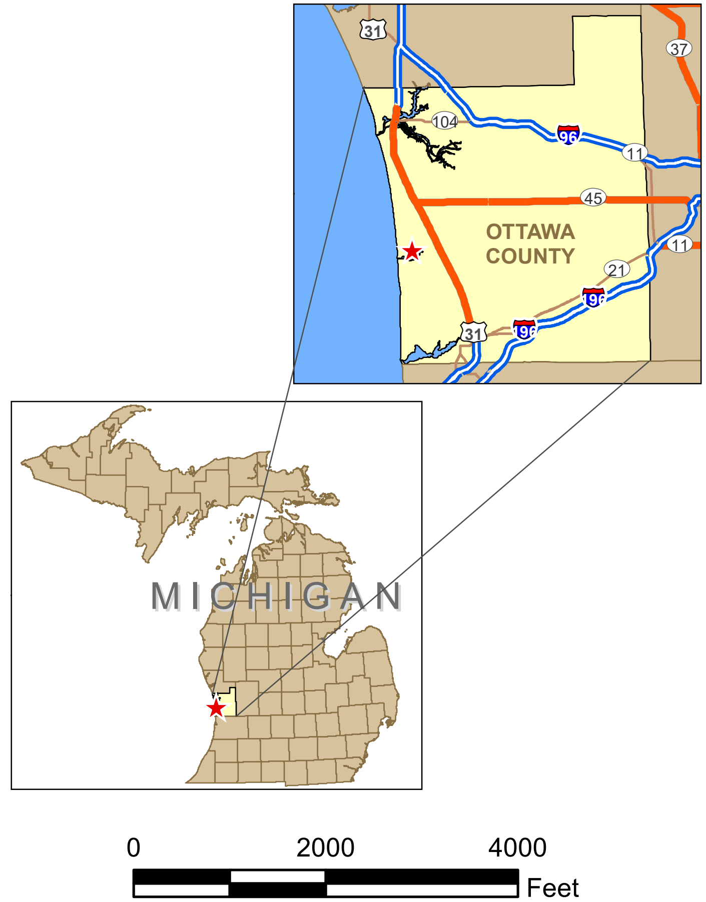

CLIENT
CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
SITE LOCATION MAP

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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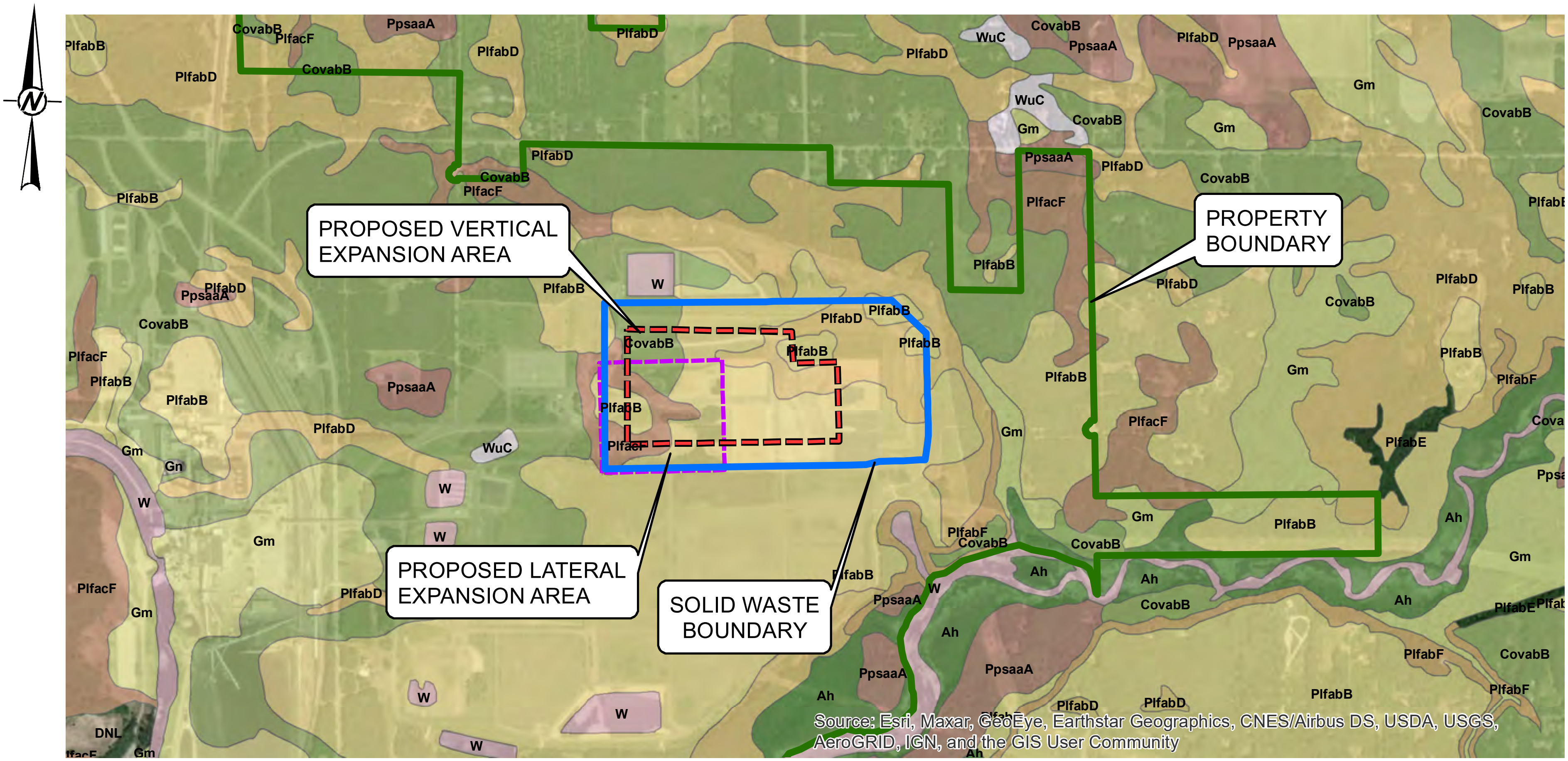

LEGEND

- PROPERTY BOUNDARY
- SOLID WASTE BOUNDARY
- PROPOSED VERTICAL EXPANSION AREA
- PROPOSED LATERAL EXPANSION AREA

MAP UNIT LEGEND

- Ah-Houghton Adrian mucks, 0 to 1% slopes
- CovabB-Covert-Pipeston sands, 0 to 6% slopes
- Gm-Granby loamy sand, lake plain, 0 to 2% slopes
- PlfabB-Plainfield sand, lake plain, 0 to 6% slopes
- PlfabD-Plainfield sand, lake plain, 6 to 18% slopes
- PlfabF-Plainfield sand, high ecological site, 30 to 50% slopes
- PlfacF-Plainfield sand, dunes, 18 to 60% slopes
- PpsaaA-Pipestone-Covert-Saugatuck sands, 0 to 3% slopes
- W-Water
- WuC-Wind eroded land, sloping

DATA SOURCE:
SOILS MAP PROVIDED BY THE U.S. DEPARTMENT OF AGRICULTURE'S (USDA) NATURAL RESOURCE CONSERVATION SERVICE (NRCS) WEB SOILS SURVEY

0 1500 3000 Feet

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CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
SOILS MAP

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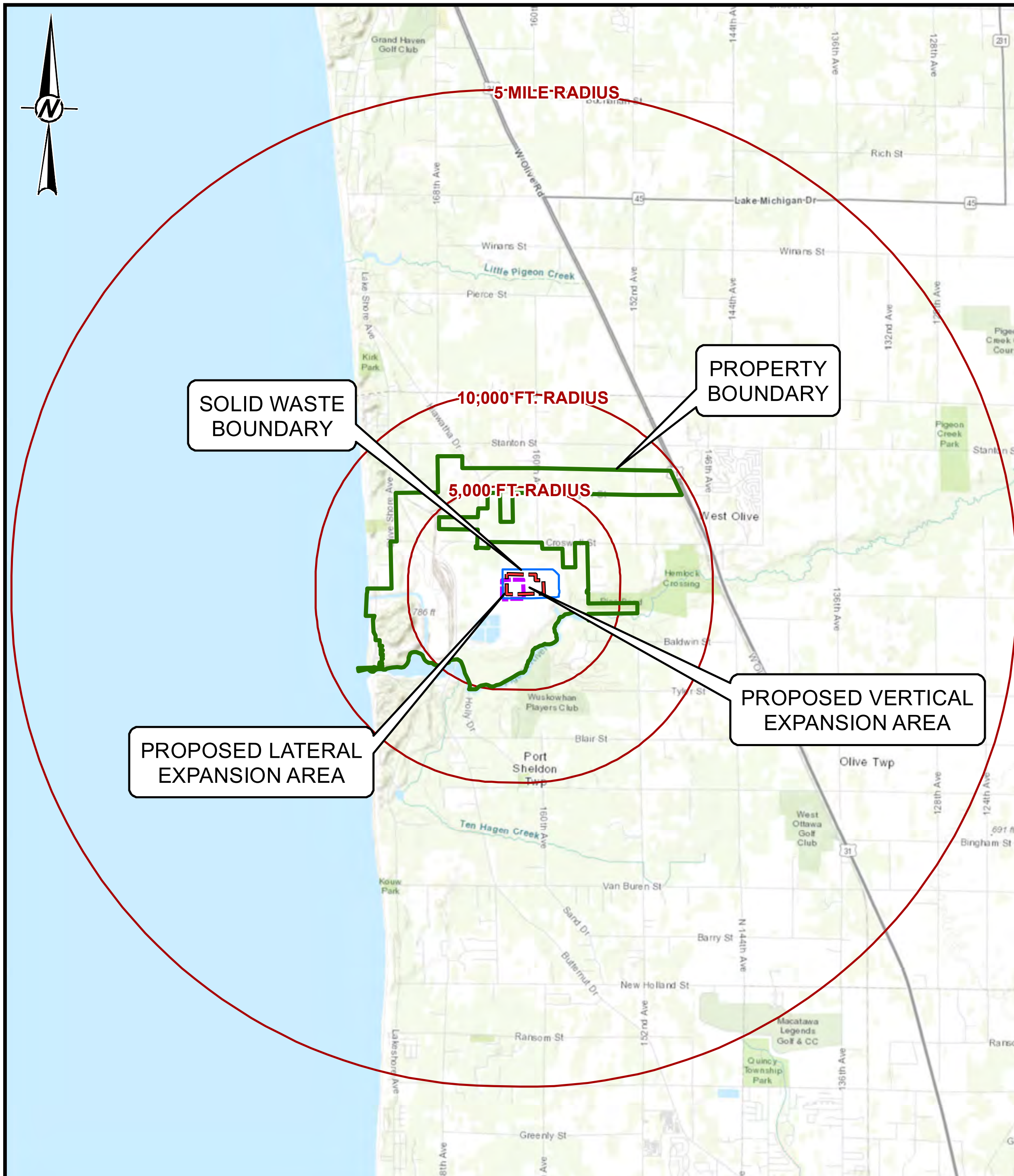

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NOTE: NO AIRPORTS LOCATED WITHIN 5 MILES OF SOLID WASTE BOUNDARY

0 2 4 Miles

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
AIRPORT LOCATION MAP

CONSULTANT
GOLDER

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DESIGN	NM
REVIEW	BAL
APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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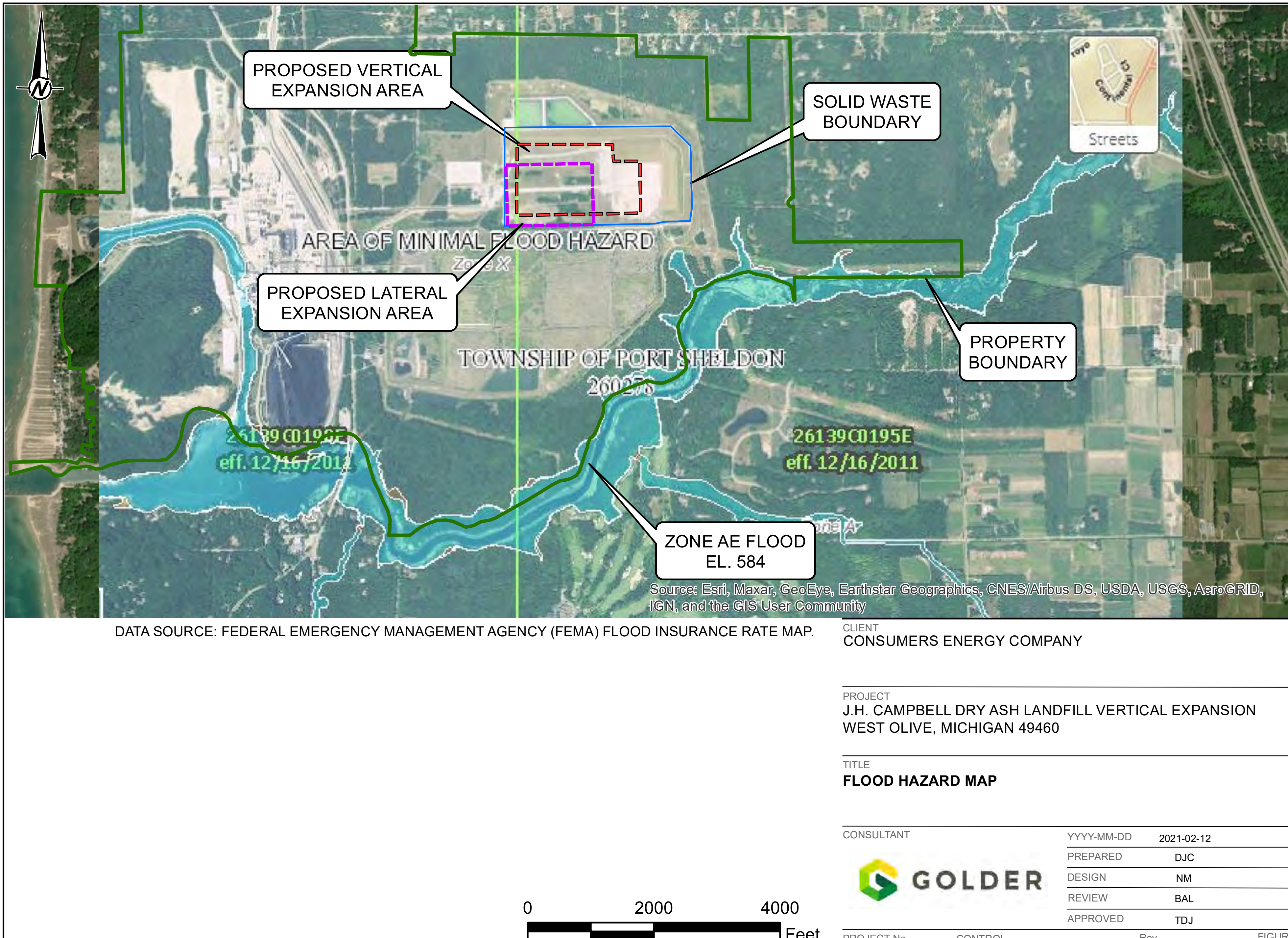

DATA SOURCE: FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) FLOOD INSURANCE RATE MAP.

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
FLOOD HAZARD MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
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PROJECT No.	CONTROL	Rev.	FIGURE
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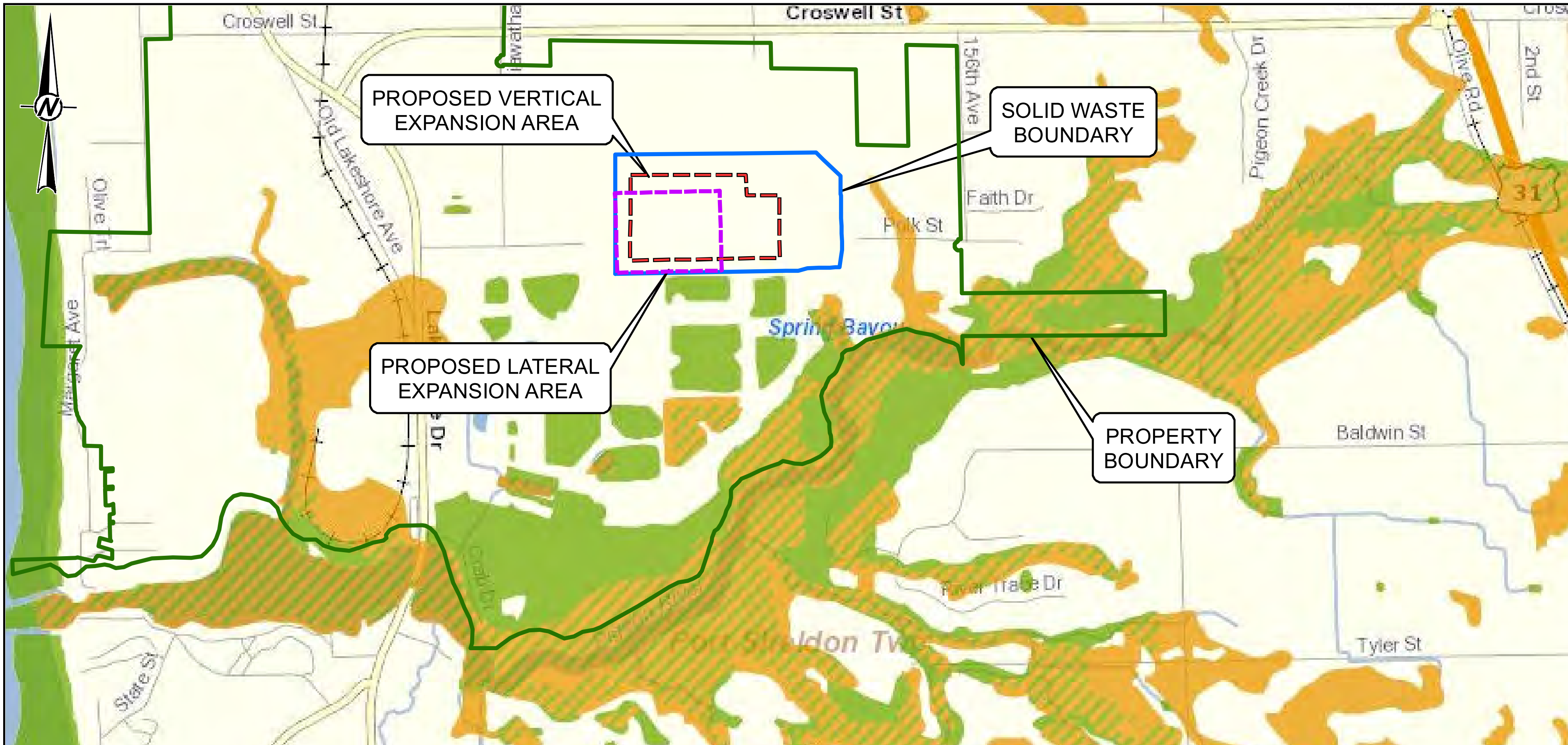

SOURCES: Esri, HERE, DeLrome, USGS, Intermap, NRCAN, Increment P Corpl, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, copyright OpenStreetMap contributors, and the GIS User Community. United States Fish and Wildlife Service National Wetland Inventory Map

MARCH 27, 2017
PART 303 FINAL WETLAND INVENTORY

- WETLANDS AS IDENTIFIED ON NWI AND MIRIS MAPS
- SOIL AREAS WHICH INCLUDE WETLAND SOILS
- WETLANDS AS IDENTIFIED ON NWI AND MIRIS MAPS AND SOIL AREAS WHICH INCLUDE WETLAND SOILS

0 2000 4000 Feet

Disclaimer: This map is not intended to be used to determine the specific locations and additional boundaries of wetlands areas subject to regulation.
More information regarding this map, including how to obtain a copy can be accessed at www.michigan.gov/wetlands. Map by: State of Michigan - CSS Copyright 2017.

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
OTTAWA COUNTY WETLANDS INVENTORY MAP

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-07-07
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
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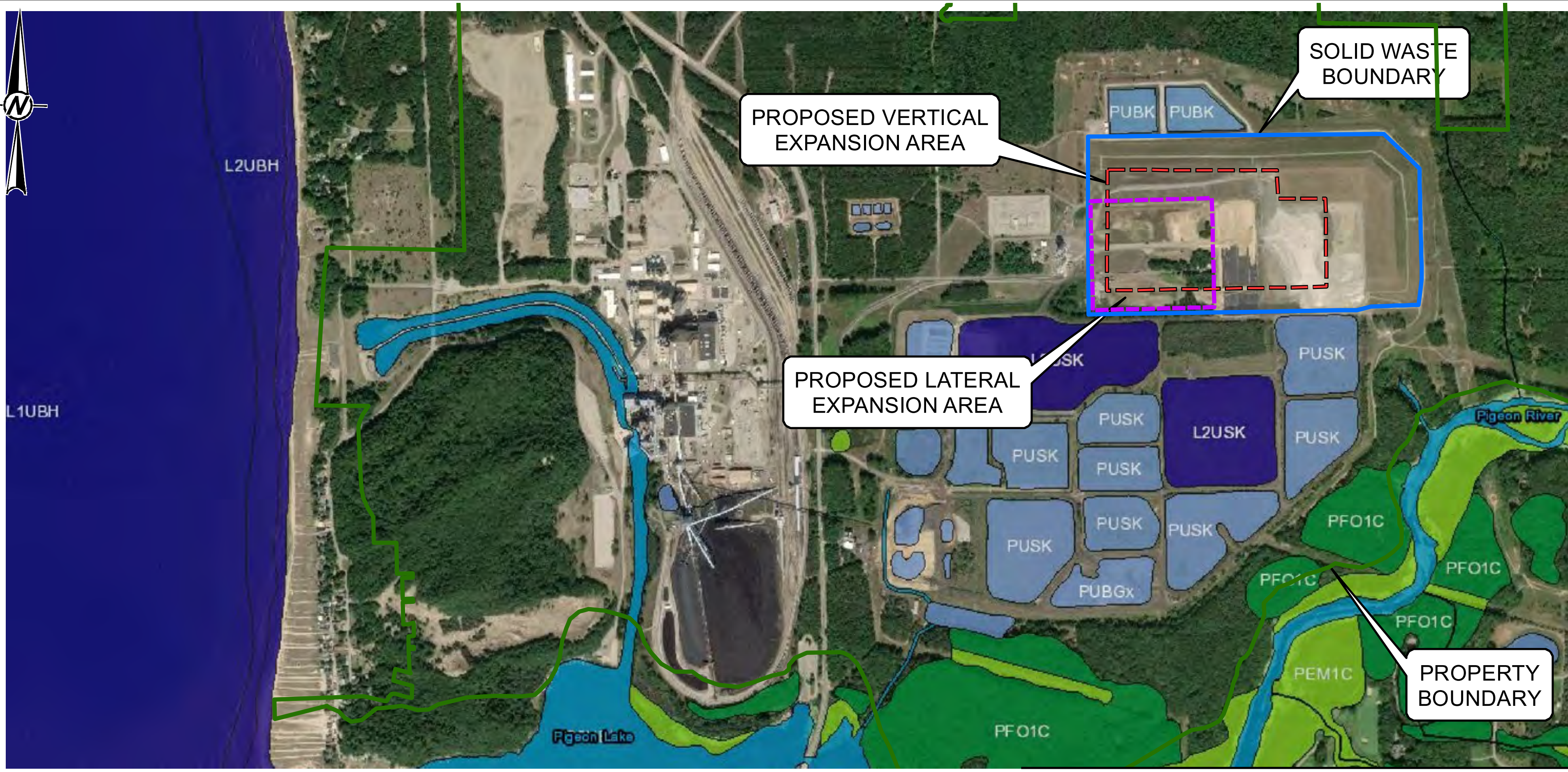

DATA SOURCE: NATIONAL WETLAND INVENTORY MAP PROVIDED BY THE UNITED STATES FISH AND WILDLIFE SERVICE.

April 15, 2020

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

0 1500 3000 Feet

Disclaimer: This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
NATIONAL WETLANDS INVENTORY MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2021-02-12
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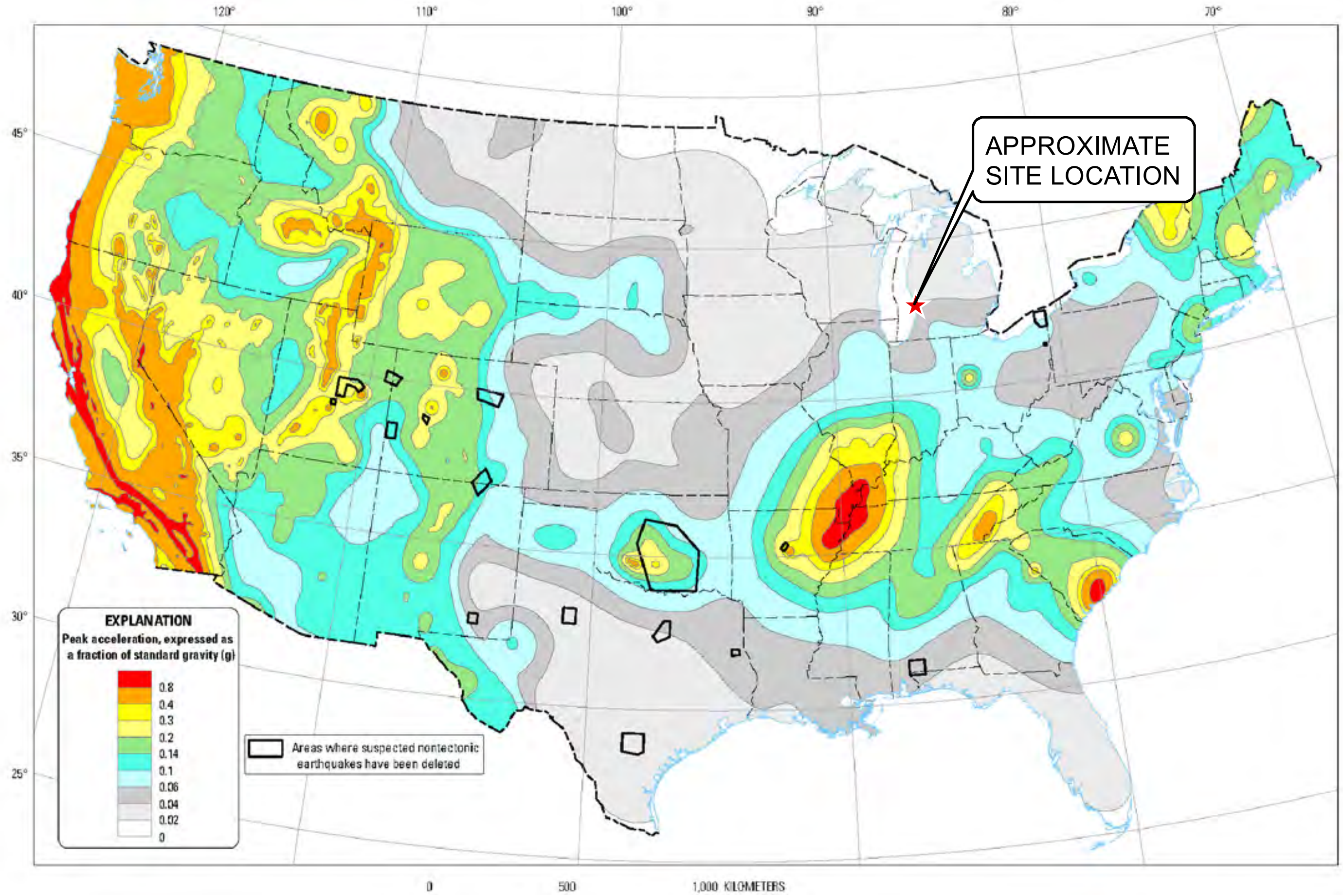

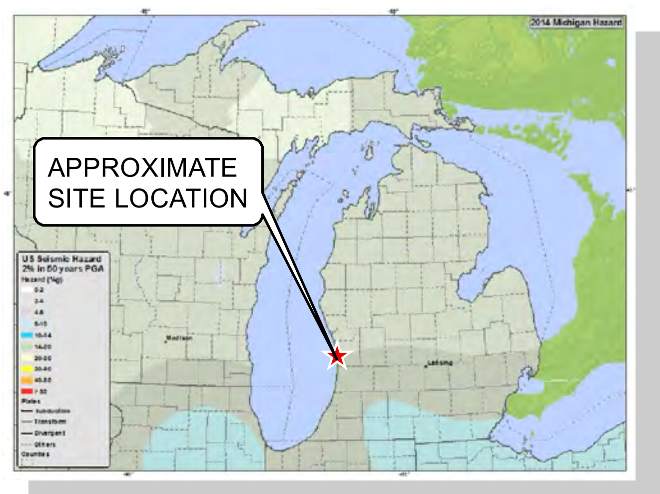

DATA SOURCE: SEISMIC IMPACT ZONE DATA PROVIDED BY THE UNITED STATES GEOLOGICAL SURVEY (USGS) EARTHQUAKE HAZARDS PROGRAM AND THE NATIONAL EARTHQUAKE INFORMATION CENTER (NEIC).

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WEST OLIVE, MICHIGAN 49460

TITLE
MICHIGAN SEISMIC IMPACT ZONE AND HAZARDS MAP

CONSULTANT
GOLDER

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MAGNITUDE

- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

DEPTH

- 0-6 km
- 6-12 km
- 12-18 km

0 25 50 100 Miles

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
MICHIGAN SEISMIC MAP

CONSULTANT

GOLDER

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DATA SOURCE:
WATERSHED MAP FOR OTTAWA COUNTY PROVIDED BY THE MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY (MDEQ).

0 37.5 75 150 Miles

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
MICHIGAN WATERSHED MAP

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
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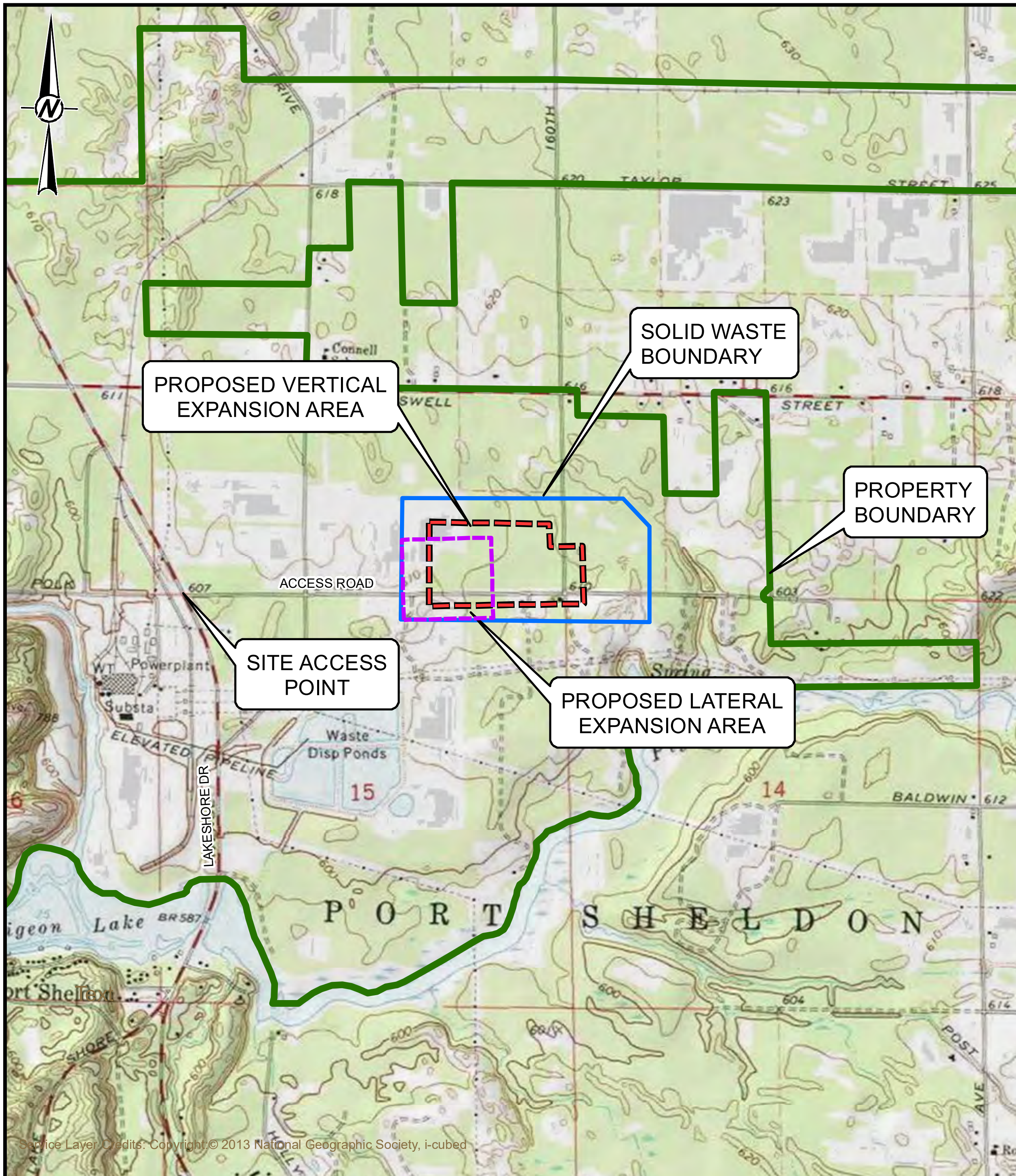

NOTE: THE EXISTING DRY ASH LANDFILL SUPPORTS THE J.H. CAMPBELL GENERATING FACILITY LOCATED DUE WEST OF THE PROPOSED VERTICAL EXPANSION AREA AND DOES NOT UTILIZE PUBLIC ROADWAYS FOR NORMAL LANDFILL OPERATIONS.

0 2000 4000
Feet

CLIENT
CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
TRUCK ROUTE

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
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APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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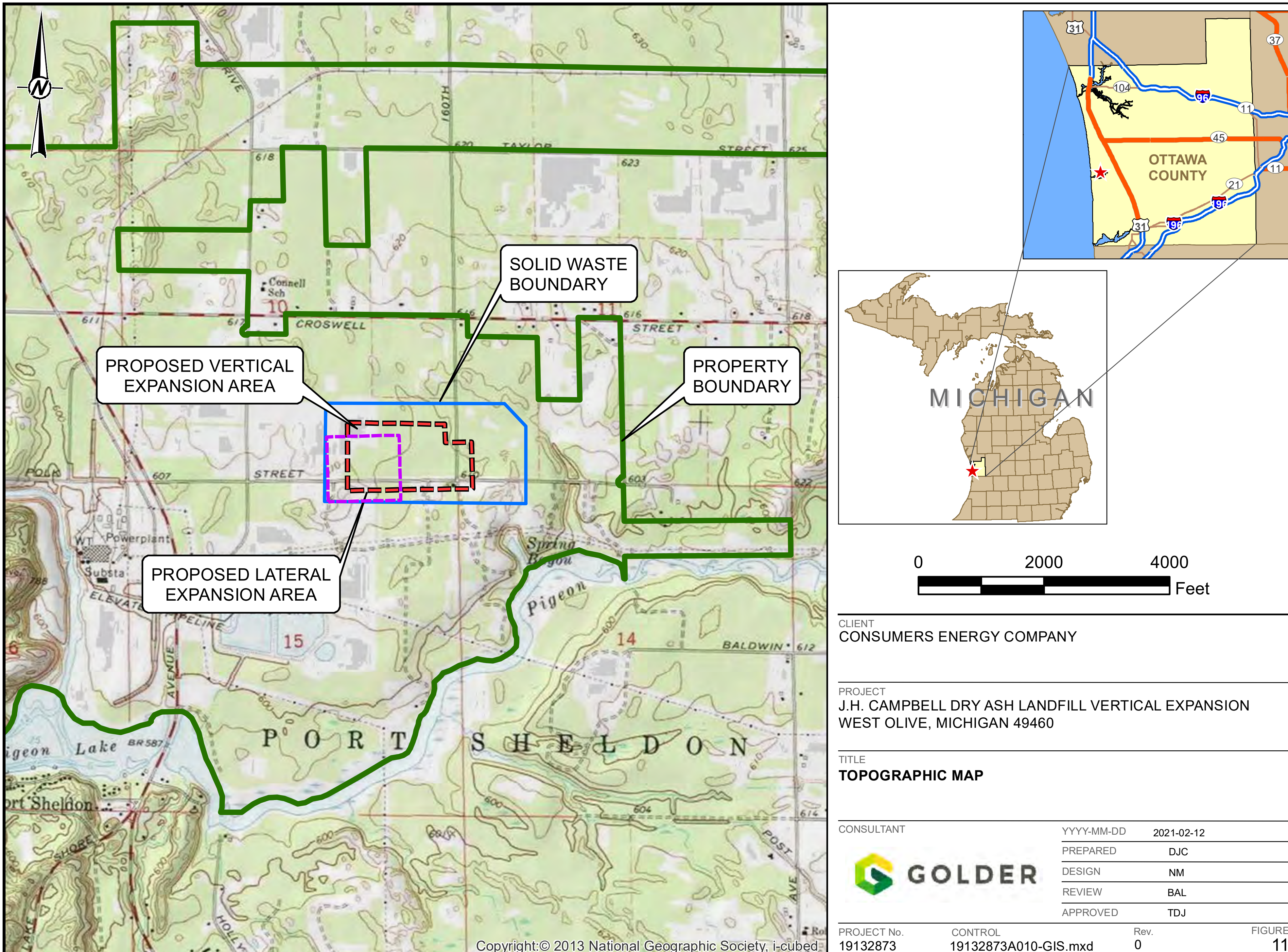

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PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
TOPOGRAPHIC MAP

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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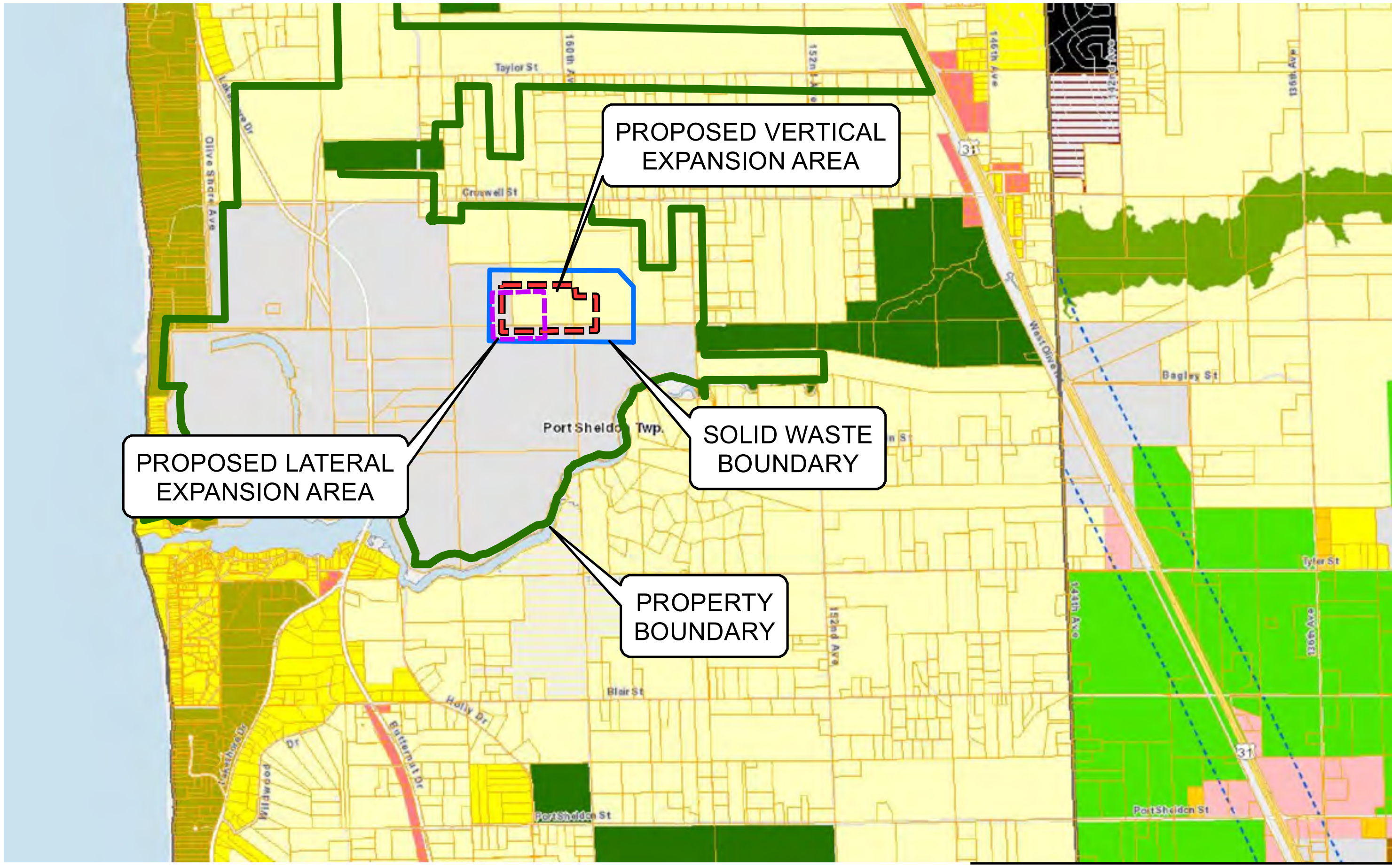

LEGEND

- AGRICULTURAL PRESERVATION (AP)
- GENERAL COMMERCIAL (C-2)
- HEAVY COMMERCIAL PUD (C-4 PUD)
- LOW DENSITY RESIDENTIAL A (LDR A)
- LOW DENSITY RESIDENTIAL PUD (LDR PUB)
- LIGHT INDUSTRIAL (LI A)
- MARINA DISTRICT (MD)
- MOBILE HOME PARK (MHP)
- PUBLIC/PARKS/QUASI-PUBLIC (PPQP)
- RURAL/AGRICULTURAL PRESERVATION (RAP)
- RURAL RESIDENTIAL A (RR A)
- RESIDENTIAL-SENSITIVE AREA (RSA)
- SENSITIVE AREA (SA)
- SINGLE FAMILY RESIDENTIAL A (SFR A)

DATA SOURCE:
ZONING MAPS FROM OTTAWA COUNTY MICHIGAN WEBSITE.

0 2,000 4,000 8,000
Feet

CLIENT
CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
ZONING MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2021-02-12
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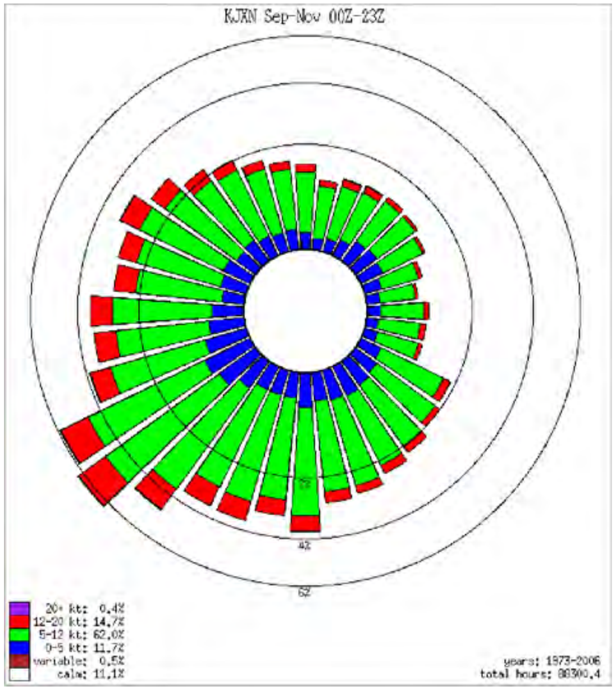

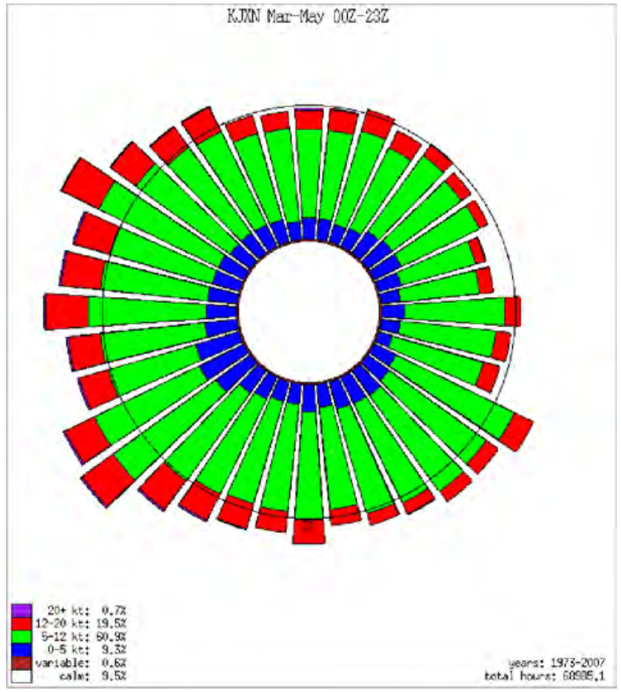

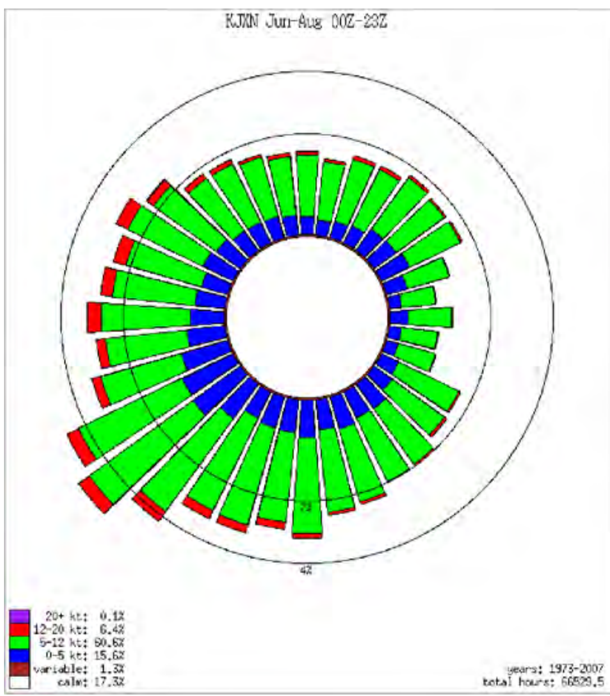

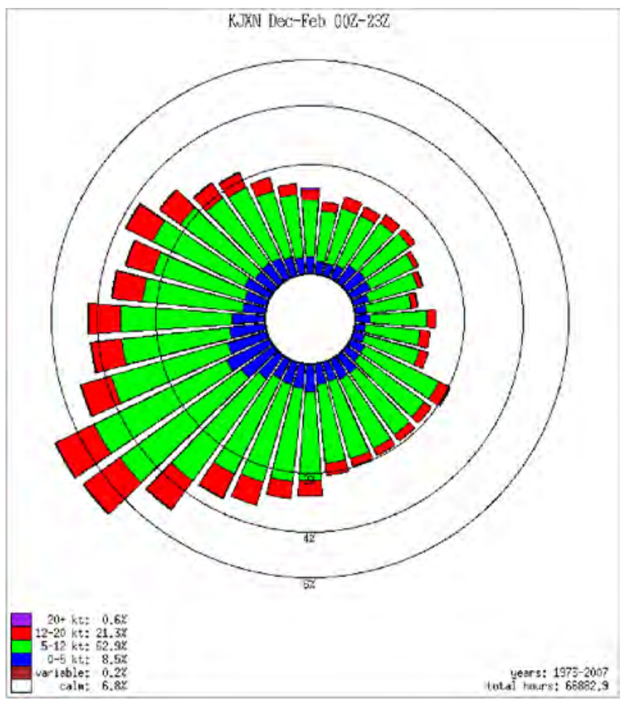

DATA SOURCE:
ANNUAL HISTOGRAM WINDROSE DATA PROVIDED BY NATIONAL WEATHER SERVICE AND THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.

CLIENT
CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
WIND ROSE - GRAND RAPIDS AREA 1973-2007

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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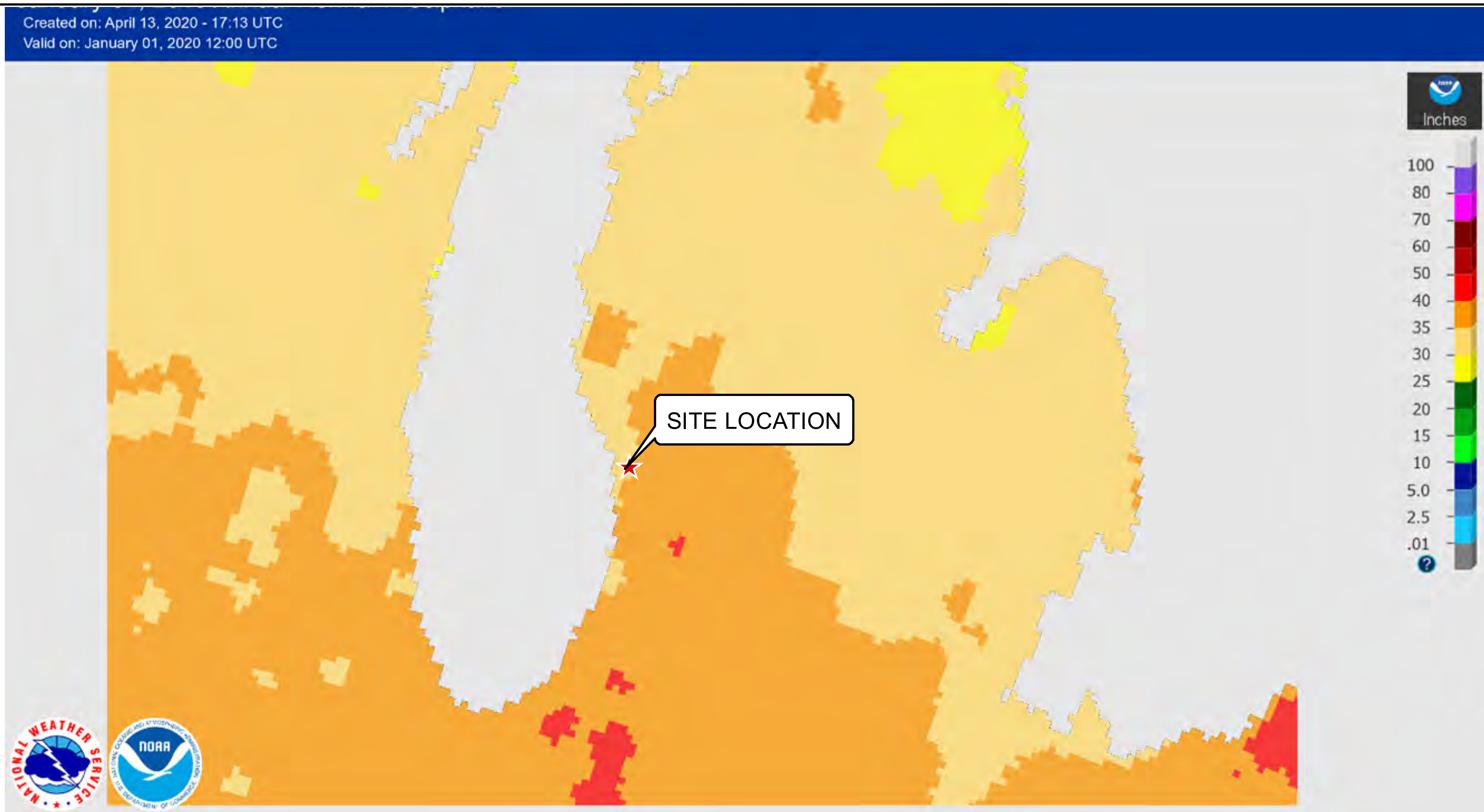

CLIENT
CONSUMERS ENERGY COMPANY

PROJECT
J.H. CAMPBELL DRY ASH LANDFILL VERTICAL EXPANSION
WEST OLIVE, MICHIGAN 49460

TITLE
AVERAGE ANNUAL PRECIPITATION MICHIGAN MAP
GRAND RAPIDS AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2021-02-12
PREPARED	DJC
DESIGN	NM
REVIEW	BAL
APPROVED	TDJ

PROJECT No.	CONTROL	Rev.	FIGURE
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0 25 50 100 Miles

DATA SOURCE:
ANNUAL NORMAL PRECIPITATION DATA PROVIDED BY NATIONAL WEATHER SERVICE AND THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ANSI A

ATTACHMENT B-1

Ottawa County Consistency Letter

miOttawa Department of
Public Health

Lisa Stefanovsky, M.Ed.
Health Officer

Paul Heidel, M.D., M.P.H.
Medical Director

December 8, 2020

Bradley T. Runkel
Senior Engineer Lead (Landfill Operations Compliance)
Consumers Energy
1945 W. Parnall
Jackson, MI 49201

Dear Mr. Runkel,

This letter is in regards to the Summary Report that was submitted for the proposed expansion of the J.H Cambell Coal Ash Landfill. The Ottawa County Solid Waste Planning Committee, in accordance with the Ottawa County Solid Waste Management Plan, does hereby certify that the proposed expansion of the J.H Cambell Coal Ash Landfill is consistent with the Ottawa County Solid Waste Management Plan.

A more detailed description of the review process is outlined below.

- The full Solid Waste Planning Committee convened on October 19, 2020, to begin the review process. The Facility Review Subcommittee was selected and a meeting date was established.
- The subcommittee met on November 11, 2020, to review the Summary Report. A review of the Summary Report against the criteria of the Ottawa County Solid Waste Management Plan showed that the Summary Report met all required criteria for a facility expansion. The subcommittee voted unanimously to recommend that the full committee vote to approve the issuance of the Letter of Consistency.
- The full committee met again on December 4, 2020 to vote on the recommendation of the subcommittee. The committee voted unanimously to issue a Letter of Consistency for the Summary Report as written.

As stated above, the Ottawa County Solid Waste Planning Committee believes that the Summary Report, proposed expansion, and processing meet all criteria required by the Ottawa County Solid Waste Management Plan and is hereby issuing this Letter of Consistency which is valid for one year from the date of this letter.

If you have any questions or require further information, please contact this office at (616) 494-5569.

Respectfully

Kimberly Wolters, REHS
Environmental Health Supervisor
Solid Waste Management Coordinator

Cc: Ottawa County Solid Waste Planning Committee
Ottawa County Board of Commissioners

ATTACHMENT B-2

Location Restrictions (Wetland, fault areas and seismic zones, and unstable areas)

J.H. Campbell Generating Facility

Dry Ash Landfill Cell 5 Expansion - Location Restriction Certification Report

Pursuant to:

40 CFR 257.60
40 CFR 257.61
40 CFR 257.62
40 CFR 257.63
40 CFR 257.64

Submitted to:

Consumers Energy Company
1945 Parnall Road
Jackson, Michigan, USA 49201

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, Michigan, USA 48906
+1 517 482-2262

1899528

December 2018

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.60-64]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Sections 257.60-64 (40 CFR Part 257.60-64), I attest that this Location Restriction Certification Report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards and with the requirements of 40 CFR Part 257.60-64.

Golder Associates Inc.

Signature

STATE OF MICHIGAN
TIFFANY D. JOHNSON
ENGINEER
NO.
49160
LICENSED PROFESSIONAL ENGINEER

12/5/18

December 5, 2018

Date of Report Certification

Tiffany D. Johnson, P.E.

Name

6201049160

Professional Engineer Certification Number

Table of Contents

1.0 INTRODUCTION

On April 17, 2015, the United States Environmental Protection Agency (EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule") to regulate the solid waste management of CCR generated at electric utilities. Sections 257.60-64 of the CCR RCRA Rule require the owner or operator of a lateral expansion of a CCR Unit to document that the lateral expansion was designed to meet the location restriction criteria outlined therein. The CCR RCRA Rule defines a lateral expansion of a CCR unit as a horizontal expansion of the waste boundaries of an existing CCR landfill or existing CCR surface impoundment made after October 19, 2015. According to Sections 257.60(b), 257.61(b), 257.62(b), 257.63(b), and 257.64(c); the documentation must be certified by a qualified professional engineer. Prior to the CCR Unit's first receipt of waste, the documentation must be placed in the facility's operating record and posted to the publicly available website per Sections 257.60(c), 257.61(c), 257.62(c), 257.63(c), and 257.64(d).

Golder Associates Inc. (Golder) is submitting this report to certify that the Consumers Energy Company (CEC) J.H. Campbell Generating Facility (JH Campbell) Dry Ash Landfill Cell 5 Expansion is located in an area that meets criteria outlined in 40 CFR 257.60-64.

2.0 PLACEMENT ABOVE THE UPPERMOST AQUIFER [40 CFR 257.60]

Section 257.60 of the CCR RCRA Rule requires that a lateral expansion of a CCR Unit be constructed with a base that is located no less than five feet above the upper limit of the uppermost aquifer or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations.

CEC submitted a construction permit upgrade request to the Michigan Department of Environmental Quality (MDEQ) Office of Waste Management and Radiological Protection for the JH Campbell Dry Ash Landfill Cells 5 through 9 in March 2018 (Golder 2018a). The construction permit upgrade request was approved by the MDEQ on June 20, 2018 (MDEQ 2018). The construction permit upgrade request included raising the floor elevations of Cells 5 through 9. The lowest point of the floor (the base of the sump), is designed to be a minimum of five feet above the historical high groundwater elevation. Specifically, the base of the Cell 5 sump is designed at 604.3 feet (NGVD 29), and the historical high groundwater elevation at this location is 599.2 feet (NGVD 29) (TRC 2017).

3.0 WETLANDS [40 CFR 257.61]

Section 257.61 of the CCR RCRA Rule requires that a lateral expansion of a CCR Unit not be located in wetlands, as defined in 40 CFR Section 232.2. The following sources were utilized, in part, to determine if the JH Campbell Dry Ash Landfill Cell 5 Expansion is located within a wetland:

- US Geological Survey (USGS) topographic map
- National Wetland Inventory (NWI) map
- Michigan Department of Environmental Quality (MDEQ) wetland map
- US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil survey map
- Aerial imagery
- Federal Emergency Management Agency (FEMA) floodplain map

According to the NWI and MDEQ maps, the Dry Ash Landfill Cell 5 Expansion is neither mapped as a wetland nor mapped with areas that include wetland soils.

A visual evaluation of the Dry Ash Landfill Cell 5 Expansion footprint was performed on May 4, 2018 by a Golder professional wetland scientist. The results of the visual evaluation confirmed the desktop study by noting that the Dry Ash Landfill Cell 5 Expansion did not exhibit characteristics of a wetland. The results of the visual evaluation of the Dry Ash Landfill Cell 5 Expansion footprint satisfy the requirements of Section 257.61. The visual evaluation is documented in the JH Campbell Dry Ash Landfill Cell 5 Wetland Assessment Technical Memorandum (Golder 2018b)

4.0 FAULT AREAS [40 CFR 257.62]

Section 257.62 requires that a lateral expansion of a CCR Unit not be located within 200 feet of the outermost damage zone of a fault that has had displacement in Holocene time (approximately 12,000 years ago to present day). According to the U.S. Geological Survey (USGS) U.S. Quaternary Faults and Folds Database (USGS 2014b), the fault zone nearest to the JH Campbell Dry Ash Landfill Cell 5 Expansion with documented displacement in Holocene time is the New Madrid Seismic Zone. While active fault zones are not expressed at the surface, movement along these faults have caused seismic activity in the region for the past 4,500 years.

According to the Missouri Department of Natural Resources, the New Madrid Seismic Zone is primarily located in southeastern Missouri, northeastern Arkansas, western Tennessee, western Kentucky, and southern Illinois. The JH Campbell Dry Ash Landfill Cell 5 Expansion is approximately 400 miles northeast of the New Madrid Seismic Zone, satisfying the requirements of Section 257.62.

5.0 SEISMIC IMPACT ZONES [40 CFR 257.63]

Section 257.63 requires that a lateral expansion of a CCR Unit not be located in seismic impact zones, defined in Section 257.53 as an area having two percent or greater probability that the maximum expected horizontal ground acceleration will exceed 10 percent of gravity (0.10g) in 50 years (return period of approximately 2,500 years). Data published in 2014 from the USGS indicates that the JH Campbell Landfill Cell 5 Expansion footprint has an annual frequency of exceedance of 8.5×10^{-5} for an earthquake with a maximum expected horizontal ground acceleration of 0.10g, which corresponds to a probability of exceedance of 0.42 percent in 50 years and a return period of 12,000 years.

Since the probability of exceedance is less than two percent in 50 years for a maximum expected horizontal ground acceleration of 0.10g, the JH Campbell Dry Ash Landfill Cell 5 Expansion is not located in a seismic impact zone, satisfying the requirements of Section 257.63.

6.0 UNSTABLE AREAS [40 CFR 257.64]

Section 257.64 requires that a lateral expansion of a CCR Unit not be located in an unstable area. As outlined in Section 257.64(b), the following must be considered when determining whether an area is unstable:

- Onsite or local soil conditions that may result in significant differential settling
- Onsite or local geologic or geomorphologic features
- Onsite or local human-made features or events (both surface and subsurface)

Previous geotechnical investigations in and around the JH Campbell Dry Ash Landfill Cell 5 Expansion indicate the onsite soils are comprised of a native sand layer that overlies glacial till (EES 2012). The sand deposit extends to an approximate depth of 45 to 60 feet below ground surface (bgs) and is underlain by fine-grained silty clay and clay silt soils which extend to bedrock at approximately 140 feet bgs (EES 1992).

Settlement of the soils forming the foundation of the JH Campbell Dry Ash Landfill Cell 5 Expansion were analyzed as part of the construction permit upgrade (Golder 2018a). The analysis assessed differential settlement along leachate collection piping resulting from maximum CCR fill heights. Results of the settlement analysis confirm that the onsite soil conditions do not result in significant differential settlement.

A desktop study was conducted using GeoWebFace (MDEQ 2018b), an online GIS database managed by the MDEQ, which confirmed that none of the following are located in a proximity that would affect the stability of the JH Campbell Dry Ash Landfill Cell 5 Expansion.

- Oil wells
- Gas wells
- Underground mines

Additionally, maps provided by the USGS (USGS 2014a) and the Michigan Natural Features Inventory (Albert, et al. 2008) indicate that the JH Campbell Dry Ash Landfill Cell 5 Expansion is not located in an area prone to karst development.

A slope stability analysis was performed as part of the design for the construction permit upgrade (Golder 2018a). Soil conditions observed during the geotechnical investigations were incorporated into the analysis to account for onsite geologic features. The analyses were conducted at:

- Locations with substantial CCR fill heights
- Locations with limited buttressing of CCR fill slopes
- Locations where forward sloping liner gradients might contribute to embankment instability

Results of the stability analysis indicated that the JH Campbell Dry Ash Landfill Cell 5 Expansion foundation and design slopes are stable.

The historical geotechnical investigations along with the results of the settlement analysis, slope stability analysis, and desktop study indicate the JH Campbell Dry Ash Landfill Cell 5 Expansion is not located in an unstable area, satisfying the requirements of Section 257.64.

7.0 CONCLUSION AND SUMMARY

Golder has determined that the JH Campbell Dry Ash Landfill Cell 5 Expansion meets the location restrictions outlined in 40 CFR 257.60-64. Prior to the CCR Unit's first receipt of waste, this report must be placed in the facility's operating record in accordance with Section 257.105(e) and must be made available on the facility's publicly accessible internet site in accordance with Section 257.107(e).

Sincerely,

Golder Associates Inc.

Tiffany Johnson, P.E.
Associate, Senior Consultant

Matt Wachholz, P.E.
Senior Consultant

8.0 REFERENCES

Albert, D.A., Cohen, J.G., Kost, M.A., Slaughter, B.S., and Enander, H.D. 2008. Distribution of Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI.

Engineering and Environmental Solutions (EES), LLC. November 18, 1992. Final Report – Subsurface Exploration and Geotechnical Summary Report for the Proposed J.H. Campbell Ash Storage Facility Cell Expansion Project, West Olive, Michigan.

Engineering and Environmental Solutions (EES), LLC. December 2012. Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation – 2012. J.H. Campbell Solid Waste Disposal Area.

Golder Associates Inc. March 2, 2018a. J.H. Campbell Dry Ash Landfill, Construction Permit Upgrade Request, Cells 5 through 9. Facility ID Number 395496.

Golder Associates Inc. May 2018b. RCRA Location Restriction Assessment. J.H. Campbell Dry Ash Landfill Cell 5, Wetland Assessment Technical Memorandum. West Olive, Ottawa County, Michigan.

Michigan Department of Environmental Quality (MDEQ). June 2018a. Construction Permit number 0299 - upgrade approval letter.

Michigan Department of Environmental Quality (MDEQ). 2018b. GeoWebFace GIS Database.

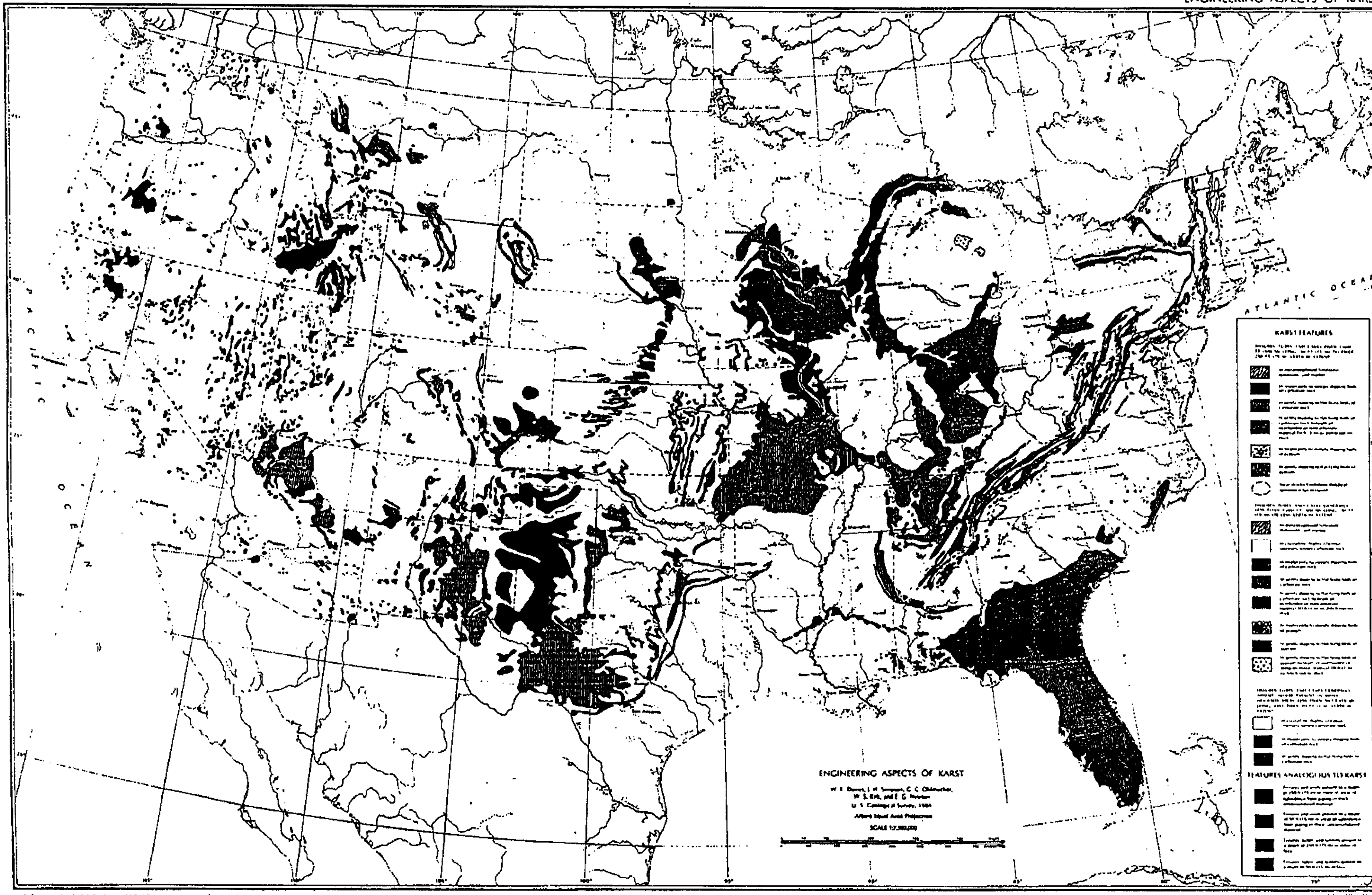
TRC Environmental (TRC). July 2017. Second Quarter 2017 Groundwater Monitoring Report – J.H. Campbell Solid Waste Disposal Area.

U.S. Geological Survey (USGS). 2014a. Karst in the United States: A Digital Map Compilation and Database.

U.S. Geological Survey (USGS). 2014b. U.S. Quaternary Faults and Folds Database.

GOLDER

golder.com



NATIONAL ATLAS OF THE UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR, U.S. GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

From "Hydrogeology for Underground Injection in Michigan, Part 1, 1981" pages II-116 through II-119

KARST

Known karst in Michigan is present in carbonate and evaporite rocks deposited during the following periods: Ordovician Black River, Trenton and Richmond Groups; Silurian Cataract, Burnt Bluff, Manistique, Niagaran and Salina Groups; Devonian Bois Blanc Formation, Detroit River and Traverse Groups; and Mississippian Grand Rapids Group (pls. 6,7, and 18). Significant evidence of dissolution is generally confined to the area of outcrop or subcrop under the glacial drift and to one or more carbonate or evaporite units within each of these groups (table 2.2).

Ordovician

Karst features in Ordovician rocks are common throughout carbonate and evaporite strata in the Northern Peninsula, and are generally limited to the area where the formations subcrop beneath the glacial drift. Solutional activity occurs in Ordovician strata as enlarged fractures and widening along bedding planes in near-surface rocks. Most solution is thought to have occurred before glaciation when the rocks were exposed at the surface, and is generally confined to areas where the carbonates are not overlain and thereby protected by younger rocks (Vanlier and Deutsch, 1958). The yeild of water from Ordovician carbonates in the Northern Peninsula is dependent upon the extent of the solutionally enlarged permeability, and decreases where soluble rocks are overlain by other strata. Bacterial contamination of karst aquifers is a serious problem because hydraulic continuity between the glacial drift and the fractured carbonate strata allows rapid movement of contaminated wastes from the overlying drift.

Silurian

Karst features in Northern Peninsula Silurian strata are generally restricted to solutionally-widened crevices and fractures along bedding planes, and to zones where interbedded lenses of evaporites, notably gypsum, have been dissolved. In the eastern Northern Peninsula evidence of solution of Early Silurian carbonates exists near Big Spring (T 42N, R 17W, Sec. 26), Schoolcraft County, where several sinkholes filled with glacial sediment have been located. These sinkholes, including Big Spring, are assumed to have been formed through dissolution of limestone or gypsum beds in the Burnt Bluff or Cataract Groups (Poindexter, 1935). Other evidence of karst activity in Northern Peninsula Silurian carbonate rocks includes sinks, a swallow hole, a subterranean stream and a karst spring in Trout Lake Township (T 44N, R 5W, Secs. 22 and 27), Chippewa County and a feature thought to be a sink in Detour Township (T 42N, R 3E, Sec. 4), Chippewa County.

Solution features in Southern Peninsula Silurian strata are generally restricted to the Bass Island Group in southeastern Michigan, and are solutionally-widened crevices and fractures along bedding planes and zones where evaporite stringers have been dissolved.

TABLE 2.2 - OCCURRENCE OF SOLUTION FEATURES IN MICHIGAN.

PERIOD	ROCK UNIT	COUNTIES
Mississippian	Michigan Formation	Kent, Iosco
Devonian	Traverse Group	Alpena, Charlevoix, Montmorency, Presque Isle
	Alpena Limestone	
	Newton Creek Limestone	
	Genshaw Formation	
	Ferron Point Formation	
	Rock Quarry Limestone	
	Mackinac Breccia	Alpena, Antrim, Charlevoix, Cheboygan, Emmet, Leelanau, Mackinac, Presque Isle
	Detroit River Group	
	Bois Blanc Formation	
	Garden Island Formation	
	St. Ignace Dolomite	
	Dundee Limestone	Alpena, Cheboygan, Emmet, Monroe, Presque Isle
	Detroit River Group	Alpena, Cheboygan, Emmet, Monroe, Presque Isle
Silurian	Salina Group	Chippewa, Delta, Mackinac, Schoolcraft
	Engadine Dolomite	
	Burnt Bluff Group	Schoolcraft, Delta, Mackinac
	Cataract Group	
Ordovician	Richmond Group	Delta, Chippewa, Luce, Menominee, Schoolcraft
	Trenton Group	
	Black River Group	

Devonian

Widespread karst development in Michigan occurs in carbonate rocks of Devonian age. Karst features have been identified in carbonates of the Devonian Detroit River, Dundee Limestone and Traverse Group rocks in southeastern Michigan. Ground-water flow has caused and is now causing solution channels to be formed in the Detroit River dolomites. Shallow sinkholes have been identified in several locations in Whiteford Township (T 6S, R 8E) (Moses, 1977, and Mozola, 1969).

Karst features in Devonian are generally restricted to solutionally-widened fractures along bedding planes and solutionally-enlarged crevices. They are most pronounced in the area where the formation outcrops or subcrops beneath the glacial drift, and are not as evident where the rocks are overlain by other rock units.

Michigan's most prominent karst development occurs in Alpena and Presque Isle Counties where Traverse Group limestones are highly fractured at the subcrop and outcrop (Kimmel, 1973). These fractures are principal factors promoting solutional activity in this area. Bedding surfaces in the thinly layered Ferron Point and Genshaw formations provide pathways for circulating ground water and thereby promote solutional activity (Ehlers and Kesling, 1970). The karst features are most evident at the surface in Alpena and Presque Isle Counties where they are thinly covered by glacial deposits. Apparently a large amount of preglacial dissolution took place over the length of the Traverse Group subcrop. The evidence of similar solutional features is probably present in the northwestern portion of the Southern Peninsula but is hidden by thick deposits of glacial materials (Smith, 1966).

The active dissolution of the Traverse Group carbonate rocks has a large bearing on the quality and availability of ground water in Alpena and Presque Isle Counties, and is a key factor in the concern for protection of the domestic drinking water supplies in the northeastern Southern Peninsula. Most of the domestic wells and some municipal wells draw water from limestone units in carbonate rocks of the Traverse Group. Only a thin layer of glacial drift overlies the limestones in much of eastern Presque Isle and Alpena Counties. Consequently a very limited amount of renovation of liquid wastes can occur before the waste liquid reaches the ground water through the highly fractured bedrock. A hepatitis outbreak in Posen, Presque Isle County, was traced to the septic tank effluent contamination of domestic wells completed in fractured limestone (Johnson, 1960; Vogt, 1961). The situation was intensified by drawdown of the water levels in the limestone by domestic wells. Also, the numerous sinkholes in Alpena and Presque Isle Counties are potential pathways for the introduction of contaminants into the drinking-water supplies. In Maple Ridge Township (T 32N, R 7E) a sinkhole has been used for the Cathro Dump. The operation was closed by the Department of Natural Resources, and its effect on the ground water in the area remains undocumented.

Mississippian

Solution activity has occurred in the Mississippian Michigan Formation and is expressed at the surface near the City of Grand Rapids, Kent County, and in southwest Iosco County. The karst features are formed by the dissolution of gypsum beds in the Michigan Formation (Moses, 1977). Several sinkholes and the Pellerito Cave are located just east of Grand Rapids (T 7N, R 12W), Kent County. Solution valleys and several sinkholes are also located in Burbright Township (T 21N, R 5E, Sec. 32), Iosco County.

MICHIGAN STATE UNIVERSITY EXTENSION

Sinkhole

Michigan Natural Features Inventory

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

Department of Environmental Quality
GeoWebFace

MICHIGAN.GOV Michigan's Official Web Site

Layers Tool | Map Tools | Data Search

GeoWebFace Layers

Toggle layer visibility by clicking the corresponding checkbox. Activate the transparency slider for a layer by clicking on the transparency slider.

- [ ] Oil and Gas Information
- [ ] Mining and Minerals
- [x] Geology
  - [ ] Michigan Watersheds
  - [ ] Great Lakes Watershed
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  - [x] Wellogic Type II Water Wells
  - [x] Wellogic Water Wells
  - [ ] Wellhead Protection Areas
  - [ ] Scanned Water Well Logs by Sectio
  - [ ] Staff Gages USGS
  - [ ] 100k Topographic Contours
  - [ ] Quaternary Geology Features
  - [ ] Glacial Lobe Boundaries
  - [ ] Quaternary Directional Indicators
  - [ ] End Moraine and Ice Contact Outw
  - [ ] Quaternary Geology

GeoWebFace Map | GeoWebFace Results

Zoom In | Zoom Out | Pan | Clear | Zoom Extents | Map Nav Info | Identify

EXHIBIT B-17

Michigan Hydrologic Atlas, Part I (Hydrology for Underground Injection Control in Michigan), Department of Geology, Western Michigan University, Kalamazoo, Michigan, 1981, Pages II-42 through II-68

West Bay Exploration Company (WBEC), Haystead #9 SWD
(Permit #MI-079-2D-0010)

Administrative Record
Item # 28

1981

Salina Group

In the Michigan Basin subsurface the Upper Silurian is represented by the Salina and Bass Islands Groups. The Salina Group is a thick sequence of carbonate, anhydrite, salt and shale. A number of these lithologies are restricted to an area roughly equivalent to the combined extent of the basin and shelf facies of the Niagaran Group.

The basal portion of the Salina was designated the "A" member by Landes (1945). The "A" was further subdivided by Evans (1950) into a basal unit he termed the A-1 and an upper unit he named the A-2. Each of these units consists of a lower evaporite unit and upper carbonate. Each of the four "A" elements are extensive enough to warrant formational status, and at least the A-1 Carbonate has been elevated to this rank (Budros, 1974).

Characteristics as an Aquifer. The Salina serves as an aquifer only in its outcrop area in southeastern Michigan and the eastern part of the Northern Peninsula, especially on the St. Ignace Peninsula, where it produces from joints and bedding planes in dolomite.

Characteristics as a Confining Layer. Throughout the central portion of the Michigan Basin where the group contains thick salts and basinward of the reef trend, the unit is essentially an aquiclude.

Characteristics as an Injection Formation. Solution and fracture permeability, variable lithology, and aquifer and hydrocarbon reservoir potential render the Salina Group generally unfavorable as an injection unit. However the Salina is utilized for brine injection in St. Clair County.

Porosity. Porosity associated with joints, brecciation fractures and solution along bedding planes is common in the Northern Peninsula.

Permeability. Highly variable fracture and bedding plane permeability in Northern Peninsula.

Oil and Gas Potential. Near the margins of the evaporite containing Salina, the A-1 and A-2 Carbonates produce hydrocarbons.

A-1 Evaporite

The A-1 Evaporite consists of a basal and upper anhydrite that enclose a thick salt in the basinal area (fig. 2.19, pl. 10). The salt consists mainly of halite ($NaCl$), but it contains up to 40 feet of sylvite (KCL) in the center of the basin (Matthews, 1970). The unit is anhydrite over most of the Niagaran shelf facies. It is generally not present south of the shelf facies and extends only a short distance onto the bank facies in the northern Lower Peninsula (fig. 2.17 and 2.19). Locally, as long a line from Holland, Michigan southeast to Wayland and beyond, the A-1 salt has been removed by dissolution and the overlying rock has been draped over the abrupt escarpment formed by the salt.

Characteristics as an Aquifer. The A-1 Evaporite is not an aquifer.

Characteristics as a Confining Layer. The anhydrite beds and salt of the A-1 Evaporite are essentially impermeable and are excellent confining layers. Furthermore, they contain only a very small amount of formation water, and fractures in either lithology should "heal" either by flowage or secondary mineral growth.

Characteristics as an Injection Formation. None.

Porosity. Extremely low.

Permeability. Essentially impermeable.

Oil and Gas Potential. The A-1 Salt contains gas over some major structures. Gas was tested from this zone over the Mio anticline in Ogemaw County and over the Kawkawlin anticline in Bay County.

A-1 Carbonate

The A-1 Carbonate overlies that portion of the Michigan Basin underlain by the basin and shelf facies of the Niagaran Group and extends northward some distance onto the northern portion of the bank facies (fig. 2.20). South of the shelf facies in the southern part of the Southern Peninsula, the A-1 Carbonate extends only a short distance onto the bank facies. The carbonates in the A-1 are generally limestone except in areas adjacent to reefal buildups, over the abrupt margin of the A-1 salt in southwestern Michigan, and in local areas along its distal margins.

The A-1 Evaporite is gradational upward into the basal A-1 Carbonate and the A-1 Carbonate is apparently gradational into the overlying A-2 Evaporite. In areas where the A-1 Carbonate is overlain by the A-2 salt and underlain by the A-1 salt, all porosity in it is plugged by salt (halite). The A-1 Carbonate is less than 60' thick in the central part of the Michigan Basin and is more than 150 feet thick where it overlies the carbonate bank facies in the northern Lower Peninsula.

Characteristics as an Aquifer. The A-1 Carbonate is not an aquifer.

Characteristics as a Confining Layer. In areas where the A-1 Carbonate is limestone and salt plugged, it is an excellent confining layer.

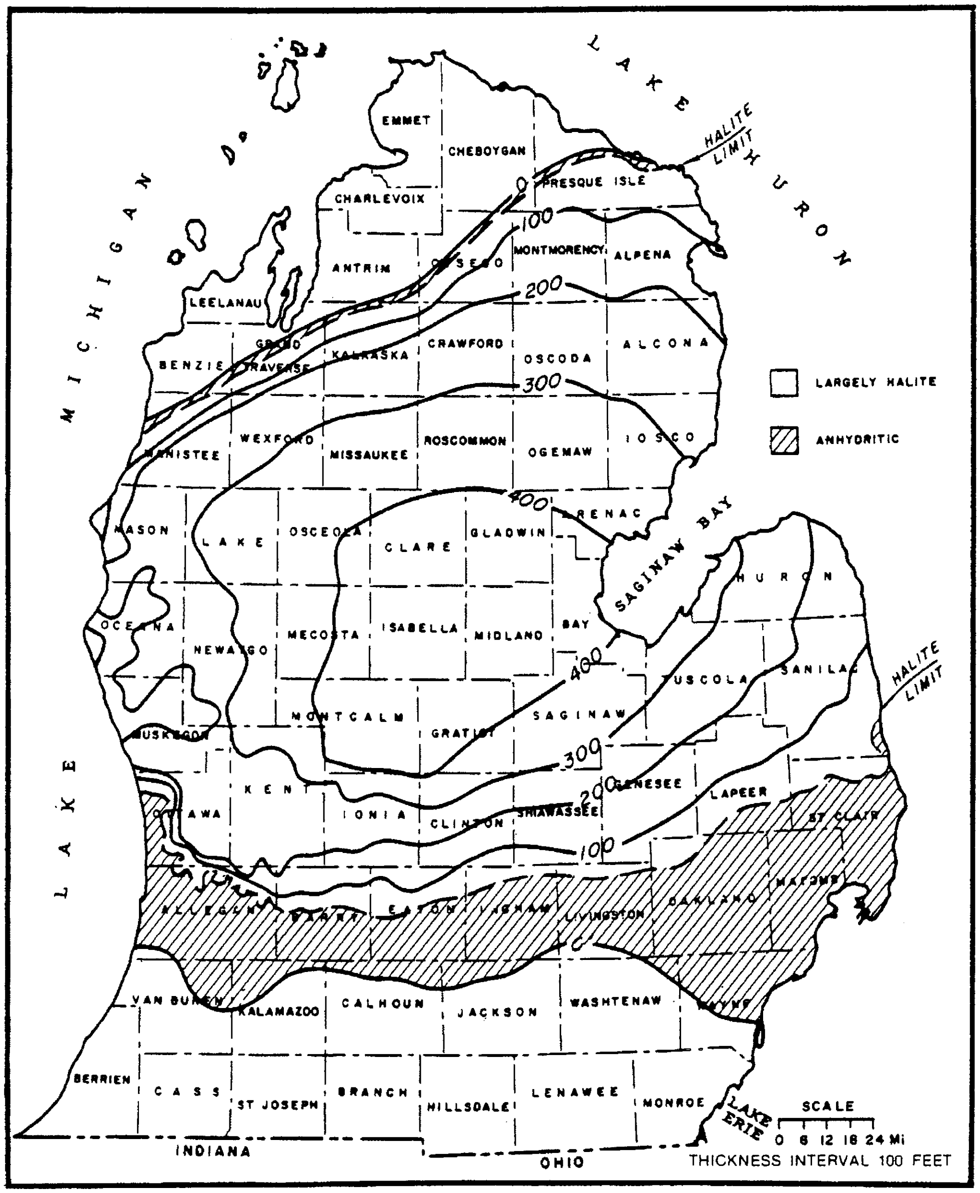

Figure 2.19. Thickness of the A-1 evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

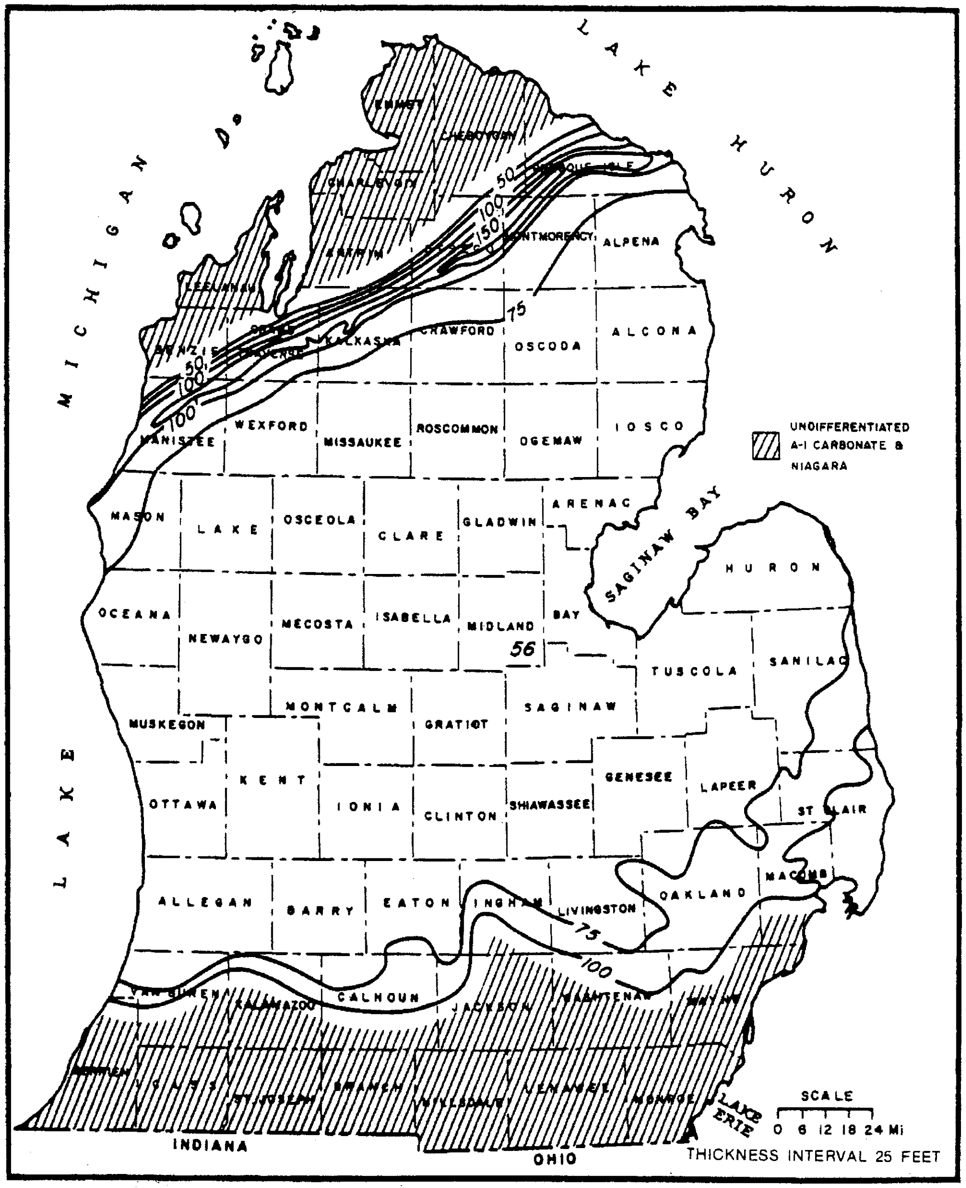

Figure 2.20. Thickness of the A-1 Carbonate. Contour interval is 25 feet. (From Mesolella, 1974.)

Characteristics as an Injection Formation. The A-1 Carbonate will accept fluids only where it is dolomite. In such areas, it is a target for oil and gas exploration, is productive of hydrocarbons, or it is in contact with very permeable reefal dolomites of the Niagaran.

Porosity. In areas where this unit is dolomite, it has low porosity. In areas where it is limestone and salt-plugged, it has extremely low porosity.

Permeability. Dolomites of the A-1 Carbonate are slowly permeable, and salt-plugged limestones are essentially impermeable.

Oil and Gas Potential. The A-1 Carbonate produces hydrocarbons and is an exploration target in those areas where reefs are developed in the Niagara Group.

A-2 Evaporite

The A-2 Evaporite conformably overlies the A-1 Carbonate except over "pinnacle" reefs where it lies directly on the Niagaran (fig. 2.21). It is dominantly halite and ranges from a zero edge at the basin margin to more than 475 feet thick in the central part of the basin (Tremper, 1973). Over the bank reef complex it is a dense anhydrite generally less than 40 feet thick. A-2 salt has been removed by dissolution southwestward of a line that extends from Muskegon southeastward to the Walker Oil Field in Kent County. The A-2 salt, may have been removed in the area just north of the Straits of Mackinac and south to the present salt margin.

Characteristics as an Aquifer. The A-2 Evaporite is not an aquifer.

Characteristics as a Confining Layer. The A-2 Evaporite is an excellent confining layer. It is the seal over the pinnacle reefs that developed in the shelf facies of the Niagaran and has the properites necessary to confine fluids under pressure.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Extremely low.

Permeability. Extremely low.

Oil and Gas Potential. None.

A-2 Carbonate

The A-2 Carbonate is limestone in the central part of the basin and is dolomite over the bank facies and over pinnacle reefs in the southern part of the Lower Peninsula. This unit is more than 150 feet thick in the middle of the basin and thins to less than 50 feet in the northernmost part of the Lower Peninsula (fig. 2.22). It also thins across the southern extension of the bank facies and is difficult to distinguish, or absent, in the area just north of the Michigan-Indiana State line.

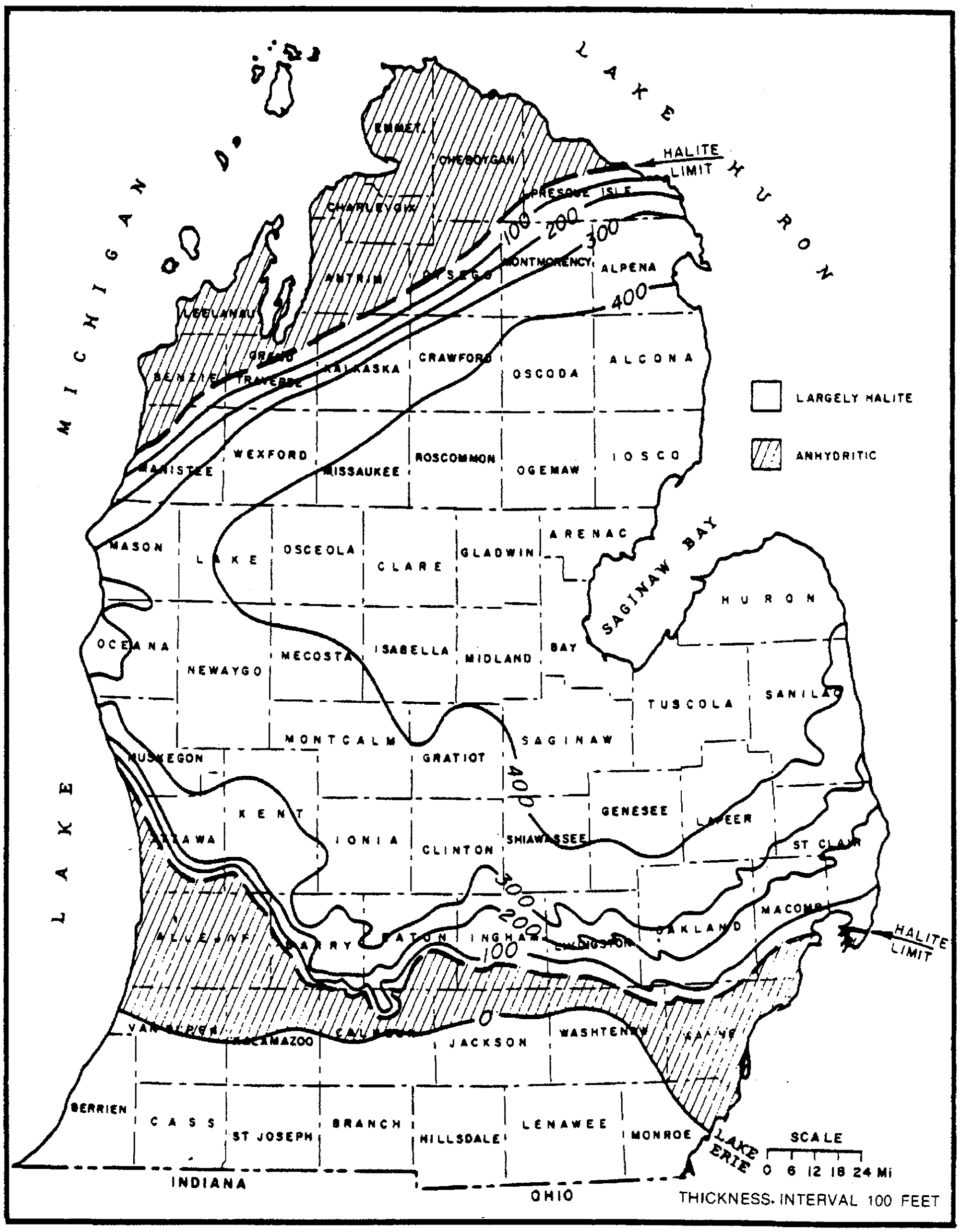

Figure 2.21. Thickness of the A-2 Evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

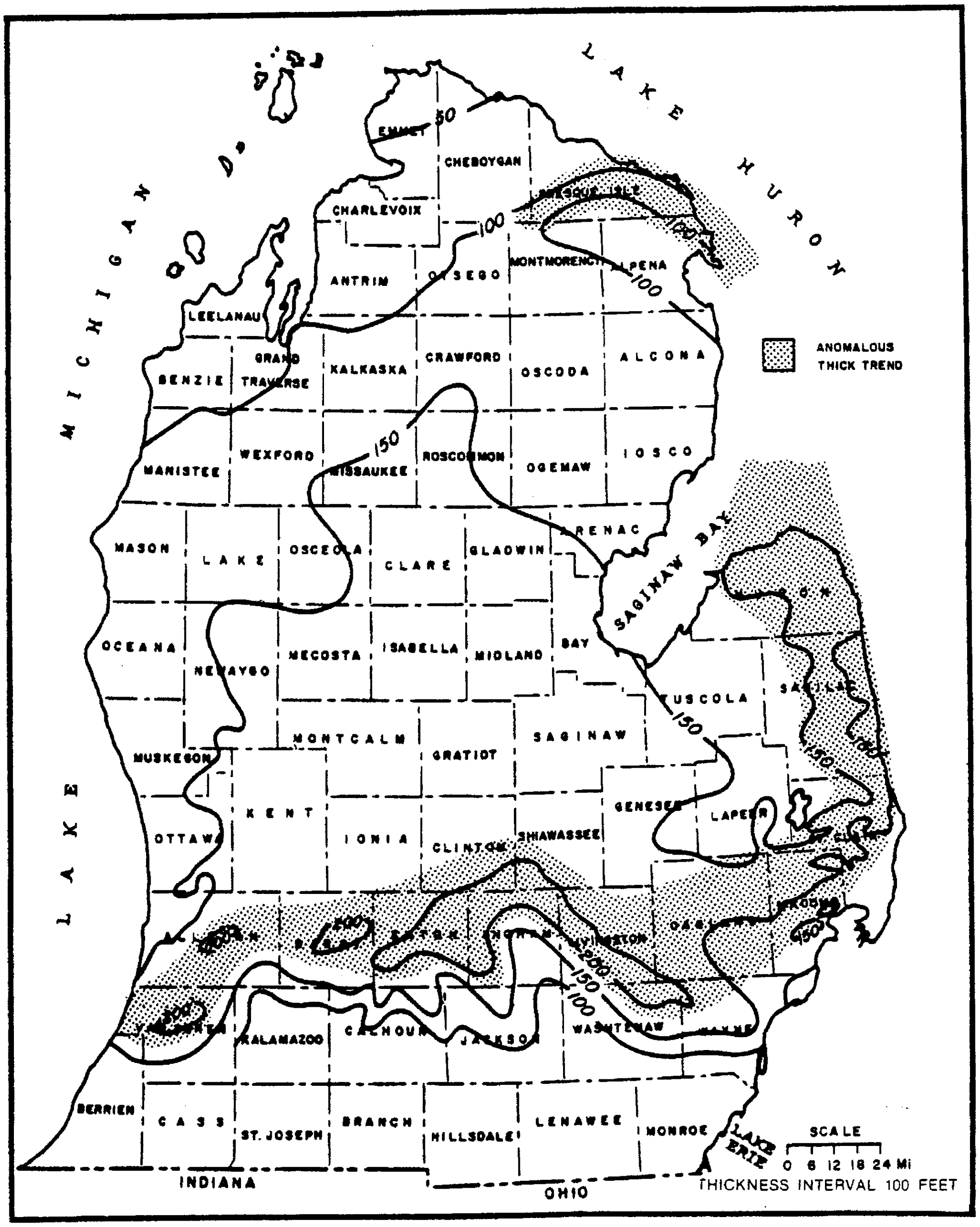

Figure 2.22. Thickness of the A-2 Carbonate. Contour interval is 50 feet. (From Mesolella, 1974.)

Characteristics as an Aquifer. The A-2 Carbonate is not an aquifer. Where the unit is a dolomite, it is slightly porous and slowly permeable, but contains oil and/or gas or brine.

Characteristics as a Confining Layer. In areas where this unit is limestone, all pore space is generally plugged with salt. In such areas it is an excellent aquiclude.

Characteristics as an Injection Formation. In areas where the A-1 Carbonate is dolomite it may serve as an injection formation, but its hydrocarbon potential should first be evaluated. It is currently used as a gas storage reservoir along the A-1 salt edge in southwestern Michigan.

Porosity. Where the A-1 Carbonate is limestone it has very little porosity. In the areas where it is dolomite, it has a porosity of a few percent.

Permeability. The A-2 Carbonate is virtually impermeable in areas where it is a limestone and is salt-plugged. Where it has undergone dolomitization, it is slowly permeable.

Oil and Gas Potential. The A-2 has produced gas in areas where it is dolomite.

B Member

The unit defined as the "B" Member by Landes (1945) includes, in the central part of the basin, up to 450 feet of basal salt and an upper unit comprised of 0 feet to about 80 feet of shale, dolomite and anhydrite (fig. 2.23). The B-salt is thickest in the basin and thins toward the northern carbonate bank where it thickens (Tremper, 1973). North of the thickest portion of the bank facies the unit thins toward the basin margin. On the southern flank of the basin, the B-salt does not extend south of the southern edge of the shelf facies of the Niagaran. The upper part of the B, termed the B-Unit by Ells (1978) thins from a maximum of more than 80 feet in the basin center to a zero edge near the Straits of Mackinac on the north and over the northern part of the bank facies and the southern flank of the basin.

Characteristics as an Aquifer. Neither the B-salt nor the B-Unit is an aquifer.

Characteristics as a Confining Layer. The B-salt and the B-Unit are excellent confining layers. The thick salt section in the central part of the basin would be most effective, but the presence of either salt or anhydrite should indicate that the member is an aquiclude.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Essentially impermeable.

Permeability. Essentially zero.

Oil and Gas Potential. Very little to none.

Figure 2.23. Thickness of the B Evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

C Shale

The C-Unit is a dolomitic shale with beds of anhydrite and dolomite. It is more than 115 feet thick in the central basin area, thins to 70 feet across the thick portion of the northern bank facies and is more than 100 feet thick near the Straits of Mackinac (fig. 2.24). The unit thins across the southern bank facies, becomes more carbonate rich, and according to Shaver (personal communication, 1980) grades into the Mississenawa Shale in Indiana.

Characteristics as an Aquifer. None.

Characteristics as a Confining Layer. The C-Shale is a plastic shale and should not maintain open fractures at depth. Thus, it is considered to be an excellent confining layer.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Effective porosity is essentially zero. Porosity associated with clay minerals is quite high.

Permeability. Essentially impermeable.

Oil and Gas Potential. None.

D-Unit

The Salina D-Unit is composed of two salt (halite) beds and an intervening argillaceous, anhydritic, fine-grained dolomite. Around the periphery of the basin the D-Unit is thin and consists mainly of shale and anhydrite. It is as much as 60 feet thick in the central basin area but thins to less than 15 at the margins of the basin (Tremper, 1973) (fig. 2.25).

Characteristics as an Aquifer. The D-Unit is not an aquifer.

Characteristics as a Confining Layer. In the basinal areas where the D-Unit salts are present the D-Unit is an aquiclude. Marginal to the area of salt development, the shaly anhydrite should be an aquitard, but would not form as formidable a barrier to the movement of fluids as a thick bed of salt (NaCl).

Characteristics as an Injection Formation. None.

Porosity. Extremely slow.

Permeability. Extremely slow.

Oil and Gas Potential. None.

E-Unit

The Salina E-Unit is a mixture of lithologies. Dominated by shales, it also contains dolomite beds that are locally oolitic and thin beds of anhydrite. It is more than 160 feet thick in the center of the Michigan Basin and thins to less than 90 feet in marginal areas (Tremper, 1973) (fig. 2.26).

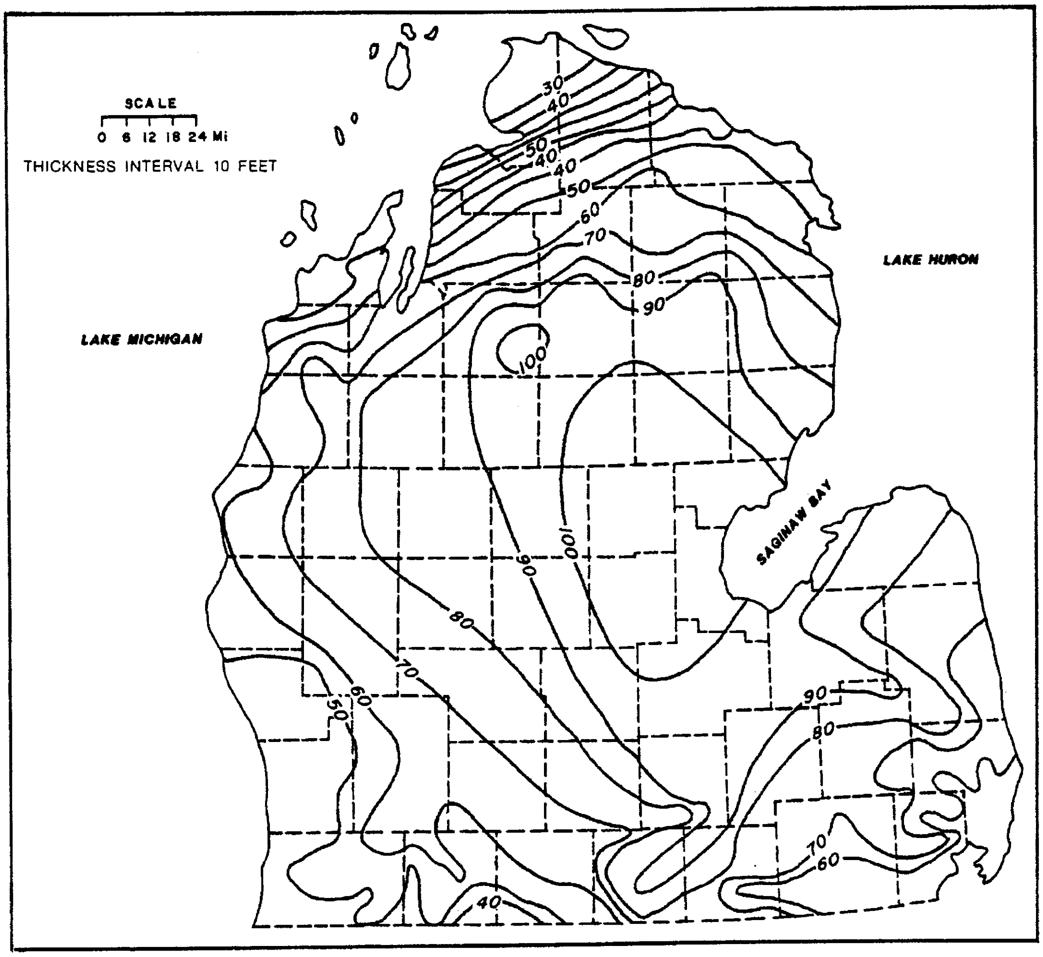

Figure 2.24. Thickness of Salina C Unit. (From Dali, 1975.)

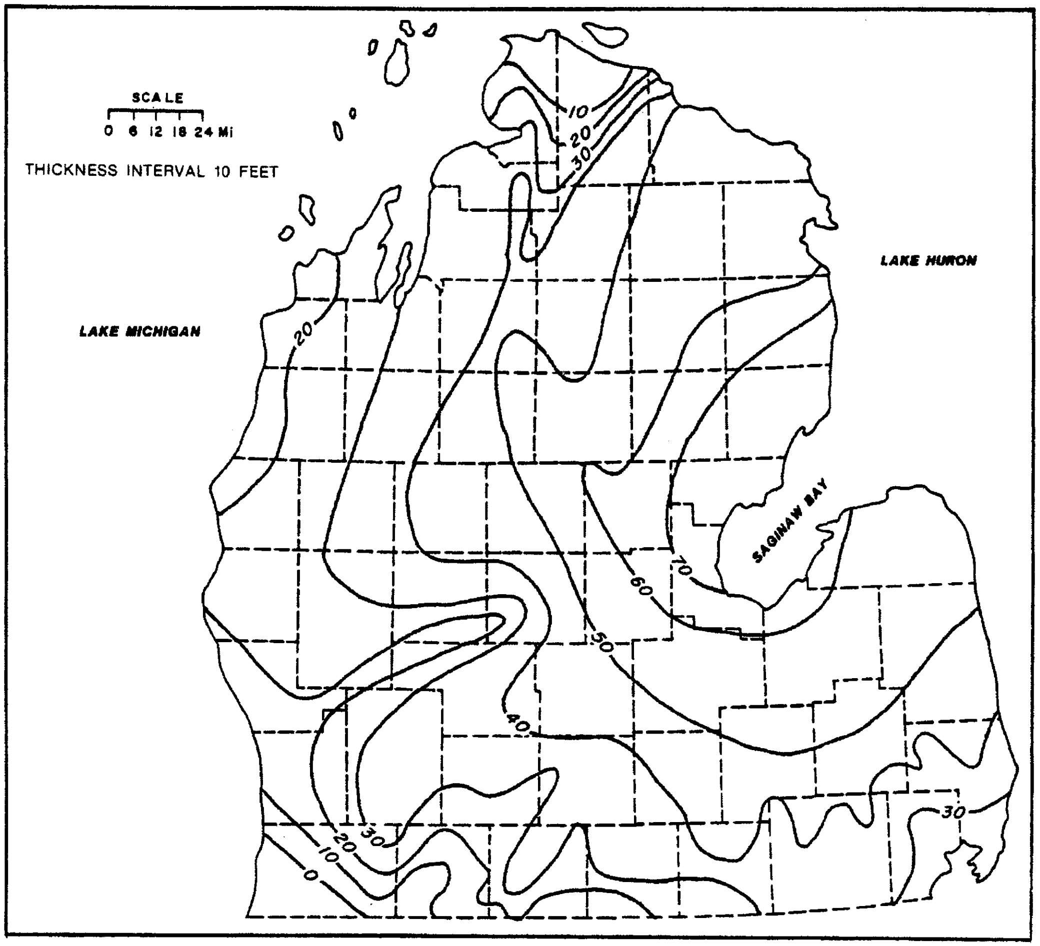

Figure 2.25. Thickness of Salina D Evaporite. (From Dali, 1975.)

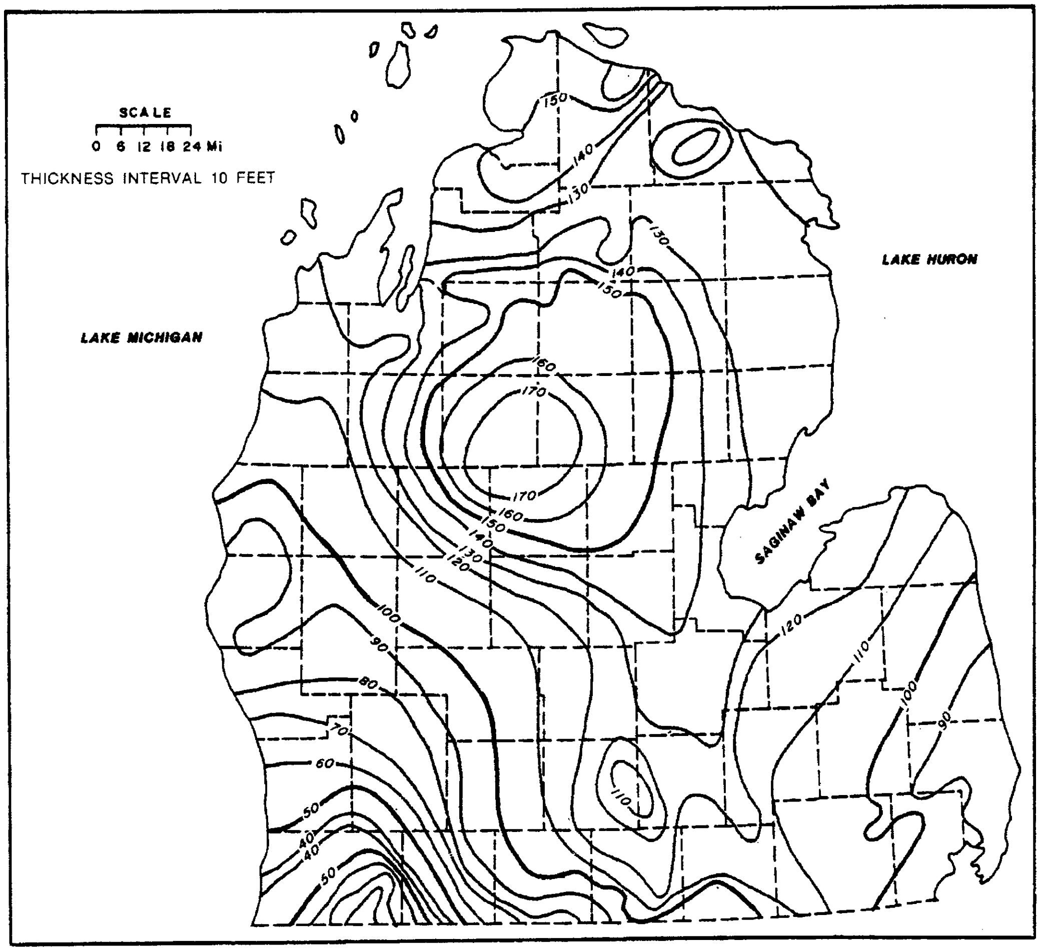

Figure 2.26. Thickness of Salina E Unit. (From Dali, 1975.)

Characteristics as an Aquifer. The E-Unit is not an aquifer.

Characteristics as a Confining Layer. Shales and anhydrite beds in the E-Unit should form a barrier to the migration of fluids. In the central portions of the basin the dolomite beds are most likely salt plugged and also form aquicludes. In areas marginal to salt development, the dolomite beds may permit vertical migration of fluids.

Characteristics as an Injection Formation. Generally unsuitable.

Porosity. Effective porosity of this unit is very low, especially in areas where salt plugging occurs. Marginal to the areas of salt development, the dolomite beds may contain some effective void space. Shales in this unit contain a high ineffective porosity associated with clay minerals.

Permeability. Where salts are developed in the Salina permeability is very low. Marginal to the area of salt development, the dolomite beds are probably permeable.

Oil and Gas Potential. Very low.

F-Unit

The Salina F-Unit comprises a sequence of salt (NaCl) beds with intervening shales and dolomite beds. The top of the unit is generally picked at the top of a buff, fine-grained, anhydritic dolomite. The unit thickens from less than 100 feet on the southwest margin of the basin to over 900 feet at the center of the basin (fig. 2.27). Around the northern margin of the Southern Peninsula the salts are absent and the F-Unit is composed mostly of shale. Southward across the state shale is of diminishing importance in this unit. Shales in the F and G Units probably correlate with the Point aux Chenes Shale in the Salina outcrop belt of the eastern Northern Peninsula.

Characteristics as an Aquifer. The F-Unit is not an aquifer.

Characteristics as a Confining Layer. In the basinal area where salts are present in this unit, and along the northern margin of the Northern Peninsula where the F-Unit is mostly salt, it is an aquiclude. South of the area of salt development the Salina does not contain thick shales and its value as a confining layer is probably minimal.

Characteristics as an Injection Formation. Generally unsuitable.

Porosity. The effective porosity of this unit is very low. Where shales are present, they contain porosity associated with clay minerals.

Permeability. Extremely slow.

Oil and Gas Potential. Extremely low.

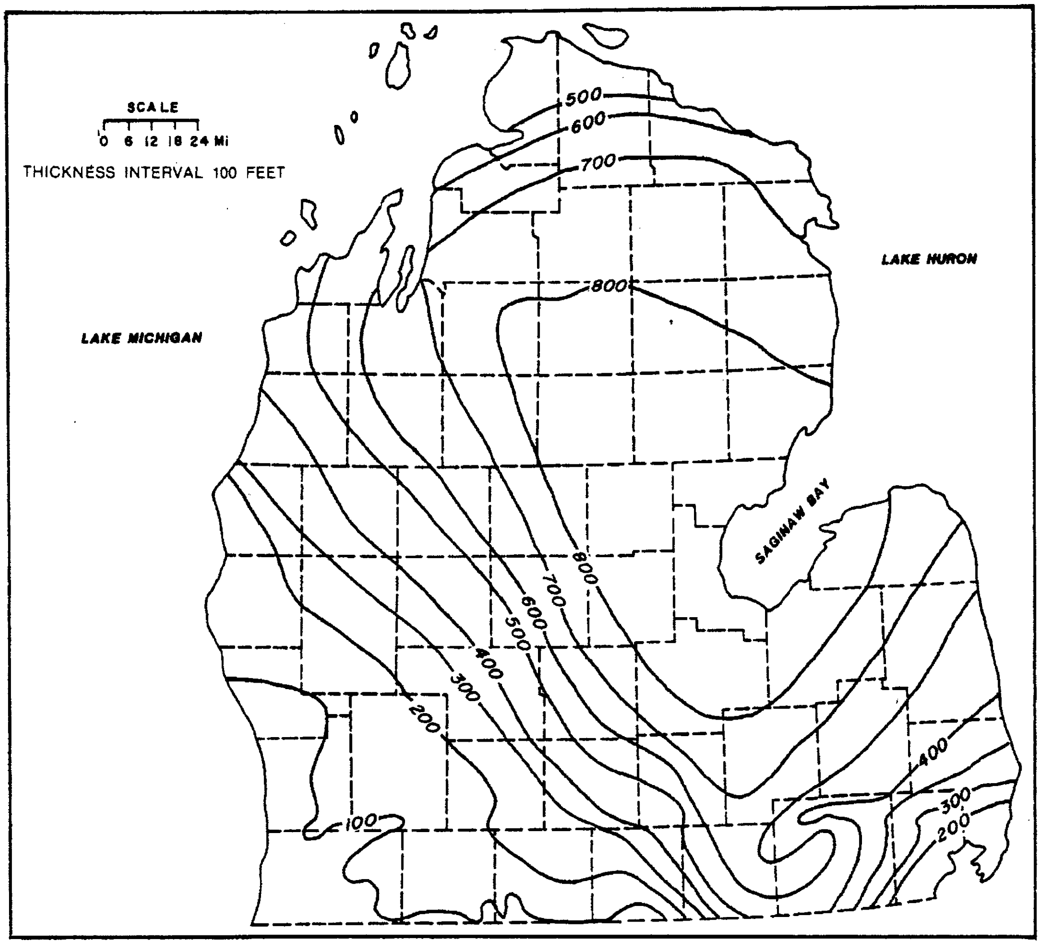

Figure 2.27. Thickness of Salina F Evaporite. (From Dali, 1975.)

G-Unit

The Salina G-Unit is a sequence of dolomitic and anhydritic shales that range in thickness from a zero edge in southern Michigan to more than 100 feet in the northeastern quadrant of the Southern Peninsula (fig. 2.28). This unit is probably correlative with the upper part of the Point aux Chense Shale in the Salina outcrop belt of the eastern Northern Peninsula.

Characteristics as an Aquifer. The G-Unit is not an aquifer.

Characteristics as a Confining Layer. In those portions of the Southern Peninsula where the shales of the G-Unit are more than 40 feet thick it is probably an aquiclude. Marginal to this area (fig. 2.28) its value as a confining layer is probably minimal.

Characterisitcs as an Injection Formation. Generally unsuitable.

Porosity. The effective porosity of the G-Unit is very low.

Permeability. Extremely slow.

Oil and Gas Potential. Extremely low.

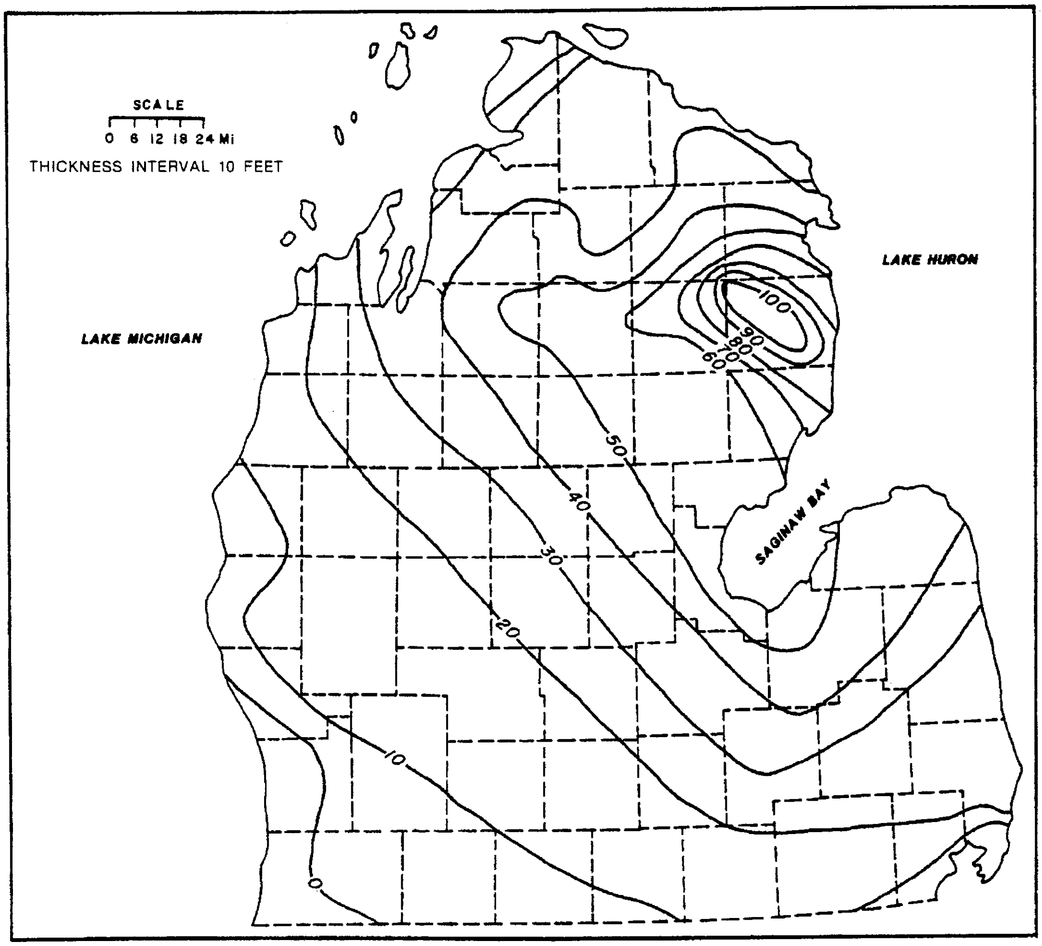

Figure 2.28. Thickness of Salina G Unit. (From Dali, 1975.)

UPPER SILURIAN

The Pointe aux Chenes Shales and the St. Ignace Dolomite comprise the Upper Silurian at outcrop in the eastern Northern Peninsula of Michigan.

Pointe aux Chenes Shale

The Pointe aux Chenes Shale consists of green and red shales, thin beds of dolomite, and small irregular masses and thin seams of gypsum. It is thought to be the equivalent of shales in the F-Unit and G-Units of the subsurface Salina Group. It is likely that it is the lateral equivalent to the shales that exist throughout the column from the B-Unit through the G-Unit.

Characteristics as an Aquifer. The Pointe aux Chenes Shale is not an aquifer.

Characteristics as a Confining Layer. The soft, non-resistant nature of this shale coupled with the presence of gypsum suggests that it is an aquiclude.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Effective porosity is very low. The rock has some porosity associated with clay minerals.

Permeability. Very low.

Oil and Gas Potential. None.

St. Ignace Dolomite

Although placed in the Salina Group by Ehlers and Kessling (1957), the stratigraphic position and lithologic characteristics of this unit clearly suggest that it is the lateral equivalent of the Bass Islands Group. Very likely these rocks are genetically related to rocks of the Salina Group in the same manner that rocks of the Bass Islands Group are related to lithologies in the Salina in more central portions of the Michigan Basin.

The St. Ignace is composed of a evenly bedded dolomite, some of which contains silt-like openings that probably resulted from the solution of anhydrite crystals. Beds of shale ranging from a few inches to a few feet thick are an inconspicuous part of the formation. The upper part of the St. Ignace consists of thick-bedded dolomites that are locally oolitic. Frosted quartz grains are present throughout the formation, but are larger and more abundant near the top.

Characteristics as an Aquifer. Possible source of drinking water on Bois Blanc and Round Islands.

Characteristics as a Confining Layer. Unsuitable.

Porosity. Solution porosity.

Permeability. Solution permeability.

Oil and Gas Potential. None.

Bass Islands Group

At the type sections on the Bass Islands of Western Lake Erie and the outcrop belt in southeastern Michigan, this sequence of dolomites has been subdivided into a number of formations. In the Michigan subsurface it is "lumped" together and referred to as the "Bass Islands". The Bass Islands is a thick sequence of fine-grained dolomites that are characterized by "floating" anhydrite and celestite crystals. In the central portions of Michigan Basin, the Bass Islands contain salt beds, and has been considered an upward continuation of the Salina (Landes, 1945). In the center of the basin, the group exceeds 700 feet in thickness (fig. 2.29).

Characteristics as an Aquifer. Unknown.

Characteristics as a Confining Layer. The Bass Islands should serve as a confining unit throughout much of the Southern Peninsula.

Characteristics as an Injection Formation. Unknown.

Porosity and Permeability. Around the margins of the Michigan Basin the Bass Islands Group has been affected by dissolution and the porosity and permeability greatly increased. Leaching of the relatively soluble anhydrite crystal laths is readily apparent in wells that penetrate these rocks in the northernmost part of the Lower Peninsula. Down dip from this leached zone, dolomites of the Bass Islands are much less soluble and in the area of salt development this unit is only slowly permeable.

DEVONIAN

LOWER DEVONIAN

Garden Island Formation

The Garden Island Formation is known only from isolated patches in the northern part of the Lower Peninsula and at the type section on Garden Island. At the type locality only three feet of dolomitic sandstone, dolomite with frosted sand grains, and hard dolomite with chert nodules is exposed above lake level (Ehler, 1945, p. 73-80).

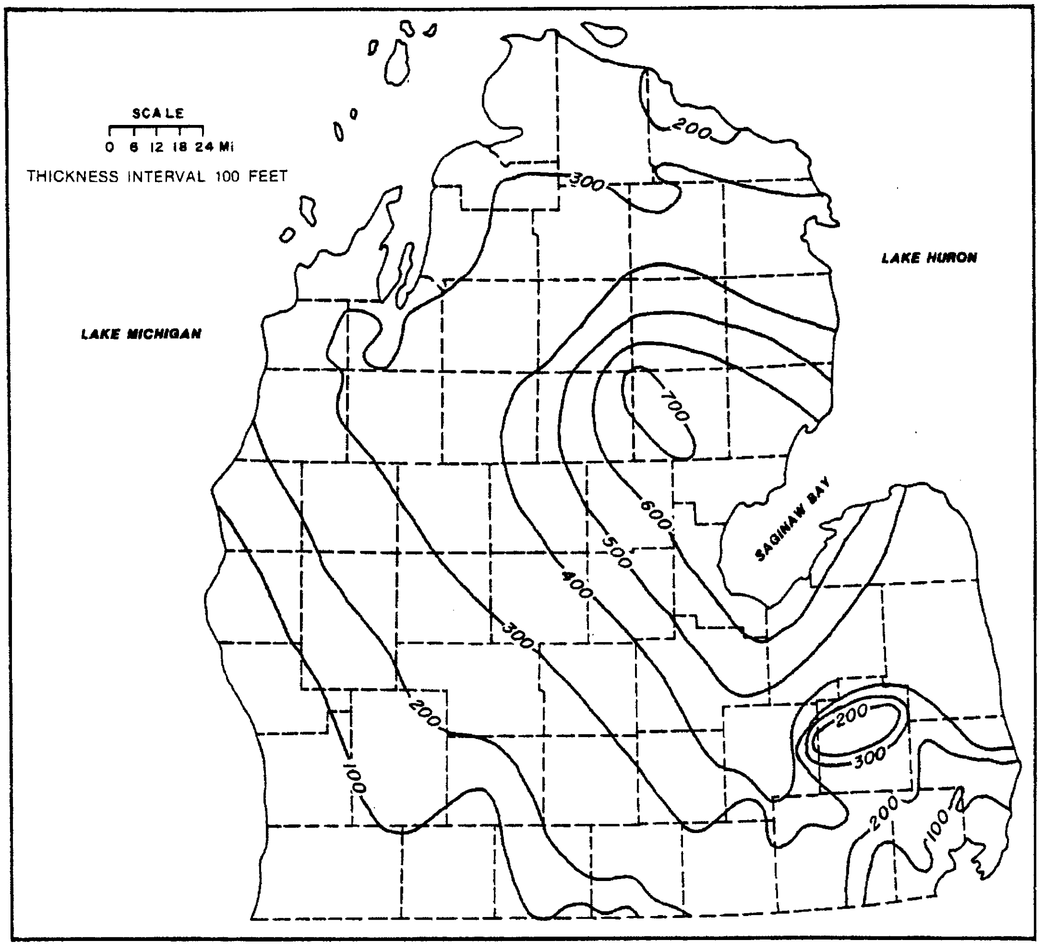

Figure 2.29. Thickness of Bass Islands Group. (After Dali, 1975.)

Characteristics as an Aquifer. Unknown.

Characteristics as a Confining Layer. Unknown. Discontinuous nature of the unit coupled with the presence of sandstone and dolomite do not recommend it as a confining layer.

Characteristics as an Injection Formation. Discontinuous nature of the Garden Island Formation suggests that it would be an inadequate injection formation.

Porosity and Permeability. Unknown.

MIDDLE DEVONIAN

Bois Blanc Formation

From its truncated margin at outcrop in the area of Mackinac Straits the Bois Blanc Formation increases to a maximum thickness of more than 600 feet in Arenac and Gladwin Counties (Cohee, et al., 1951) (fig. 2.30, pls. 5, 6 and 11). The basal 75 feet of the unit is dolomite with interbeds of chert and is overlain by about 200-300 feet of very cherty dolomite and limestone. The upper 75 feet of the unit is fossiliferous limestone.

Characteristics as an Aquifer. The Bois Blanc is not used as an aquifer. In and near the outcrop area it has been leached and could be used as a source of water in the area near the Straits of Mackinac. Proximity of the outcrop area to Lake Michigan and the availability of water in the glacial aquifer have made the use of this aquifer unnecessary to date.

Characteristics as a Confining Layer. Away from the outcrop area the Bois Blanc is very dense and should form a barrier to the movement of fluids. The cherty dolomites are likely to be quite brittle and may have some fracture porosity and permeability. The unit was involved in the subsidence that produced the Mackinac Breccia, and it is very likely highly fractured in the area where this process has occurred (pl. 18).

Characteristics as an Injection Formation. The Bois Blanc Formation is unsuitable for use as an injection formation.

Porosity. Very low.

Permeability. Unknown. Fracture porosity may be present.

Oil and Gas Potential. Low.

Sylvania Sandstone

The Sylvania Sandstone is composed of well-rounded and sorted, fine (0.18 mm) to medium (0.40 mm) grained quartz grains notably free of clay. The sandstone overlies dolomites of the Bass Islands Group with distinct

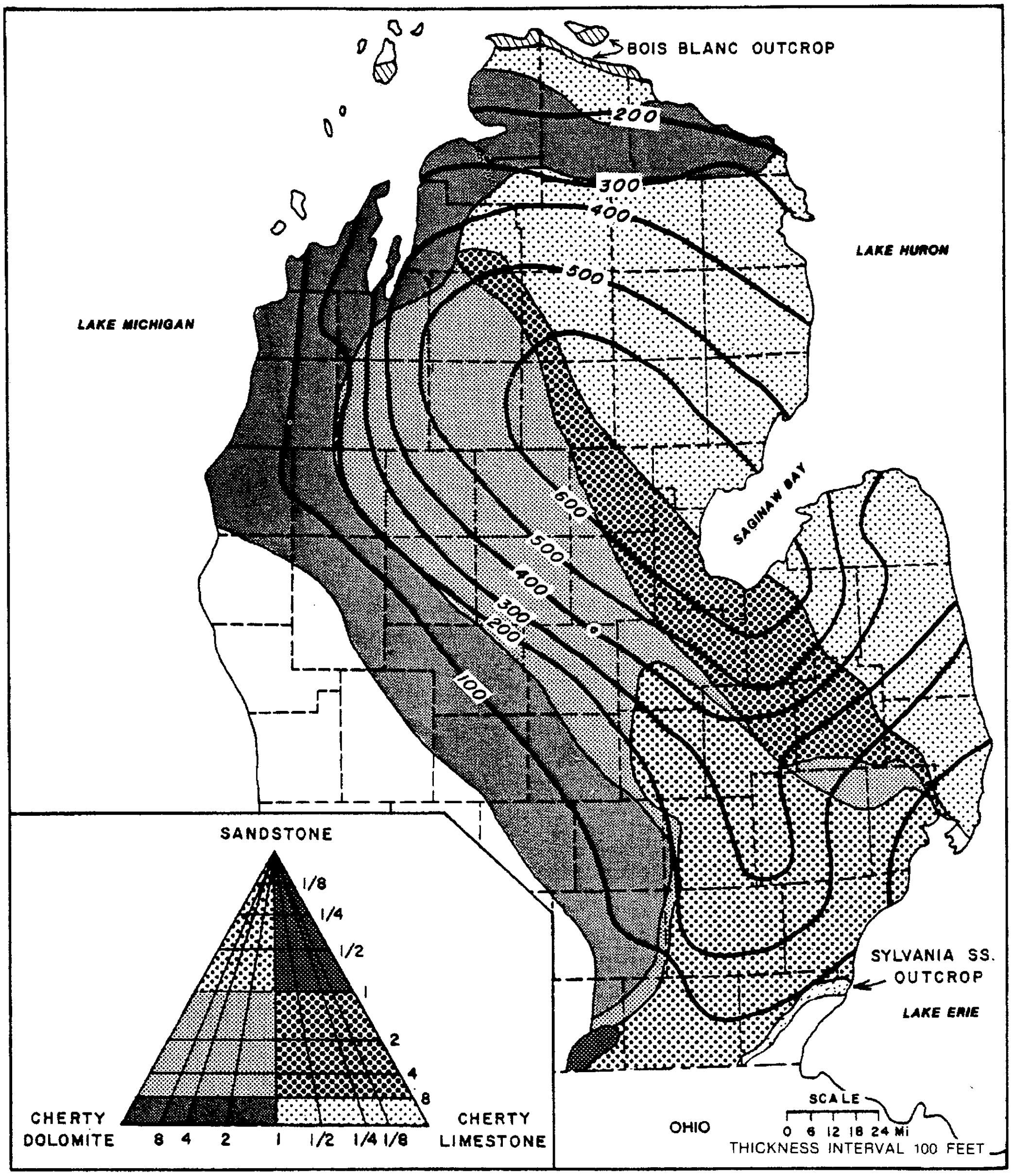

Figure 2.30. Thickness-lithofacies map of Bois Blanc-Sylvania. (From Gardner, 1974.)

disconformity along the northern margin of its development in northern Ohio and southeastern Michigan. To the north where the Bois Blanc Formation is the basal unit of the Middle Devonian, the Sylvania Sandstone interfingers with cherty carbonates. Contact with the overlying Detroit River beds is transitional from sandstone to dolomitic sandstone to sandy dolomite to dolomite. To the northwest in Wexford, Grand Traverse, Missaukee and Kalkaska Counties, the Sylvania contains thick deposits of tripolitic (de-vitrified) chert with amber dolomite rhombohedrons. The Sylvania outcrops in southeastern Michigan and ranges in thickness from a zero edge in southern Michigan to more than 500 feet in the central part of the Michigan Basin (fig. 2.30).

Characteristics as an Aquifer. In and near the outcrop area where it has been flushed the Sylvania Sandstone is a good aquifer, but because it is overlain by glacial lake beds, composed of silt and clay, water in it commonly contains methane and hydrogen sulfide.

Characteristics as a Confining Layer. The Sylvania is far too permeable to be a confining layer.

Characteristics as an Injection Formation. In areas where the Sylvania is overlain by the anhydrite of the Detroit River, it is a potential injection formation and has been used for both chemical and brine disposal. Care should be taken to avoid areas near the outcrop as the overlying carbonate section may have fracture permeability.

Porosity. High effective porosity exists away from the upper transition with the Detroit River and southwest of the area where the Sylvania and Bois Blanc interfinger.

Permeability. Permeability is very high in those portions of the unit that are free of carbonate and chert cement (see above).

Potential for Oil, Gas and Brine Production. No oil or gas fields have been developed in the Sylvania. It is used extensively as a source of brine especially in the vicinity of Midland County.

Amherstburg

The Amherstburg is a dark brown to black, carbonaceous limestone throughout most of the basin, but around the southern and western margins of the Southern Peninsula it has been dolomitized. The informal name "Black Limestone" has been in use for many years as a driller's term. The lithology is very distinctive in the central-basin area, and was used as a marker at which to bottom exploratory tests into the Richfield zone of the Detroit River. The unit is poorly bedded, dense, and ranges in thickness from a zero edge in southwestern Michigan to more than 300 feet in the area of Saginaw Bay (fig. 2.31).

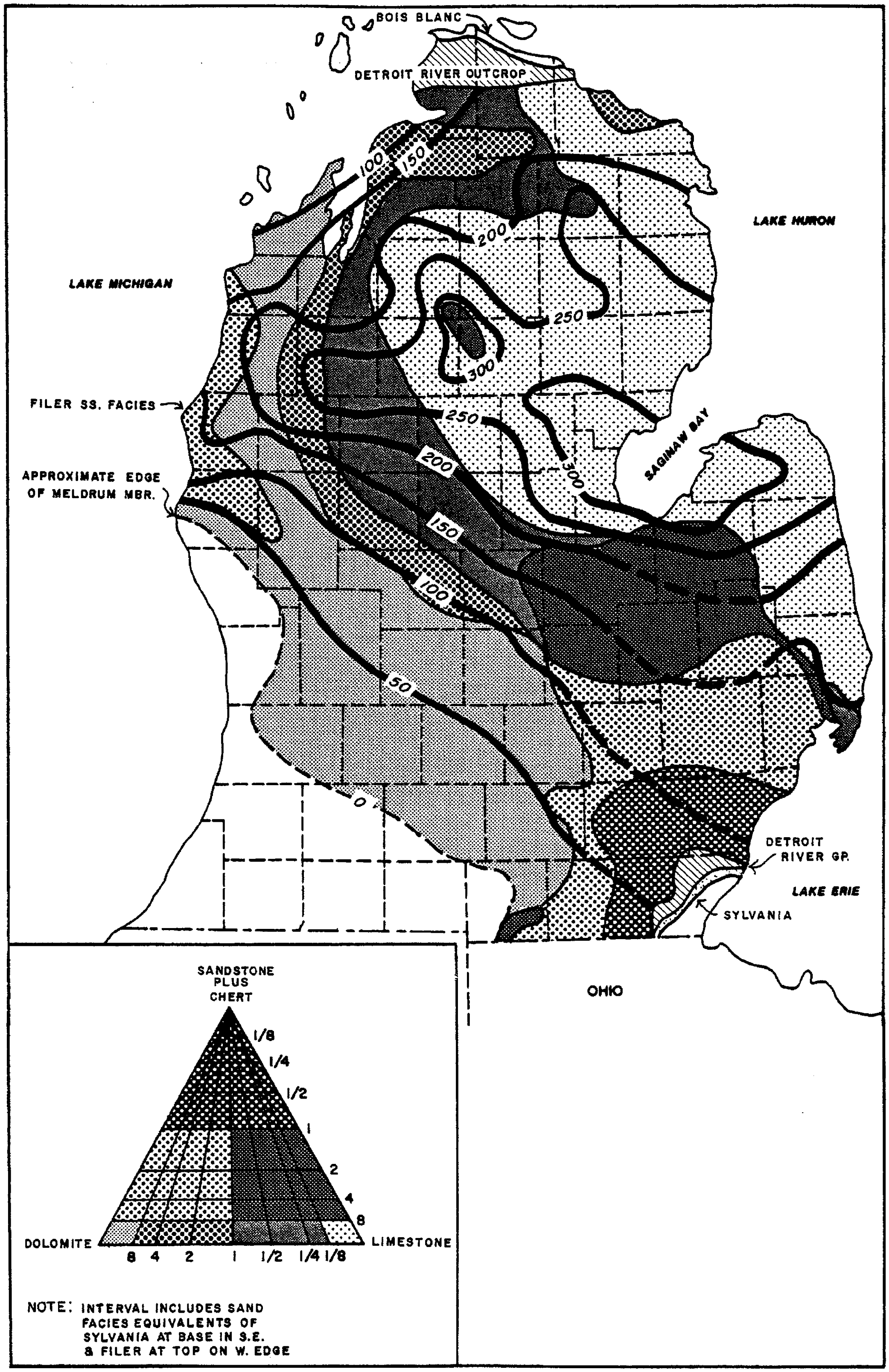

Figure 2.31. Thickness-lithofacies map of Meldrum Member of Amherstburg Formation. (From Gardner, 1974.)

Characteristics as an Aquifer. The Amherstburg is not an aquifer.

Characteristics as a Confining Layer. Except where dolomitized, the Amherstburg is an aquiclude and could be used as a confining layer, in the central portion of the Michigan Basin.

Porosity. The effective porosity of the Amherstburg is low where it is dolomite and very low where it is limestone.

Permeability. The Amherstburg has very low permeability where it is dolomite and is virtually impermeable in those areas where it is a limestone.

Oil and Gas Potential. Very low.

Filer Sandstone Member

The Filer Sandstone is best developed along the western margin of the Southern Peninsula in the area of Manistee. The Filer is a fine to medium grained, quartz sandstone that appears to have been deposited as coastal dunes. Local lenticular sandstone bodies in the central part of the basin appear to be roughly correlative with this unit, and one such unit has been named the Freer Sandstone after a well that penetrated it.

Characteristics as an Aquifer. The Filer Sandstone has excellent aquifer characteristics, but it contains brine.

Characteristics as a Confining Layer. The Filer is far too porous and permeable to be used as a confining layer.

Characteristics as an Injection Formation. The Filer has excellent injection formation characteristics and is used as an injection formation in Michigan.

Porosity. The formation has up to 25 percent effective porosity.

Permeability. Very high.

Oil, Gas and Brine Potential. The Filer has been explored for oil and gas, but to date no sustained production has been developed. The Freer Sandstone had a "one-well" field developed in it. The Filer is a source of brine in the Manistee area.

Detroit River

Although the Bois Blanc Formation, Sylvania Sandstone, Amherstburg (Black Limestone), Lucas and Anderdon Formations have been included in the Detroit River Group, general practice is to call that portion of the column between the Amherstburg (Black Limestone) and the Dundee Limestone the "Detroit River," although it has been named the Lucas Formation. This suite of rocks is quite complex and contains a wide variety of lithologies including sandstone, limestone, dolomite, anhydrite (or gypsum) and halite (figs. to). The Basal unit of the "Detroit River" is the "Richfield zone" or more properly the Richfield Member.

Richfield Zone

The Richfield zone is a sequence of interbedded limestone, dolomite, and anhydrite with minor amounts of sand in the central portion of the basin and a relatively thick sand body, the Filer Sandstone, along the western margin of the Lower Peninsula (fig. 2.32). The limestone beds are dense micrites and contrast with the dolomites which are lighter in color and more permeable. The anhydrite beds have mosaic textures and generally overlie the dolomitized units.

Characteristics as an Aquifer. The Richfield zone is not an aquifer.

Characteristics as a Confining Layer. The anhydrites of the Richfield zone are excellent confining layers. The fact that several of the dolomite zones produce oil attests to the impervious nature of the interbedded anhydrites.

Characteristics as an Injection Formation. The Richfield contains too little permeable rock to be an injection formation.

Porosity. The dolomite zones in the Richfield are slightly porous, but the limestones and anhydrite beds essentially lack porosity.

Permeability. The limestone and anhydrite beds are virtually impermeable. The dolomite units have permeabilities that range from 4.0 to 6.5 milli-darcys.

Oil and Gas Potential. The Richfield has produced oil and gas from several fields in Michigan since the early 1940's.

Massive Anhydrite

The driller's term "Massive Anhydrite" has been traditionally applied to a thick (75-100 feet) anhydrite bed that overlies the Richfield Zone (fig. 2.33). The unit is widespread in the central portions of the basin and thins toward the basin margins. It is best developed in the north-central part of the Southern Peninsula.

Characteristics as an Aquifer. The Massive Anhydrite is not an aquifer.

Characteristics as a Confining Layer. The Massive Anhydrite is essentially impermeable and an excellent confining unit.

Characteristics as an Injection Formation. None.

Porosity. Extremely low.

Permeability. Extremely low to essentially impermeable.

Oil and Gas Potential. None.

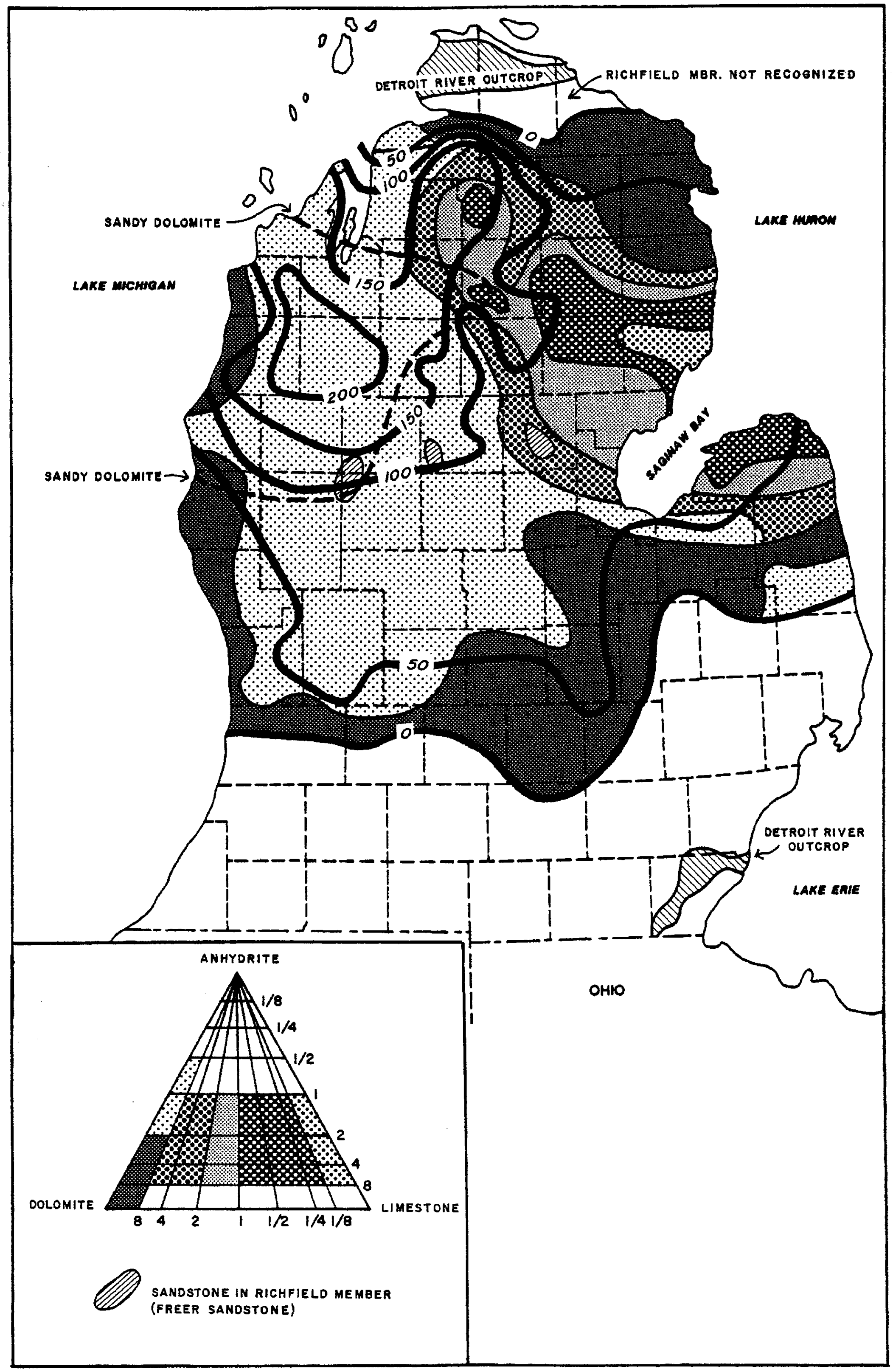

Figure 2.32. Thickness-lithofacies map of Richfield Member of Lucas Formation. (From Gardner, 1974.)

ATTACHMENT B-3

Sensitive Areas (Flood Plains, Endangered Species, Historical and Archeological Areas, Soil Types)

IPaC Information for Planning and Consultation **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Ottawa County, Michigan

Local office

Michigan Ecological Services Field Office

(517) 351-2555
(517) 351-1443

2651 Coolidge Road Suite 101
East Lansing, MI 48823-6360

http://www.fws.gov/midwest/endangered/section7/s7process/step1.html

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species

[1] and their critical habitats are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service (USFWS) and the fisheries division of the National Oceanic and Atmospheric Administration (NOAA Fisheries[2]).

Species and critical habitats under the sole responsibility of NOAA Fisheries are **not** shown on this list. Please contact NOAA Fisheries for species under their jurisdiction.

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1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.
2. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Indiana Bat Myotis sodalis There is **final** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/5949	Endangered
Northern Long-eared Bat Myotis septentrionalis No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9045	Threatened

Birds

NAME	STATUS
Piping Plover Charadrius melodus There is **final** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/6039	Endangered
Red Knot Calidris canutus rufa This species only needs to be considered if the following condition applies: • Only actions that occur along coastal areas during the Red Knot migratory window of MAY 1 - SEPTEMBER 30. No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/1864	Threatened
Whooping Crane Grus americana No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/758	EXPN

Reptiles

NAME	STATUS
Eastern Massasauga (=rattlesnake) Sistrurus catenatus This species only needs to be considered if the following condition applies: • All Projects: Project is Within EMR Range No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/2202	Threatened

Clams

NAME	STATUS
Snuffbox Mussel Epioblasma triquetra No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/4135	Endangered

Flowering Plants

NAME	STATUS
Pitcher's Thistle Cirsium pitcheri No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/8153	Threatened

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act

[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)
American Golden-plover *Pluvialis dominica* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Dec 1 to Aug 31
Black-billed Cuckoo *Coccyzus erythropthalmus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9399	Breeds May 15 to Oct 10

Eastern Whip-poor-will *Antrostomus vociferus* — Breeds May 1 to Aug 20

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Red-headed Woodpecker *Melanerpes erythrocephalus* — Breeds May 10 to Sep 10

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Rusty Blackbird *Euphagus carolinus* — Breeds elsewhere

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Willow Flycatcher *Empidonax traillii* — Breeds May 20 to Aug 31

This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA
https://ecos.fws.gov/ecp/species/3482

Wood Thrush *Hylocichla mustelina* — Breeds May 10 to Aug 31

This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ “Proper Interpretation and Use of Your Migratory Bird Report” before using or attempting to interpret this report.

Probability of Presence ( )

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.

3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

Breeding Season (■)

Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)

Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

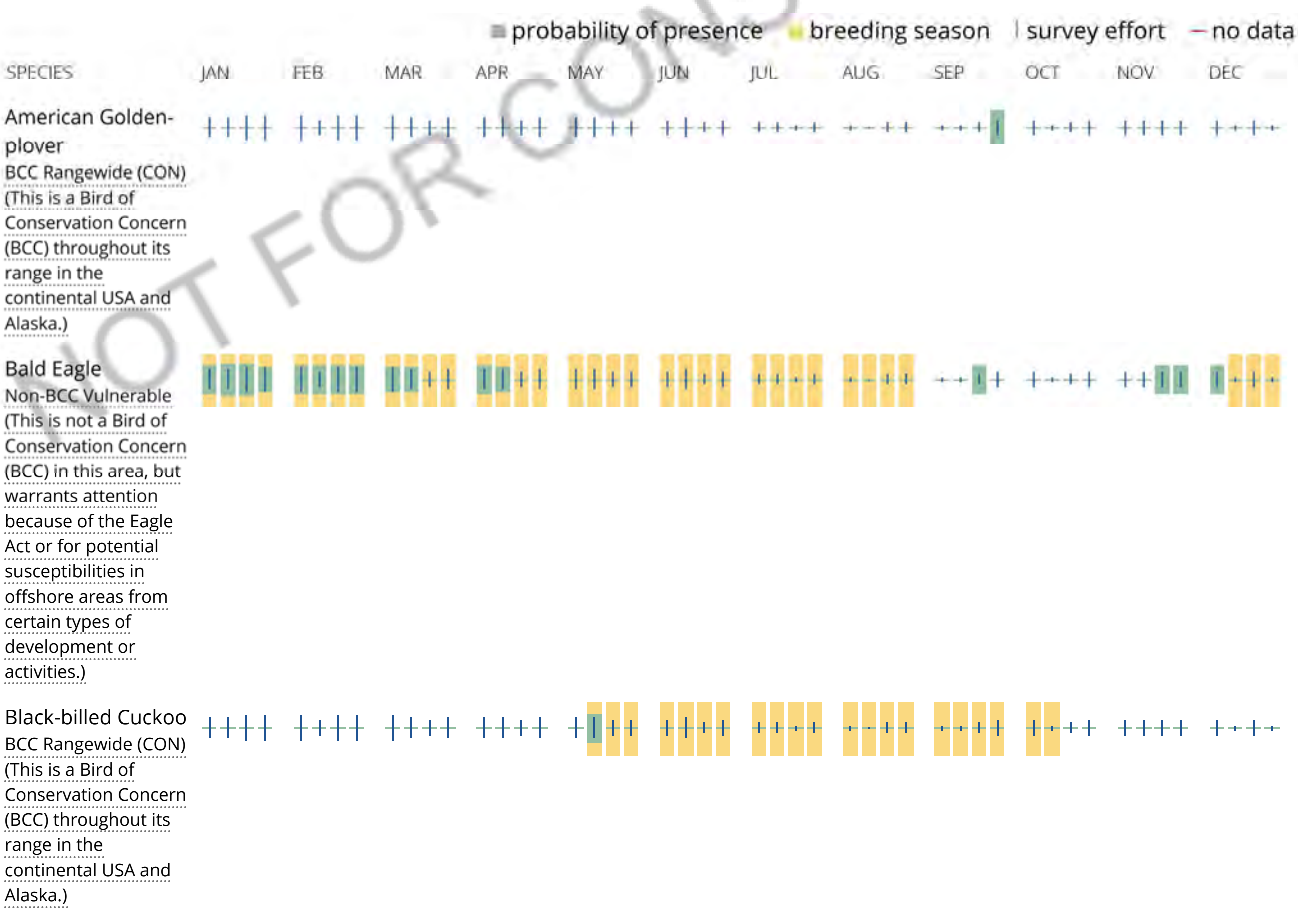
To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)

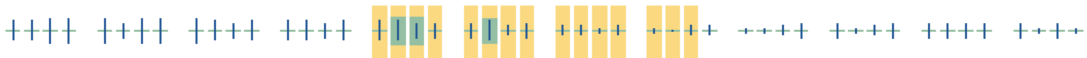
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe

Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

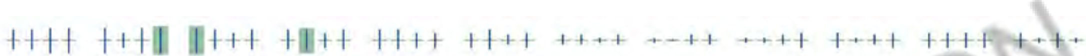


Eastern Whip-poor-will
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



Red-headed Woodpecker
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Rusty Blackbird
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



Willow Flycatcher
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Wood Thrush
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the AKN Phenology Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially *occurring in my specified* location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

THERE ARE NO FISH HATCHERIES AT THIS LOCATION.

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

THERE ARE NO KNOWN WETLANDS AT THIS LOCATION.

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters. Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

TECHNICAL MEMORANDUM

DATE April 28, 2020 **Project No.** 19132873

TO Consumers Energy Corporation

CC Keith Tollenaere and Brian Huebner (Golder)

FROM Chris Tinti (Golder) **EMAIL ctinti@golder.com**

PHASE IA CULTURAL RESOURCE REVIEW FOR THE J.H. CAMPELL LANDFILL CELL 6 PROJECT IN OTTAWA COUNTY, MICHIGAN

1.0 INTRODUCTION

Golder Associates Inc. (Golder) on behalf of Consumers Energy Corporation (Consumers) completed a Phase IA cultural resource review to assist with site planning for the J.H. Campbell Landfill Cell 6 project. The proposed project is located in the SE ¼ of Section 10 in Township 6N, Range 16W within the Consumers J.H. Campbell power generation facility in Ottawa County, Michigan (Figure 1).

2.0 AREA OF POTENTIAL EFFECT

The direct area of potential effect (APE) consists of a rectangular 32.7-arce parcel within the Consumers J.H. Campbell generating complex. The built environment of the direct APE was cleared of native vegetation and consists of access roads, storage yards, a distribution line, and small stands of timber. The indirect APE consists of a half-mile radius centered on the direct APE. The indirect APE is composed of retention ponds, transmission lines, distribution lines, a substation, the J.H. Campbell generating complex, forested areas, and unimproved access roads (Figure 2).

3.0 BACKGROUND REVIEW

Golder performed a background literature review to determine if the project area had been surveyed for cultural resources or if any known cultural resources were located within the project area. To conduct this review, Golder contacted the Michigan State Historic Preservation Office (SHPO) on April 14, 2020 and provided the staff with a map of the proposed project location. The SHPO staff compared the direct and indirect APE to their internal records and provided the results of the background review to Golder. Golder also examined aerial photographs, the National Register of Historic Places (NRHP) database, General Land Office maps, and historical USGS topographic maps. These sources provided information on the nature and location of known cultural resource sites and the potential for undocumented sites within the proposed project area.

4.0 RESULTS

The background literature review indicated one cultural resource investigation (ER-920292) occurred in the direct APE and one additional investigation (ER-00-7.06.050661) occurred in the indirect APE. Investigation ER-920292 was conducted in 1993 by Commonwealth Cultural Resources Group for the J.H. Campbell Ash Pond Expansion and 345 kV transmission line relocation project. The investigation examined 130 acers in Sections 10, 11, and 14 in Township 6N, Range 16W and visited two cultural resource sites. This investigation covered the entire direct APE and portions of the indirect APE.

Investigation ER-00-7.06.050661 was conducted in 2006 by Archaeological Consultants of Ossian for a G2 cellular tower. The investigation examined 0.06 acres in Section 10 in Township 6N, Range 16W and no cultural resource were recorded or visited. This investigation is located in the half-mile indirect APE.

The background review further indicates that no cultural resources are located in the direct APE and two cultural resources (20OT202 and 20OT203) are located in the half-mile indirect APE. Site 20OT202 is located in Section 14 in Township 6N, Range 16W and is last described as an Allegan phase winter camp that dates from AD 600 to 1000. The site has been determined eligible for the NRHP by the Michigan SHPO. The site is approximately 0.46 miles southeast of the direct APE.

Site 20OT203 is located in Section 14 in Township 6N, Range 16W and consisted of a sparse lithic scatter that was initially surface collected. An attempt to locate the site was made by Commonwealth Cultural Resources Group in 1993 but the site could not be located. The site has been determined not eligible for the NRHP by the Michigan SHPO. The site is approximately 0.45 miles southeast of the direct APE.

5.0 RECOMMENDATIONS

The Phase IA cultural resource records review indicates no cultural resources are located in the direct APE and two cultural resources are located in the indirect APE. Based on these findings, Golder recommends that no cultural resources will be impacted within the direct APE of the proposed project. Furthermore, Golder recommends that no known cultural resources within the half-mile indirect APE will be adversely impacted.

6.0 CLOSING

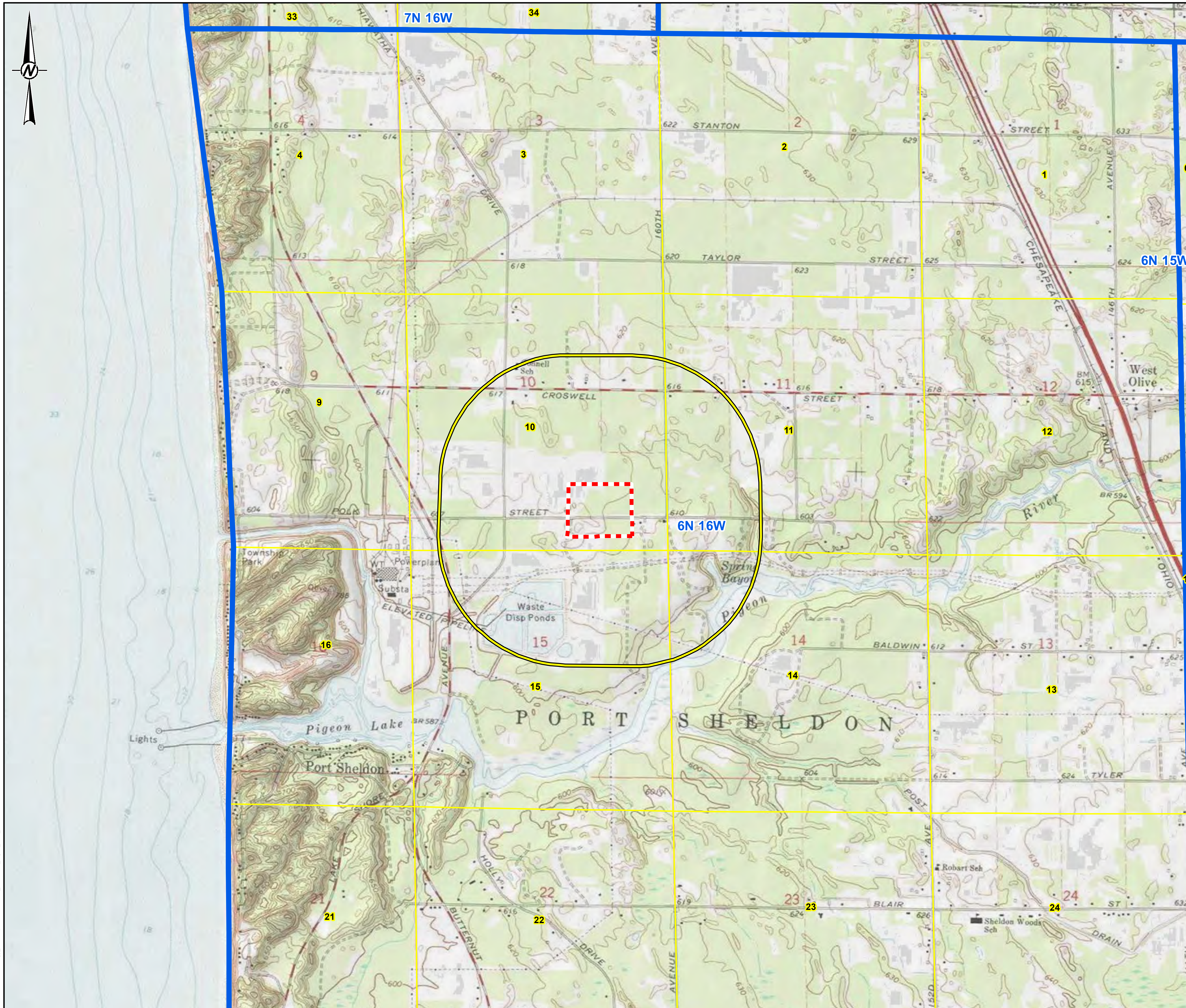
Golder is pleased to complete this Phase IA cultural resource records review for Consumers. Please feel free to contact the undersigned at 920-370-4966 or ctinti@golder.com if you have any questions about this review.

Sincerely,

GOLDER ASSOCIATES INC.

Chris Tinti, M.A. RPA
Project Archaeologist

Figures



LEGEND

- DIRECT APE
- INDIRECT APE
- SECTION
- TOWNSHIP/RANGE

0 1,000 2,000 4,000 Feet

REFERENCE

1. TOPOGRAPHIC BACKGROUND: ESRI BASEMAP SERVICES. USGS 1:24,000 TOPOGRAPHIC QUADRANGLES SHOWN: PORT SHELDON.

CLIENT
CONSUMERS ENERGY

PROJECT
JHC AIRSPACE AND CELL 6
CONSTRUCTION PERMIT APPLICATION

TITLE
SITE LOCATION MAP
USGS TOPOGRAPHIC MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-27
PREPARED	RHG
DESIGN	RHG
REVIEW	BJH
APPROVED	TJ

PROJECT No.
19132873

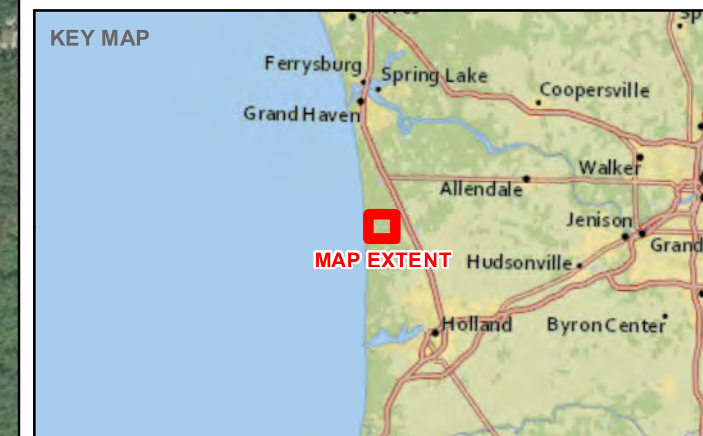
FIGURE
1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

LEGEND

DIRECT APE

INDIRECT APE



0 500 1,000 2,000 Feet

REFERENCE

1. AERIAL IMAGERY: ESRI PROVIDED BASEMAP, VIVID, MAXAR. IMAGERY FLOWN ON 8/22/2018.
2. STREAMS DATASET: NATIONAL HYDROGRAPHY DATASET (NHD), USGS.

CLIENT
CONSUMERS ENERGY

PROJECT
JHC AIRSPACE AND CELL 6
CONSTRUCTION PERMIT APPLICATION

TITLE
SITE LOCATION MAP
AERIAL IMAGERY

CONSULTANT

GOLDER

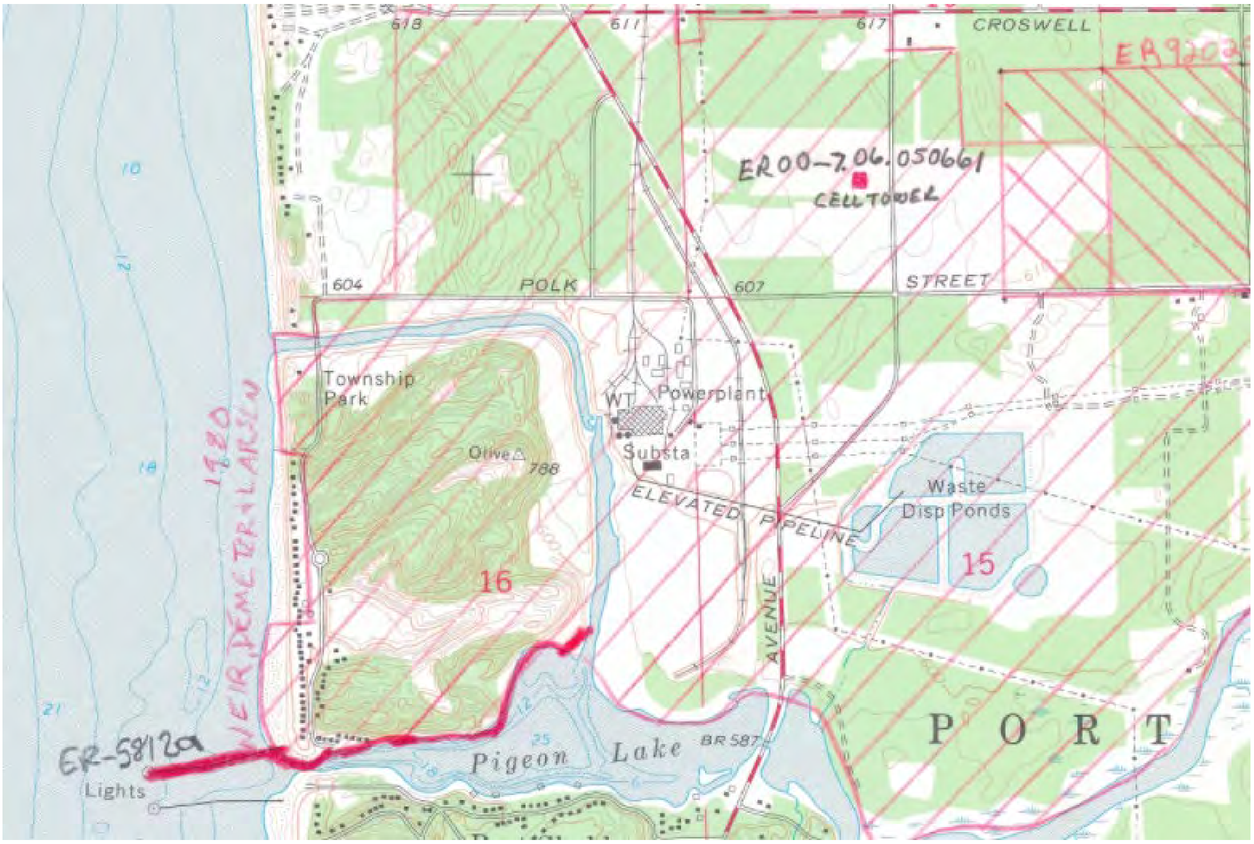
YYYY-MM-DD	2020-04-27
PREPARED	RHG
DESIGN	RHG
REVIEW	BJH
APPROVED	TJ

PROJECT No.
19132873

FIGURE
2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Sch
10
11
616
617
611
CROSWELL
STREET
ER920292 1993
ER00-7.06.050661
CELLTOWER
607
STREET
610
603
0T203
0T202
Spring
Bayou
Pigeon
WT
Powerplant
Substa
Waste
Disp Ponds
ELEVATED PIPELINE
15
14
AVENUE
Lake
BR 587
P O R T S H E L D O N
604



618
611
617
CROSWELL
ER00-7.06.050661
CELLTOWER
604
POLK
607
STREET
Township
Park
WT
Powerplant
Substa
Olive
788
ELEVATED PIPELINE
Waste
Disp Ponds
AVENUE
16
15
1980
WEIR, DEMETER + LARSEN
ER-58120
Lights
Pigeon Lake
BR 587
P O R T

PROJECT BIBLIOGRAPHY REPORT

PROJECT DETAILS

Project ID	ER-920292
Project Name	J. H. Campbell Landfill, Port Sheldon Twp.

PROJECT BIBLIOGRAPHY RECORDS

	Bibkey
Citation: Andrews, Wesley L., C. Stephan Demeter and Mary L. Jeakle. 1993. Phase I Archaeological Survey of the Proposed Campbell Ash Pond Expansion and 345 kV Line Relocation, Holland, Michigan. R-0126. Commonwealth Cultural Resources Group, Inc. **Notes**: The proposed work required survey of 130 acres in Sections 10,11 and 14, T6N R16W, Ottawa County. The transmission line is being rerouted to avoid site 20OT202, an Allegan phase Late Woodland winter camp. Site 20OT203, a previously recorded disturbed scatter, could not be relocated, but its reported location will also be avoided.	01840

PROJECT BIBLIOGRAPHY REPORT

PROJECT DETAILS

Project ID	ER00-7.06.050661
Project Name	G2 Cellular Tower Site Review #050661

PROJECT BIBLIOGRAPHY RECORDS

	Bibkey
Citation: Stillwell, Larry N. 2006. An Archaeological Field Reconnaissance of a Proposed Cellular Phone Tower (Project #050661) in Port Sheldon, Ottawa County, Michigan. Archaeological Consultants of Ossian **Notes**: No sites were found as a result of this Phase I survey of 0.06 acres of land in Ottawa County.	07320

Bibliography Report

Filter Summary

Author(s) (Bibliography)	Title (Bibliography)	Publication Date (Year) (Bibliography)	Publisher (Bibliography)	Volume (Bibliography)	Notes (Bibliography)	Project ID (Project)
Weir, Donald J., C. Stephan Demeter and Curtis E. Larsen	Cultural Resource Management Assessment Study of Eight Candidate Power Plant Sites.	1980	Commonwealth Associates, Inc.	R-2098	This project was conducted for Consumers Power Company conducted in 1979. Project areas in Van Buren, Ottawa, Muskegon, Monroe, Bay, Iosco, Presque Isle and Alpena counties were surveyed. It is uncertain how much acerage was inspected. Seven sites were discovered: 20MR744 (Woodland camp), 20MU111 (find spot - uniface), 20OT203 (lithic scatter), and four 20th century homesteads (20PI42, 20IS197, 20BY368 and 20MU113). The sites are only briefly mentioned in the report. The collections are curated at the Office of the State Archaeologist.	

MICHIGAN ARCHAEOLOGICAL SITE FILE
CONFIDENTIAL-NOT FOR PUBLIC DISTRIBUTION

Name: Campbell

Site Number: 20OT202

Other Names:

County: Ottawa

Township: Port Sheldon

Region: Grand

River Basin: Grand

Map: Port Sheldon Quadrangle, 7.5' USGS

Township	Range	Section	Quarter
06N	16W	14	NE-SW-NE-NW

Longitude:

Latitude:

Narrative Description: Single component, largely undisturbed Allegan phase camp. Shovel testing at one meter intervals yielded 37 positive tests with Allegan ware, expanding stemmed projectile point bases, a scraper, debitage, fire-cracked rock and burned animal bone. The chert was all locally available varieties. Some erosion has taken place resulting from logging and construction of an electrical line. No significant disturbance was evident below the existing ground surface. Ceramics and fire-cracked rock were concentrated in the north and central parts of the site; bone was most common in the south part.

"The occurrence of Allegan type pottery at the site, its small compact size, its location on an east and southern exposed slope, and the fact that 72 percent of the lithic debitage consists of flat tertiary flakes of local cherts, suggest that this site represents an early Late Woodland short-term winter hunting camp of perhaps a small family group. It may well represent the most northerly known site of the Allegan tradition known to date" (Weir et al 1993:33).

The site lay outside the areas to be affected by the construction project which generated the 1992 survey (Weir et al 1993).

Information Sources: Recon. Level Survey (Meets Fed. S&G), Field Verified

Field Evidence: Positive shovel-test(s)

Period	Date	Culture	Function
K - Late Woodland Period	AD 600-1000	Allegan phase	winter camp

Field Work Summary: - 1992: survey using shovel-testing by Commonwealth Cultural Resources Group (Wes Andrews)

Collections: 20OT202/A94.16

Publications:

Author	Year	Title	Publisher

MICHIGAN ARCHAEOLOGICAL SITE FILE
CONFIDENTIAL-NOT FOR PUBLIC DISTRIBUTION

Andrews, Wesley L., C. Stephan Demeter and Mary L. Jeakle	1993	Phase I Archaeological Survey of the Proposed Campbell Ash Pond Expansion and 345 kV Line Relocation, Holland, Michigan.	Commonwealth Cultural Resources Group, Inc.
		Port Sheldon Quadrangle, 7.5' USGS	

Other Documentation: - Office of the State Archaeologist: CCRG 1992 lab notes and photos of projectile points in accession file A94.16

NRHP Status: Eligible for Listing in the National Register of Historic Places

Evaluation	Date of Evaluation	Evaluation Comment
determined NR eligible by staff	7/22/1998	

Ownership: Recorder

Projects: ER-920292

Record Created: 4/3/2015

Record Last Modified: 11/26/2019

By: # SA_MiSHPO_CRM

MICHIGAN ARCHAEOLOGICAL SITE FILE
CONFIDENTIAL-NOT FOR PUBLIC DISTRIBUTION

Name: 20OT203

Site Number: 20OT203

Other Names: CPCoC-1

County: Ottawa

Township: Port Sheldon

Region: Grand

River Basin: Lake Michigan

Map: Port Sheldon Quadrangle, 7.5' USGS

Township	Range	Section	Quarter
06N	16W	14	NE-SE-NW-NW

Longitude:

Latitude:

Narrative Description: Lithic scatter of 6 blocky flakes. The site has been disturbed by construction of a transmission line.

Information Sources: Field Verified

Field Evidence: Surface scatter

Period	Date	Culture	Function
A - Prehistoric Period		Native American	undetermined

Field Work Summary: - 1979, surface survey, collection. Commonwealth Associates, Inc. Donald Weir, field director.

- 1992, Phase I survey. Commonwealth Cultural Resources Group, Inc. Wesley Andrews, field work.

Collections: 20OT203/A94.29

Publications:

Author	Year	Title	Publisher
		Port Sheldon Quadrangle, 7.5' USGS	
Weir, Donald J., C. Stephan Demeter and Curtis E. Larsen	1980	Cultural Resource Management Assessment Study of Eight Candidate Power Plant Sites.	Commonwealth Associates, Inc.

Other Documentation: - Jeakle, Mary, 1993, Letter dated 3/24/93 to Mead, with copy of Commonwealth Associates Inc. Report #2098, on file at the Office of the State Archaeologist.

NRHP Status: Not Eligible for Listing in the National Register of Historic Places

MICHIGAN ARCHAEOLOGICAL SITE FILE
CONFIDENTIAL-NOT FOR PUBLIC DISTRIBUTION

- Andrews, Wesley, et al., 1993, Phase I Archaeological Survey of the Proposed Campbell Ash Pond Expansion and 345 kV Line Relocation, Holland, Michigan. Commonwealth Cultural Resources Group R-0126. Copy on file at the Office of the State Archaeologist. [Surveyors were unable to relocate the site.]

Evaluation	Date of Evaluation	Evaluation Comment
determined NR ineligible by staff	8/8/1996	

Ownership: Recorder, Private Owner

Projects:

Record Created: 4/3/2015 **Record Last Modified:** 11/26/2019

By: # SA_MiSHPO_CRM

MICHIGAN STATE UNIVERSITY | Extension

Greer Harewood
Project Ecologist
Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, MI 48906
(517) 482-2262

April 27, 2020

Re: Rare Species Review #2599 – 29-acre parcel review, West Olive, Ottawa County, MI (T06N R16W Section 10).

Ms. Harewood:

The location for the proposed project was checked against known localities for rare species and unique natural features, which are recorded in the Michigan Natural Features Inventory (MNFI) natural heritage database. This continuously updated database is a comprehensive source of existing data on Michigan's endangered, threatened, or otherwise significant plant and animal species, natural plant communities, and other natural features. Records in the database indicate that a qualified observer has documented the presence of special natural features. The absence of records in the database for a particular site may mean that the site has not been surveyed. The only way to obtain a definitive statement on the status of natural features is to have a competent biologist perform a complete field survey.

Under Act 451 of 1994, the Natural Resources and Environmental Protection Act, Part 365, Endangered Species Protection, "a person shall not take, possess, transport, …fish, plants, and wildlife indigenous to the state and determined to be endangered or threatened," unless first receiving an Endangered Species Permit from the Michigan Department of Natural Resources (MDNR), Wildlife Division. Responsibility to protect endangered and threatened species is not limited to the lists below. Other species may be present that have not been recorded in the database.

Although several at-risk species have been documented within 1.5 miles of this activity, **it is not likely** that negative impacts will occur. Keep in mind that MNFI cannot fully evaluate this project without visiting the project site. MNFI offers several levels of Rare Species Reviews, including field surveys which I would be happy to discuss with you.

Sincerely,

Michael A. Sanders

Michael A. Sanders
Environmental Review Specialist/Zoologist
Michigan Natural Features Inventory

MSU EXTENSION

Michigan Natural Features Inventory

PO Box 13036
Lansing MI 48901

(517) 284-6200
Fax (517) 373-9566

mnfi.anr.msu.edu

Comments for Rare Species Review #2599: It is important to note that it is the applicant's responsibility to comply with both state and federal threatened and endangered species legislation. Therefore, if a state listed species occurs at a project site, and you think you need an endangered species permit please contact: Casey Reitz, Wildlife Division, Michigan Department of Natural Resources, 517-284-6210, or ReitzC@michigan.gov. If a federally listed species is involved and, you think a permit is needed, please contact Carrie Tansy, Endangered Species Program, U.S. Fish and Wildlife Service, East Lansing office, 517-351-8375, or Carrie_Tansy@fws.gov.

Special concern species and natural communities are not protected under endangered species legislation, but efforts should be taken to minimize any or all impacts. Species classified as special concern are species whose numbers are getting smaller in the state. If these species continue to decline they would be recommended for reclassification to threatened or endangered status.

Please consult MNFI's Rare Species Explorer for additional information on management and survey methods regarding the listed species: http://mnfi.anr.msu.edu/explorer/search.cfm.

Table 1: Occurrences threatened and endangered species within 1.5 miles of RSR #2599

ELCAT	SNAME	SCOMNAME	USESA	SPROT	G_RANK	S_RANK	FIRSTOBS	LASTOBS	EORANK
Animal	*Acris blanchardi*	Blanchard's cricket frog		T	G5	S2S3	1968	1968-04-07	H
Animal	*Falco peregrinus*	Peregrine falcon		E	G4	S3	2004	2018	A?
Plant	*Panax quinquefolius*	Ginseng		T	G3G4	S2S3	1979	1980	A
Plant	*Zizania aquatica*	Wild rice		T	G5	S2S3	1940	1940-08-01	H

Concerns for Table 1:
No concerns. Occurrences are Historic and/or far removed from the project site.

Table 2: Occurrences of special concern species & other natural features within 1.5 miles of RSR #2599

ELCAT	SNAME	SCOMNAME	USESA	SPROT	G_RANK	S_RANK	FIRSTOBS	LASTOBS	EORANK
Animal	*Lithobates palustris*	Pickerel frog		SC	G5	S3S4	2013-04-30	2018-04-26	E
Plant	*Strophostyles helvula*	Trailing wild Bean		SC	G5	S3		1918-08-18	H

Concerns for Table 2:
No concerns. Occurrences are Historic and/or far removed from the project site.

Special concern species and natural communities are not protected under endangered species legislation, but efforts should be taken to minimize any or all impacts. Species classified as special concern are species whose numbers are getting smaller in the state. If these species continue to decline they would be recommended for reclassification to threatened or endangered status.

Codes to accompany Tables:

State Protection Status Code Definitions (SPROT)
E: Endangered
T: Threatened
SC: Special concern

Federal Protection Status Code Definitions (USESA)
LE = listed endangered
LT = listed threatened
LELT = partly listed endangered and partly listed threatened
PDL = proposed delist
E(S/A) = endangered based on similarities/appearance
PS = partial status (federally listed in only part of its range)
C = species being considered for federal status

Global Heritage Status Rank Definitions (GRANK)
The priority assigned by NatureServe's national office for data collection and protection based upon the element's status throughout its entire world-wide range. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.
G1 = critically imperiled globally because of extreme rarity (5 or fewer occurrences range-wide or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3: Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single western state, a physiographic region in the East) or because of other factor(s) making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.
G4: Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5: Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
Q: Taxonomy uncertain

State Heritage Status Rank Definitions (SRANK)
The priority assigned by the Michigan Natural Features Inventory for data collection and protection based upon the element's status within the state. Criteria not based only on number of occurrences; other critical factors also apply. Note that ranks are frequently combined.
S1: Critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state.
S2: Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.
S3: Rare or uncommon in state (on the order of 21 to 100 occurrences). S4 = apparently secure in state, with many occurrences.
S5 = demonstrably secure in state and essentially ineradicable under present conditions. SX = apparently extirpated from state.

Section 7 Comments for Rare Species Review #2599
Golder
29-acre site development
West Olive
Ottawa County, MI
April 27, 2020

<u>For projects involving federal funding or a federal agency authorization</u>

The following information is provided to assist you with Section 7 compliance of the Federal Endangered Species Act (ESA). The ESA directs all Federal agencies "to work to conserve endangered and threatened species. Section 7 of the ESA, called "Interagency Cooperation," is the means by which Federal agencies ensure their actions, including those they authorize or fund, do not jeopardize the existence of any listed species."

This project falls within the range of seven (7) federally listed/proposed species which have been identified by the U.S. Fish and Wildlife Service (USFWS) to occur in Ottawa County, Michigan:

<u>Federally Endangered</u>

Indiana bat - there appears to be suitable habitat within the 1.5-mile area. Indiana bats (*Myotis sodalis*) are found only in the eastern United States and are typically confined to the southern three tiers of counties in Michigan. Indiana bats that summer in Michigan winter in caves in Indiana and Kentucky. This species forms colonies and forages in riparian and mature floodplain habitats. Nursery roost sites are usually located under loose bark or in hollows of trees near riparian habitat. Indiana bats typically avoid houses or other artificial structures and typically roost underneath loose bark of dead elm, maple and ash trees. Other dead trees used include oak, hickory and cottonwood. Foraging typically occurs over slow-moving, wooded streams and rivers as well as in the canopy of mature trees. Movements may also extend into the outer edge of the floodplain and to nearby solitary trees. A summer colony's foraging area usually encompasses a stretch of stream over a half-mile in length. Upland areas isolated from floodplains and non-wooded streams are generally avoided.

Management and Conservation: the suggested seasonal tree cutting range for Indiana bat is between October 1 and March 31 (i.e., no cutting April 1-September 30). This applies throughout the Indiana bat range in Michigan.

Piping plover – there does not appear to be suitable habitat within the 1.5-mile search buffer. In the Great Lakes region, the federal and state endangered piping plover *(Charadrius melodus)* prefers to nest and forage on sparse or non-vegetated sand-pebble beaches with less than 5% vegetative cover. Nests are simple depressions in the sand are generally placed in level areas between the water's edge and the first dune. Associated bodies of water and interdunal wetlands enhance these areas by increasing food availability. Optimal foraging areas are especially crucial along Lake Superior, where shoreline and benthic invertebrate communities are known to be naturally sparse. While feeding, open shoreline is preferred to vegetated beach areas. Piping plovers begin arriving in mid- to late-April. The nesting season is under way by mid-May and lasts until mid-August.

Management and Conservation - this species is declining throughout the Midwest due to habitat destruction and disturbance. The nests are simple depressions in the sand and are difficult to see. People walking on the beach may inadvertently destroy nests. Dogs on the beach can be especially dangerous for chicks and adults. Piping plovers are protected under the Federal Endangered Species Act and are very sensitive to human disturbance. Please avoid activity along the shoreline in this compartment between May and September.

Snuffbox – there does not appear to be suitable habitat within 1.5-miles of the proposed project. The state and federally endangered snuffbox mussel (*Epioblasma triquetra*) has been known to occur in the Huron River. The snuffbox inhabits rivers and streams with cobble, gravel, or sand bottoms in swift currents and usually is deeply buried in the substrate. Glochidia, the parasitic larval stage of the mussel, are released from May to mid-July. In Michigan, the only host fish known for snuffbox is the log perch (*Percina caprodes*). In other parts of their range the banded sculpin (*Cottus carolinae*) is also a known host. After completing the parasitic stage and reaching adulthood, snuffbox remain relatively sessile on the river bottom, living between 8-10 years. The best time to survey for snuffbox is April through September.

Conservation and Management: the snuffbox mussel is sensitive to river impoundment, siltation and disturbance, due to its requirement for clean, swift current and relative immobility as an adult. To maintain the current populations in Michigan, rivers need to be protected to reduce silt loading and run-off. Maintaining or establishing vegetated riparian buffers can aid in controlling many of the threats to mussels. Control of zebra mussels is critical to preserving native mussels. And as with all mussels, protection of their hosts habitat is also crucial. Because the life cycle of the snuffbox is inherently linked with that of the logperch in Michigan, conservation and management of this fish species is needed to ensure that of the snuffbox.

Federally Threatened

Northern long-eared bat - Northern long-eared bat (*M. septentrionalis*) numbers in the northeast US have declined up to 99 percent. Loss or degradation of summer habitat, wind turbines, disturbance to hibernacula, predation, and pesticides have contributed to declines in Northern long-eared bat populations. However, no other threat has been as severe to the decline as White-nose Syndrome (WNS). WNS is a fungus that thrives in the cold, damp conditions in caves and mines where bats hibernate. The disease is believed to disrupt the hibernation cycle by causing bats to repeatedly awake thereby depleting vital energy reserves. This species was federally listed in May 2015 primarily due to the threat from WNS.

Although no known hibernacula or roost trees have been documented within the 1.5-mile area, this activity occurs within the designated WNS zone (i.e., within 150 miles of positive counties/districts impacted by WNS. In addition, there is suitable habitat within the 1.5-mile buffer. The USFWS has prepared a dichotomous key to help determine if this action may cause prohibited take of this bat. Please consult the USFWS Endangered Species Page for more information.

Also called northern bat or northern myotis, this bat is distinguished from other *Myotis* species by its long ears. In Michigan, northern long-eared bats hibernate in abandoned mines and caves in the Upper Peninsula; they also commonly hibernate in the Tippy Dam spillway in Manistee County. This species is a regional migrant with migratory distance largely determined by locations of suitable hibernacula sites.

Northern long-eared bats typically roost and forage in forested areas. During the summer, these bats roost singly or in colonies underneath bark, in cavities or in crevices of both living and dead trees. Roost trees are selected based on the suitability to retain bark or provide cavities or crevices. Common roost trees in southern Lower Michigan include species of ash, elm and maple. Foraging occurs primarily in areas along woodland edges, woodland clearings and over small woodland ponds. Moths, beetles and small flies are common food items. Like all temperate bats this species typically produces only 1-2 young per year.

Management and Conservation: when there are no known roost trees or hibernacula in the project area, we encourage you to conduct tree-cutting activities and prescribed burns in forested areas during October 1 through March 31 when possible, but you are not required by the ESA to do so. When that is not possible, we encourage you to remove trees prior to June 1 or after July 31, as that will help to protect young bats that may be in forested

Pitcher's thistle – there does not appear to be suitable habitat within the 1.5-mile search area. The federal and state threatened Pitcher's thistle *(Cirsium pitcheri)* grows on open sand dunes and occasionally on lag gravel associated with dunes. All of its habitats are along the Great Lakes shores, or in very close proximity. This monocarpic (once-flowering) plant produces a rosette that will mature to flowering in 2-8 years, after which the plant dies. Seeds germinate in June, and most seedlings (rosettes) appear within 1-3 meters of parent plants. The taproot of this thistle, which can reach 2 m in length, enhances its ability to survive the often-desiccating conditions of its dune habitat. Pitcher's thistle blooms from approximately late-June to early September.

Management and Conservation - Pitcher's thistle can be locally extirpated by destruction or major disturbance of its habitat (e.g. by shoreline development, vehicular or ORV traffic, heavy foot traffic and/or intensive recreation).

Rufa red knot – there does not appear to be suitable habitat within the 1.5-mile search area. The federally threatened rufa red knot (*Calidris canutus rufa*) is one of the longest-distance migrants in the animal kingdom, flying some 18,000 miles annually between its breeding grounds in the Canadian Arctic to the wintering grounds at the southern-most tip of South America. Primarily occurring along the Atlantic and Gulf coasts, small groups of this shorebird regularly use the interior of the United States such as the Great Lakes during the annual migration. The Great Lakes shorelines provide vital stopover habitat for resting and refueling during their long annual journey.

The largest concentration of rufa red knots is found in May in Delaware Bay, where the birds stop to gorge on the eggs of spawning horseshoe crabs; a spectacle attracting thousands of birdwatchers to the area. In just a few days, the birds nearly double their weight to prepare for the final leg of their long journey to the Arctic. This species may be especially vulnerable to climate change which affects coastal habitats due to rising sea levels.

Management and Conservation: applies to actions that occur along coastal areas during the Red Knot migratory window of MAY 1 - SEPTEMBER 30.

Eastern massasauga rattlesnake - the project falls outside Tier 1 and Tier 2 eastern massasauga habitat as designated by the U.S. Fish & Wildlife Service (USFWS). The federally threatened and state special concern eastern massasauga rattlesnake *(Sistrurus catenatus)* is Michigan's only venomous snake occurring in a variety of wetland habitats including bogs, fens, shrub swamps, wet meadows, marshes, moist grasslands, wet prairies, and floodplain forests. Eastern massasaugas occur throughout the Lower Peninsula but are not found in the Upper Peninsula. Populations in southern Michigan are typically associated with open wetlands, particularly prairie fens, while those in northern Michigan are better known from lowland coniferous forests, such as cedar swamps. These snakes normally overwinter in crayfish or small mammal burrows often close to the groundwater level and emerge in spring as water levels rise. During late spring, these snakes move into adjacent uplands they spend the warmer months foraging in shrubby fields and grasslands in search of mice and voles, their favorite food.

Often described as "shy and sluggish", these snakes avoid human confrontation and are not prone to strike, preferring to leave the area when they are threatened. However, like any wild animal, they will protect themselves from anything they see as a potential predator. Their short fangs can easily puncture skin and they do possess potent venom. Like many snakes, the first human reaction may be to kill the snake, but it is important to remember that all snakes play vital roles in the ecosystem. Some may eat harmful insects. Others like the massasauga consider rodents a delicacy and help control their population. Snakes are also a part of a larger food web and can provide food to eagles, herons, and several mammals.

Management and Conservation: any sightings of these snakes should be reported to the Michigan Department of Natural Resources, Wildlife Division. If possible, a photo of the live snake is also recommended.

USFWS Section 7 Consultation Technical Assistance can be found at:

https://www.fws.gov/midwest/endangered/section7/index.html

The website offers step-by-step instructions to guide you through the Section 7 consultation process with prepared templates for documenting “no effect.” as well as requesting concurrence on "may affect, but not likely to adversely affect" determinations.

Please let us know if you have questions.

Mike Sanders
Environmental Review Specialist/Zoologist
Sander75@msu.edu
517-284-6215

ATTACHMENT B-4

Contaminated Sites

Table 1: Contaminated Sites

Site Name	Street Address	City / Township	State	Zip	County	Type of Operation	Distance to Expansion	Considered Proximate to the Expansion
14900 Croswell Street	14900 Croswell Street	Port Sheldon Township	MI	49460	Ottawa	-	> 1/2 Mile	No
152nd Ave. and Luce Street	152nd Ave. and Luce Street	Port Sheldon	MI	49460	Ottawa	-	> 1/2 Mile	No
Sandy Point Restaurant & Cocktail Lounge	7175 Lakeshore Drive	Port Sheldon Township	MI	49460	Ottawa	Resturanut	> 1/2 Mile	No
Rock Solid Granite Company	9524 West Olive Road	West Olive	MI	49460	Ottawa	Granite Company	> 1/2 Mile	No

Notes:

1. The list of contaminated sites in surrounding cities was obtained from the Michigan Department of Environmental Quality Internet Site. More specifically, the database was obtained from the 201 site database in the Environmental Response Division's web page (https://secure1.state.mi.us/FacilitiesInventoryQueries/).

2. Rule 903 (2) (b) (vii) provides that an environmental assessment shall include "a list of any known sites of environmental contamination, proximate to the facility, including sites that are listed pursuant to the provisions of Act 307." The regulations do not define what "proximate to the facility" means. Therefore, for purposes of this evaluation, any site within 1/2 mile of the expansion is considered to be "proximate to the facility."

Department of Environmental Quality

Inventory of Facilities Search Results

District	Facility ID	BEA Number	Facility Name	Address	County	Township	City	Zip	Latitude	Longitude	Data Source
Grand Rapids		200000695GR	14900 Croswell Street	14900 Croswell Street	Ottawa	Port Sheldon Township					BEA
Grand Rapids	70000402		152nd Ave. and Luce Street	152nd Ave. and Luce Street	Ottawa		Port Sheldon	49460	42.94905	-86.15687	Part 201
Grand Rapids		200702014GR	7175 Lakeshore Drive	7175 Lakeshore Drive	Ottawa	Port Sheldon Township		49460			BEA
Grand Rapids	70000530		9524 West Olive Road, West Olive	9524 West Olive Road, West Olive	Ottawa	Port Sheldon			42.94172	-86.15995	Part 201
Grand Rapids		200100966GR	Sandy Point Restaurant & Cocktail Lounge	7175 Lakeshore Drive	Ottawa	Port Sheldon Township					BEA

GOLDER

MEMBER OF WSP

golder.com

Dry Ash Landfill Hydrogeological Report

JH Campbell Power Plant
West Olive, Michigan

October 2020

Prepared For:

Consumers Energy Company
1945 W. Parnall Road
Jackson, Michigan 49201

Prepared By:

TRC
1540 Eisenhower Place
Ann Arbor, Michigan 48108

Sarah B. Holmstrom, P.G.
Project Manager

Amanda L. Smith
Project Geologist

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APPENDICES

1.0 Introduction

1.1 Background and Scope

Consumers Energy Company (CEC) owns and operates the Type III Solid Waste Disposal Facility as described above. CEC proposes to develop a landfill expansion (Cells 6 through 9) collocated with the existing Cells 1 through 5 portions of the Type III disposal facility. The purpose of this report is to geologically and hydrogeologically assess the suitability of the site for a Type III Solid Waste Disposal Facility in accordance with Part 115 of the Natural Resources and Environmental Protection Act, PA 451 of 1994, as amended (Part 115), Rule 902(1)(d). The following tasks have been completed for this project:

1. The existing water quality has been determined in the aquifer per Rule 904(1)(a).
2. The following aquifers have been defined per Rule 904(1)(e)(i)-(iii):
   - The aquifer and all hydraulically connected aquifers.
   - The aquifer that is utilized by Type I and Type IIa public water supplies within ½ mile of the proposed active work area.
   - The aquifer that is utilized by Type IIb and Type III public water supply within 1,000 feet of the proposed active work area.
3. The areal and vertical extent of the earth materials beneath the site has been defined per Rule 904(4)(e).
4. The groundwater flow directions and hydrodynamics have been defined per Rule 904(4)(c) and (i).
5. A Hydrogeologic Monitoring Plan is proposed based on the site-specific conditions encountered in accordance with Rule 905 (provided in a separate document).

1.2 Site Location

Figure 1 is a site location map showing the facility and the surrounding area, and **Figure 2** is a site features map showing the location of the proposed construction area: Cells 6 through 9, in addition to the location of all wells and borings referenced in this report.

2.0 Regional Geology and Hydrogeology

The hydrogeologic conditions of the site have been extensively studied since the power plant first began operations in the 1960s. A brief description of the regional geology and a summary of site-specific geologic and hydrogeologic conditions, determined through previously conducted investigations, are provided below in accordance with Rule 904(b) through (f), and (i). The regional and site-specific geology and hydrogeology descriptions are based upon previous investigations performed by multiple firms including STS Consultants Inc (STS), Natural Resource technology (NRT), Arcadis NV (Arcadis), AECOM, Golder Associates, Inc (Golder) and TRC. Well construction details are summarized on **Table 1**. Soil boring logs and well construction diagrams for wells in the vicinity of Cells 6 through 9 are included in **Appendix A** (Rule 904(4)(c)).

2.1 Regional Geology

The surface soils at the site range from organic silts near the Pigeon River to sand in the area within the project boundary (USDA, 1972. Soil Survey of Ottawa County, Michigan conducted by the United States Department of Agriculture, December 1972). The two dominant soil associations onsite are:

- The Croswell and Au Gres sands, 0 to 6 percent slopes. This soil consists of moderately well drained dark brown to gray sand of former outwash and lake plains.
- The Rubicon sands, 0 to 6 percent slopes. This well-drained soil occurs as large areas on outwash and lake plains, as long narrow areas on dunes, and as small, irregularly shaped areas on parts of the uplands. The surface soils consist of very dry gray sand.

The uppermost unlithified deposits in the area of the Site consist of coarse glacial lacustrine deposits, principally sand and silt with varying amounts of gravel. Along the shore of Lake Michigan these deposits take the form of sand dunes. The lacustrine deposits are principally coarse-grained materials, but varying amounts of silt and clay occur within the sand, and silt and clay layers of varying thickness and lateral continuity may also occur in some areas. The coarse upper lacustrine deposits can exceed a thickness of 100 feet (ft) in the vicinity of the Site. Beneath the surficial lacustrine deposits is till, which underlies most of Ottawa County, including the vicinity of the Site. The till was deposited during the Wisconsin glacial epoch of the Pleistocene and is predominantly clay and silt with varying amounts of sand, gravel, and boulders. These glacial sediments have a high porosity but low permeability (Apple and Reeves, 2007). The till layer extends to the top of bedrock; although it is typically less than 100 ft in thickness it may exceed 100 ft in some areas.

Regional geologic maps show the immediate vicinity of the Site is underlain by the Coldwater Shale (from the early Mississippian Period), which is a major confining unit within the Michigan Basin that ranges in thickness from 500 to 1,300 ft. Deep drilling associated with the JH Campbell Power Plant demonstrated that the till material extends to shale bedrock, to a depth of approximately 140 ft below the existing ground surface at the Site. Associated figures that show the regional geology, underlying clay thickness, and bedrock surface are provided in **Appendix B** (Rule 904(4)(c)).

2.2 Regional Hydrogeology

Regional groundwater flow enters the site from the north, northeast and regionally flows west toward Lake Michigan and south towards the nearby surface water features: Spring Bayou, the Pigeon River, and Pigeon Lake (**Figure 1**). The vicinity of the Site is located within the Ottawa Lowlands, a broad, low-lying sandy plain found in the western half of Ottawa County. Apart from the large sand dunes that flank the Site to the west towards Lake Michigan, land elevations generally range from 580 to 630 ft. above mean sea level (AMSL). The Site lies at the western edge of the Macatawa Watershed, which drains the southeastern portion of the County and has two principal rivers - the Lower Grand and the Pigeon. The Pigeon River, which forms the southern boundary of the Site, is approximately 12 miles in length and flows westward into the 225 acre area of Pigeon Lake, which in turn flows into Lake Michigan.

The sand and gravel of the lacustrine deposits and dune sand are the most important source of water in the vicinity of the Site. Most if not all water wells within at least three miles of the Site obtain their supply from the uppermost unconfined sand deposits (lacustrine sand) above the till confining unit. Sand dunes present along the western portion of Ottawa County, bordering Lake Michigan, oftentimes lie above the water table and may provide areas of recharge (Farrand and Bell, 1982; IWRDEE, 2013). Yields to wells in the glaciofluvial deposits may exceed 2,000 gallons per minute (gpm) (Westjohn and Weaver, 1998). Interpolated hydraulic conductivity distribution based on well lithology from the bottom of wells to static water levels or land surface conducted by the State of Michigan in 2006 (IWRDEE, 2013) range from 10 to 40 meters per day (0.01 to 0.05 centimeters per second [cm/s]). The higher values were for the thicker dune and lacustrine sands located within a few miles of Lake Michigan. The glaciofluvial aquifer, which is connected to and underlies the Pigeon River in the vicinity and upgradient from the Site, is a major groundwater discharge area providing base flow to the river (IWRDEE, 2013).

The subsurface materials encountered at the JH Campbell site generally consist of approximately 40 to 60 feet of poorly graded, fine-grained lacustrine sand, which makes up the uppermost aquifer encountered in the vicinity of the Landfill. Groundwater in this aquifer is unconfined and typically encountered at depths ranging from 7 to 35 feet below ground surface (ft bgs), varying based on ground elevation, and generally flows to the south-southeast across the Dry Ash Landfill toward the Pigeon River. Just west of the Landfill, a series of six demineralization pumping wells associated with the JH Campbell Power Plant draws the natural groundwater flow westward toward the pumps.

The aquifer is underlain by a laterally extensive clay-rich till, which serves as the confining base of the aquifer and prevents vertical groundwater flow. The till is generally encountered within approximately 40 to 60 ft bgs across the Landfill based on soil boring data collected at the Site in 2012. A representative cross-section in the area of the Landfill is shown on **Figure 3** (Rule 904(4)(f)).

On November 10, 2015, ARCADIS performed hydraulic tests (slug tests) at nine monitoring wells (JHC MW-15005, JHC MW-15007, JHC MW-15015, JHC MW-15018, JHC MW-15024, JHC MW-15028, JHC MW-15030, JHC MW-15033, and JHC MW-15036) within the unconsolidated sand unit at the Site. During the slug testing activities, three tests were completed at each of the monitoring wells. The slug tests at these wells were completed to estimate hydraulic conductivity (K) by introducing a water table displacement by removing a known volume of water or depressing the water level by compressed air and measuring the rate of recovery. Well construction logs are included in **Appendix A**; well construction details are summarized in **Table 1.** The results indicated an estimated hydraulic conductivity range from 21 to 139 feet per day (ft/d) with an average of 73 ft/d and a geometric mean of 62 ft/d. The results of this test seem to be a reasonable fit with the sandy formation of the unconfined aquifer where the wells are screened. The monitoring well locations where slug tests were conducted are shown on **Figure 2** and the results of the hydraulic conductivity tests are included in **Appendix C**.

Porosity and effective porosity are essentially identical for unconsolidated materials such as those found on this site (STS Consultants, Inc., May 9, 1996 report, Appendix D). The porosity of the local sand is approximately 46% and as reported by STS in the Hydrogeological Report dated February 8, 1993. STS's May 9, 1996 report calculates the porosity of the silty clay/ clayey silt till is approximately 40%. Permeability test results on the clayey silt/silty clay till indicate a vertical hydraulic conductivity of 6.0 x 10^{7} cm/sec. The results of the Atterberg Limit tests completed on samples of the underlying till show that the soils consist of low plasticity (CL) silty clay/clayey silts.

2.2.1 Horizontal Gradient and Groundwater Flow Direction

Groundwater elevation data for the Landfill has been collected since 1992, during the baseline monitoring period prior to construction of the Landfill. Quarterly groundwater contour maps of the uppermost aquifer unit have been provided to the Michigan Department of Environmental Quality (EGLE) in the quarterly hydrogeologic monitoring reports for the existing Landfill since ash placement began in early 1997. These data show consistent groundwater elevation and flow data. Groundwater elevations at the onsite monitoring wells were most recently measured in April 2020 during the second quarter 2020 monitoring event. These data were used to prepare the representative groundwater contour map on **Figure 4** (Rule 904(4)(d)). A summary of groundwater elevation data is also included in **Table 2**.

The Landfill, including the proposed unconstructed Cells 6 through 9, is located north-northwest of the Pigeon River and/or Spring Bayou and northeast of Pigeon Lake. Groundwater within the uppermost aquifer is typically encountered at depths ranging from around 7 to 35 ft bgs and generally flows to the south-southeast across the site, with a southwesterly groundwater flow component on the west edge of the site.

Consistently, average hydraulic gradient throughout the site has been estimated at within 0.004 to 0.005 ft/ft. The average groundwater flow velocity of 0.43 ft/day was calculated using the most recent static water level data, and hydraulic conductivity (62 ft/day) and assumed effective porosity (0.46 n_e).

Constants		
K (ft/day)	62	Hydraulic conductivity
n_e	0.46	Effective porosity
h1 (ft)	609.38	Static water elevation of MW-3
h2 (ft)	590.74	Static water elevation of PZ-23
h3 (ft)	583.10	Static water elevation of MW-14-96/14-01
h4 (ft)	581.98	Static water elevation of MW-11-96/11A-01

Distances		
MW-3 to PZ-23	6,225	ft
MW-3 to MW-14-96	5,850	ft
MW-3 to MW-11-96	4,275	ft

$$S = \frac{\left(\frac{h1-h2}{6,225}\right)+\left(\frac{h1-h3}{5,850}\right)+\left(\frac{h1-h4}{4,275}\right)}{3} = 0.0046$$

$$V\left(\frac{ft}{day}\right) = 62 * \frac{0.0046}{0.46} = 0.62\,\frac{ft}{day}$$

2.2.2 *Vertical Gradient and Groundwater Flow Direction*

The uppermost aquifer is hydraulically confined by the underlying till. Therefore, groundwater flow is limited to within the lacustrine sand that makes up the uppermost aquifer. Monitoring well MW-8 is paired with MW-8B and MW-8C at varying depths within the uppermost aquifer (**Figure 2**). Water level data collected from 2017 through 2020 show that the vertical flow potential within those wells is consistently upward (**Table 2**).

2.2.3 *Anticipated Effects of Proposed Construction on Groundwater Flow*

The proposed Cells 6 through 9 will be constructed a minimum of 5 feet above the water table. The landfill cells will not physically divert groundwater flow, nor will any engineered modifications be made to groundwater flow. A contour map showing the maximum groundwater elevation data measured within 2017 through 2020 at all monitoring wells within the vicinity of the Landfill are shown on **Figure 5**.

The proposed construction of Cells 6 through 9 will prevent groundwater recharge throughout the footprint of the cells. Stormwater will be diverted through a network of perimeter ditches and retention ponds designed to manage drainage throughout the site. Due to the high permeability of the aquifer underlying the proposed development area, the diversion of surface water over the landfill footprint is not anticipated to have a noticeable impact on groundwater elevations or flow. Specifically, groundwater is not expected to mound in the vicinity of the surface water management features.

3.0 Topography and Surface Water

The topography and Site features shown on **Figure 2** and described below per Rule 904(4)(b).

3.1 Local Topography

The site and surrounding areas are characterized by very contiguous topographic features as the result of continental glaciation, which left the foundation rock buried by many feet of glacial debris and shaped this area relatively flat.

Site topography prior to Cells 6 through 9 construction and associated earthwork is illustrated on **Figure 2**. Topography in the Cells 6 through 9 area is generally flat surrounded by existing Landfill Cells 1 through 5, perimeter ditches, berms and other surface features associated with the management of solid waste and storm water at the site. Outside of the immediate Cells 6 through 9 area, the topographic surface slopes downward to the south, from approximately 686 feet above mean sea level (ft AMSL) at the southern perimeter of the Landfill to approximately 595 ft AMSL near the Pigeon River.

3.2 Proposed Topographic Changes

The proposed Cells 6 through 9 is collocated with the existing landfill area Cells 1 through 5. Topographic changes will be localized to Cells 6 through 9 during construction activities. The ground surface elevation in the Cells 6 through 9 area is approximately 600 ft. AMSL and is anticipated to remain consistent with the surrounding landfill features. At this time, the north faces of Cells 1 (~606 ft AMSL) and 2 (~606 ft. AMSL) and the eastern face of Cell 2 (~601 ft AMSL) have been closed along with Cell 3 (~596 ft. AMSL). Cell 4 (~597 ft AMSL) is currently being filled with ash and partial cover has been constructed. Cell 5 (~600 ft AMSL) was constructed in 2018 and put into service in 2019. **Figure 3** shows a cross-sectional view of current and proposed grades.

3.3 Surface Water and Wetlands

The Pigeon River is located south-southeast of the Landfill varying from approximately 2,500 to 5,500 feet from the proposed construction area.

Any stormwater discharges from the construction of Cells 6 through 9 will be collected by the existing perimeter ditch network and retention ponds which are managed through a National Pollutant Discharge Elimination System (NPDES) Permit # MI0001422.

3.4 Surface Drainage

Surface drainage at the facility is largely controlled by the existing disposal units and their associated storm water management features. Due to the highly permeable surficial soils, water from precipitation outside of the engineered drainage system predominantly seeps into the subsurface.

4.0 Groundwater Quality

The determination of existing and background groundwater quality is required per Rule 904(1)(b) and Rule 904(4)(a), respectively, and is provided below.

4.1 Background Water Quality

Background groundwater quality for the site, and in the vicinity of the Cells 6 through 9 construction area, has been evaluated since early 1997 in adherence with the EGLE-approved Hydrogeological Monitoring Plan (HMP) (Consumers Energy, 1996). These data have been provided to the EGLE in quarterly reports for the existing Landfill. In addition, groundwater in the area of proposed Cells 6 through 9 has been monitored in accordance with United States Environmental Protection Agency's (U.S. EPA's) Resource Conservation and Recovery Act (RCRA) Coal Combustion Residual rule ("CCR Rule") promulgated on April 17, 2015, as amended, since 2015.

The most recent data that represents background quality at the site is provided in Tables 1 through 4 in **Appendix D** as presented in the 2019 Annual Report on the Implementation of the Remedial Action Plan (TRC, September 2019), the 2019 Annual Groundwater Monitoring and Corrective Action Report (TRC, January 2020), and the Second Quarter 2020 Groundwater Monitoring Report (TRC, July 2020).

4.2 Existing Groundwater Quality

Downgradient and immediately adjacent to the Landfill are 142 acres of closed former coal ash surface impoundments referred to as "Cells B-K". In the most recent operating license for the JH Campbell solid waste disposal area issued by EGLE in January 2019, Cells B-K are indicated as pre-existing units where the final cover has been certified closed and accepted by the EGLE. Cells B-K were closed pursuant to the Consumers Energy Remedial Action Plan (RAP) first prepared on August 9, 1999 and finalized with the 2005 Agreement for a Limited, Site-Specific, Criteria-Based Remedial Action LAND-WMD-2005-2. The RAP was prepared to address concentrations of selenium, boron, antimony, and lithium which occasionally exceeded generic groundwater-surface water (GSI) criteria in limited areas downgradient of Cells B-K. The performance of the RAP is achieved through a combination of active remediation, land and groundwater use restrictions, and routine groundwater monitoring for both generic and site-specific performance criteria.

The groundwater monitoring network for the Landfill is separate and upgradient of closed Cells B-K. Limited statistically significant exceedances for boron and selenium in monitoring wells immediately adjacent to Cell 1 were observed in 2007. Consumers Energy submitted a Response Action Plan to address those concentrations. This resulted in a 2008 addendum to the RAP developed for Cells B-K, which specifically amended the RAP to address concentrations in the groundwater monitoring well network for the Landfill.

In 2011, Consumers Energy submitted a Response Action Plan to address elevated concentrations of boron and selenium in additional wells in the Landfill well network. At the same time EGLE determined the Landfill no longer met the definition of a "monitorable unit". As a result, the current compliance of the landfill is measured by a combination of groundwater monitoring data and flow rates in the Landfill secondary collection system. As of the writing of this report, flow rates in the secondary collection system have been below the Response Flow Rate of 25 gallons per acre per day at each operating cell in the Landfill for 14 consecutive months.

As outlined in the 2011 Response Action Plan and subsequent correspondence with EGLE, Consumers Energy has made significant changes to operations at the landfill and improvements to cell design that have resulted in improved groundwater quality throughout the Landfill monitoring well network. Under the federal CCR Rule, a new monitoring well network was installed at the Landfill in 2015. This network has been sampled concurrently with the wells in the approved state HMP. Under the federal monitoring program, the Landfill remains in Assessment Monitoring, and has not triggered requirements for corrective action related to groundwater constituent concentrations.

As a result, Consumers Energy has re-evaluated the statistical approach for the Landfill monitoring program to provide a more suitable assessment of current groundwater conditions as presented in the 2020 Hydrogeological Monitoring Plan submitted as Section D of this application.

Land and groundwater use restrictions employed at the site are in the form of a land-use restrictive covenant for the 410-acre area and for a prohibition of groundwater use for drinking water for a 33-acre area on the south side of Cells B-K as shown on **Figure 6**. Areas where concentrations of select metals constituents in groundwater, including antimony, boron, lithium, and selenium are observed in groundwater above generic residential drinking water criteria and generic groundwater surface water interface (GSI) are shown on **Figures 6** and **7**.

Currently, groundwater at the solid waste disposal area is not used for drinking water. The nearest residential drinking water wells are located north and east of the Landfill (north of the upgradient/background monitoring wells) and to the south-southeast of the site, on the opposite side of the Pigeon River, where there is no risk of influence from onsite groundwater.

There is a site-specific mixing zone determination for a portion of the site as part of the RAP (**Figure 7**), in addition to the operation of a groundwater extraction system to address groundwater concentrations at the GSI. As described in the 2019 Annual Report on the Implementation of the Remedial Action Plan (TRC, September 2019), a site-wide RAP is being developed pursuant to WMRPD Agreement No. 115-01-2018 by Consumers Energy for October 2021 to further address selenium concentrations in groundwater above relevant GSI criteria. The site-wide RAP will further advance the completion of the original remediation objectives defined in 2005 and comply with requirements in the federal CCR Rule.

4.3 Anticipated Effects of Proposed Construction on Groundwater Quality

As described previously, the footprint of proposed construction of Cells 6 through 9 will be built in the unconstructed area of the Landfill shown on **Figure 2**. Construction of Cells 6 through 9 will follow construction guidance set forth by Part 115 to include a double-liner system that will prevent impacts to groundwater associated with waste management activities within the proposed cells.

5.0 Groundwater Use and Well Records

Well logs were reviewed within ½ mile of the proposed Cells 6 through 9 construction area in accordance with Rule 904(4)(b)(a). There are no existing wells and properties with the potential for groundwater supplies within ½ mile of the proposed construction area as discussed in detail below.

5.1 Public Water Supply Wells

There are no public water supply wells within the 1,000 feet vicinity of the proposed construction of Cells 6 through 9 based on publicly available data within the EGLE's GeoWebFace platform. The closest well that appears in the search is a CEC-owned Type II well located ½ mile northwest of the proposed Cell 6 through 9 area, but records confirm that the water well was never installed. A copy of the uninstalled well log and GeoWebFace map are provided in **Appendix E**.

5.2 Domestic Water Wells

There are no domestic water wells within the 1,000 feet vicinity of the proposed construction of Cells 6 through 9 based on publicly available data within the EGLE's GeoWebFace platform, Wellogic platform and the Drinking Water and Municipal Assistance Division Scanned Water Well Record Retrieval System.

5.3 Oil and Gas Well Records

There are no oil and gas well records within the 1,000 feet vicinity of the proposed construction of Cells 6 through 9 based on publicly available data within the EGLE's GeoWebFace and Environmental Mapper platform.

6.0 Reference Documents

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Tables

Table 1
Monitoring Well Survey and Construction Data
JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	Date Installed	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Borehole Terminus Depth (ft BGS)	Borehole Terminus Elevation (ft)
Background												
JHC-MW-15023	620.48	10/1/2015	Sand	2" PVC, 10 Slot	14.0	to	24.0	603.5	to	593.5	25.0	592.51
JHC-MW-15024	617.12	10/1/2015	Sand	2" PVC, 10 Slot	7.0	to	17.0	607.3	to	597.3	20.0	594.29
JHC-MW-15025	617.67	10/1/2015	Sand	2" PVC, 10 Slot	7.0	to	17.0	607.6	to	597.6	20.0	594.64
JHC-MW-15026	618.54	10/2/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	607.6	to	597.6	20.0	595.59
JHC-MW-15027	617.80	10/2/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	605.3	to	595.3	20.0	595.27
JHC-MW-15028	614.30	10/2/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	603.5	to	593.5	20.0	591.52
JHC-MW-15029	611.45	10/5/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	600.6	to	590.6	20.0	588.58
JHC-MW-15030	607.67	10/5/2015	Sand	2" PVC, 10 Slot	4.0	to	14.0	600.5	to	590.5	20.0	584.55
Landfill												
JHC-MW-15017	617.11	9/29/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	604.2	to	594.2	20.0	594.19
JHC-MW-15018	617.52	9/29/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	604.8	to	594.8	20.0	594.76
JHC-MW-15019	613.36	9/29/2015	Sand	2" PVC, 10 Slot	6.0	to	16.0	604.3	to	594.3	16.0	594.31
JHC-MW-15022	624.29	9/30/2015	Sand	2" PVC, 10 Slot	23.0	to	33.0	598.4	to	588.4	33.0	588.42
JHC-MW-15031	636.37	10/6/2015	Sand	2" PVC, 10 Slot	33.0	to	43.0	600.4	to	590.4	45.0	588.44
JHC-MW-15032	614.79	10/6/2015	Sand	2" PVC, 10 Slot	13.0	to	23.0	598.8	to	588.8	25.0	586.82
JHC-MW-15033	621.49	10/6/2015	Sand	2" PVC, 10 Slot	16.0	to	26.0	602.6	to	592.6	30.0	588.58
JHC-MW-15034	616.47	10/6/2015	Sand	2" PVC, 10 Slot	11.0	to	21.0	602.4	to	592.4	25.0	588.40
JHC-MW-15035/MW-B5	634.78	3/14/2001	Sand	2" PVC, 10 Slot	33.0	to	43.0	600.0	to	590.0	43.5	589.53
JHC-MW-15036/MW-B6	618.84	3/13/2001	Sand	2" PVC, 10 Slot	20.0	to	30.0	598.4	to	588.4	30.5	587.94
JHC-MW-15037/MW-B7	616.56	8/29/2001	Sand	2" PVC, 10 Slot	23.0	to	28.0	591.8	to	586.8	28.5	586.28

Notes:
Survey conducted November 2016, October 2017, April 2018, December 2018,and August 2019 by Nederveld Inc., Grand Rapids, Michigan.
Elevation in feet relative to National Geodetic Vertical Datum of 1929 (NGVD 29)
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
ft BGS: Feet below ground surface.
NA = Not Applicable.
Staff gauge reference elevations corrected to the zero mark for purpose of calculating static water elevation.
Recovery Wells RW1 through RW7 surveyed at top of steel well cover.
(1) - Staff gauge water level was measured by surveyor on August 14, 2019.
(2) - Water level measurement collected prior to sample collection on August 14, 2019.

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Well Location	TOC Elevation (ft)	Date Installed	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Borehole Terminus Depth (ft BGS)	Borehole Terminus Elevation (ft)
Downgradient Wells												
MW-1	614.64	6/8/1992	Sand	2" Galvanized, 10 Slot	11.5	to	14.5	600.9	to	597.9	15.6	596.80
MW-3	617.99	6/8/1992	Sand	2" Galvanized, 10 Slot	12.0	to	15.0	603.7	to	600.2	15.0	600.70
MW-4	635.69	6/6/1992	Sand	2" Galvanized, 10 Slot	30.0	to	33.0	603.8	to	600.3	33.0	600.80
MW-5	615.79	6/6/1992	Sand	2" Galvanized, 10 Slot	10.0	to	13.0	603.6	to	600.1	13.0	600.60
MW-8	618.25	6/7/1992	Sand	2" Galvanized, 10 Slot	28.0	to	31.0	588.1	to	584.6	31.0	585.06
MW-8B	618.60	6/3/1994	Sand	2" Galvanized, 10 Slot	43.8	to	46.3	572.4	to	569.4	46.3	569.89
MW-8C	618.93	6/6/1994	Sand	2" Galvanized, 10 Slot	59.5	to	62.0	557.2	to	554.2	62.0	554.66
MW-9B	608.74	6/7/1994	Sand	2" Galvanized, 10 Slot	24.2	to	26.7	582.2	to	579.2	26.7	579.68
MW-9C	608.03	6/2/1994	Sand	2" Galvanized, 10 Slot	35.3	to	37.8	571.0	to	568.1	37.8	568.55
MW-9D	607.95	6/6/1994	Sand	2" Galvanized, 10 Slot	49.9	to	52.4	555.8	to	552.8	52.4	553.31
MW-10B	602.88	6/1/1994	Sand	2" Galvanized, 10 Slot	18.6	to	21.1	582.3	to	579.3	21.1	579.82
MW-11A	590.54	3/13/2001	Sand	2.25" PVC, 10 Slot	4.0	to	14.0	584.5	to	574.1	20.5	568.05
MW-12	591.12	1/10/1996	Sand	2" Galvanized, 10 Slot	4.1	to	6.6	583.7	to	580.7	6.0	581.80
MW-13	595.86	1/9/1996	Sand	2" Galvanized, 10 Slot	5.5	to	8.0	588.4	to	585.4	8.0	585.89
MW-14	590.73	1/9/1996	Sand	2" Galvanized, 10 Slot	6.4	to	8.9	581.3	to	578.3	8.9	578.81
MW-15	593.75	3/6/2001	Sand	2" PVC, 10 Slot	4.0	to	14.0	587.0	to	576.5	17.0	573.99
MW-A1	614.07	8/28/1996	Sand	2" Galvanized, 10 Slot	13.1	to	15.6	598.6	to	595.6	15.6	596.10
MW-A2	613.96	6/1/1994	Sand	2" Galvanized, 10 Slot	13.8	to	16.3	597.4	to	594.4	16.3	594.86
MW-A3	611.63	6/2/1994	Sand	2" Galvanized, 10 Slot	12.1	to	14.6	597.2	to	594.2	14.6	594.70
MW-B1	635.58	12/13/2007	Sand	2" PVC, 10 Slot	27.0	to	32.0	605.0	to	599.5	32.0	600.00
MW-B2	635.24	12/13/2007	Sand	2" PVC, 10 Slot	30.0	to	35.0	602.0	to	596.5	35.0	597.00
MW-B3	635.16	12/13/2007	Sand	2" PVC, 10 Slot	32.0	to	37.0	599.0	to	593.5	37.0	594.00
MW-B4	636.66	5/23/2011	Sand	2" PVC, 10 Slot	40.0	to	45.0	594.3	to	588.8	45.0	589.30
PZ-23	603.87	8/5/1976	Sand	2" Metal, 10 Slot	15.6	to	18.6	587.5	to	584.0	18.6	584.51
PZ-24	588.06	8/6/1976	Sand	2" Metal, 10 Slot	10.2	to	13.2	577.2	to	573.7	13.2	574.15
PZ-37	602.20	9/6/1979	Sand	1.5" PVC, 10 Slot	15.7	to	18.7	585.1	to	581.6	18.7	582.10
PZ-40	590.42	9/7/1979	Sand	1.5" PVC, 10 Slot	18.8	to	21.8	571.0	to	568.0	21.8	567.99

Notes:
Survey conducted November 2016, October 2017, April 2018, December 2018,and August 2019 by Nederveld Inc., Grand Rapids, Michigan.
Elevation in feet relative to National Geodetic Vertical Datum of 1929 (NGVD 29)
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
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JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	Date Installed	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)			Borehole Terminus Depth (ft BGS)	Borehole Terminus Elevation (ft)
RAP Area												
RW1	611.46	4/10/2001	Sand	8" Carbon Steel, 0.020" Slot	20.0	to	50.0	593.1	to	563.1	50.0	563.08
RW2	615.69	4/9/2001	Sand	8" Carbon Steel, 0.020" Slot	25.0	to	55.0	592.1	to	562.1	55.0	562.14
RW3	592.54	4/11/2001	Sand	8" Carbon Steel, 0.020" Slot	9.0	to	24.0	585.3	to	570.3	24.0	570.30
RW4	589.85	3/7/2001	Sand	8" Carbon Steel, 0.020" Slot	8.0	to	23.0	583.5	to	568.5	23.0	568.48
RW5	587.06	4/11/2001	Sand	8" Carbon Steel, 0.020" Slot	8.0	to	23.0	580.5	to	565.5	23.0	565.55
RW6	590.21	4/5/2010	Sand	8" Carbon Steel, 0.020" Slot	9.0	to	24.0	583.0	to	568.0	25.0	567.04
RW7	588.01	4/5/2010	Sand	8" Carbon Steel, 0.020" Slot	7.0	to	22.0	582.7	to	567.7	24.0	565.72

Notes:
Survey conducted November 2016, October 2017, April 2018, December 2018,and August 2019 by Nederveld Inc., Grand Rapids, Michigan.
Elevation in feet relative to National Geodetic Vertical Datum of 1929 (NGVD 29)
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
ft BGS: Feet below ground surface.
NA = Not Applicable.
Staff gauge reference elevations corrected to the zero mark for purpose of calculating static water elevation.
Recovery Wells RW1 through RW7 surveyed at top of steel well cover.
(1) - Staff gauge water level was measured by surveyor on August 14, 2019.
(2) - Water level measurement collected prior to sample collection on August 14, 2019.

Table 2
Summary of Groundwater Elevation Data – February 2017 - April 2020
JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	February 2017		April 2017		June 2017		July 2017		August 2017		September 2017	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background													
JHC-MW-15023	620.48	--	--	16.31	604.67	17.13	603.85	--	--	18.07	602.91	18.73	602.25
JHC-MW-15024	617.12	--	--	11.78	605.84	12.22	605.40	--	--	13.15	604.47	13.84	603.78
JHC-MW-15025	617.67	--	--	11.13	607.04	11.53	606.64	--	--	12.58	605.59	13.10	605.07
JHC-MW-15026	618.54	--	--	13.04	606.00	13.17	605.87	--	--	14.30	604.74	14.62	604.42
JHC-MW-15027	617.80	--	--	13.37	604.93	13.63	604.67	--	--	14.25	604.05	15.00	603.30
JHC-MW-15028	614.30	--	--	12.57	602.23	12.74	602.06	--	--	16.01	598.79	13.91	600.89
Landfill													
JHC-MW-15017	617.11	--	--	14.10	603.51	14.21	603.40	--	--	14.62	602.99	15.25	602.36
JHC-MW-15018	617.52	--	--	14.94	603.08	15.00	603.02	--	--	15.40	602.62	15.97	602.05
JHC-MW-15019	613.36	--	--	11.41	602.45	11.45	602.41	--	--	11.83	602.03	12.45	601.41
JHC-MW-15022	624.29	--	--	28.16	596.63	28.43	596.36	--	--	28.95	595.84	29.37	595.42
JHC-MW-15031	636.37	--	--	42.58	594.29	42.47	594.40	--	--	42.83	594.04	42.78	594.09
JHC-MW-15032	614.79	--	--	16.17	599.12	16.76	598.53	--	--	17.42	597.87	17.91	597.38
JHC-MW-15033	621.49	--	--	20.87	601.12	21.58	600.41	--	--	22.35	599.64	22.90	599.09
JHC-MW-15034	616.47	--	--	14.58	602.39	15.33	601.64	--	--	16.46	600.51	16.79	600.18
JHC-MW-15035	634.78	--	--	39.78	595.50	39.58	595.70	--	--	40.02	595.26	40.39	594.89
JHC-MW-15036	618.84	--	--	26.24	593.10	26.21	593.13	--	--	26.59	592.75	26.88	592.46
JHC-MW-15037	616.56	--	--	24.77	592.29	24.87	592.19	--	--	25.27	591.79	25.52	591.54
HMP													
MW-1	614.14	11.44	603.20	10.16	604.48	--	--	9.11	605.53	--	--	--	--
MW-3	617.49	11.50	606.49	10.31	607.68	--	--	11.04	606.95	--	--	--	--
MW-4	635.19	30.78	604.91	29.75	605.94	--	--	30.68	605.01	--	--	--	--
MW-5	615.29	10.57	605.22	9.48	606.31	--	--	10.66	605.13	--	--	--	--
MW-08	618.25	29.00	589.75	28.71	590.04	--	--	28.51	590.24	--	--	--	--
MW-08B	618.60	29.27	589.83	28.99	590.11	--	--	28.67	590.43	--	--	--	--
MW-08C	618.93	29.58	589.85	29.33	590.10	--	--	29.52	589.91	--	--	--	--
MW-09B	608.74	20.90	588.34	20.78	588.46	--	--	21.32	587.92	--	--	--	--
MW-09C	608.03	20.46	588.07	20.04	588.49	--	--	20.37	588.16	--	--	--	--
MW-09D	607.96	20.26	588.20	19.85	588.61	--	--	21.20	587.26	--	--	--	--
MW-10B	602.88	11.58	591.80	10.90	592.48	--	--	12.64	590.74	--	--	--	--
MW-11A	590.54	11.11	579.93	10.15	580.89	--	--	8.96	582.08	--	--	10.30	580.74
MW-12	591.13	8.92	582.71	8.57	583.06	--	--	9.14	582.49	--	--	--	--
MW-13	595.87	9.91	586.46	9.38	586.99	--	--	9.51	586.86	--	--	--	--
MW-14	590.73	10.67	580.56	9.85	581.38	--	--	9.66	581.57	--	--	--	--
MW-15	593.75	14.27	579.98	13.13	581.12	--	--	12.58	581.67	--	--	12.95	581.30

Notes:

Survey conducted by Nederveld, November 2015 and October 2018.

Elevation in feet relative to Plant Datum (NGVD 29).

TOC: Top of well casing.

ft BTOC: Feet below top of well casing.

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(1) - Monitoring well decommissioned on June 14, 2018.

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Well Location	TOC Elevation (ft)	February 2017		April 2017		June 2017		July 2017		August 2017		September 2017	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
HMP contd.													
MW-A1	613.57	10.83	603.24	10.03	604.04	--	--	10.44	603.63	--	--	--	--
MW-A2	613.46	11.17	602.79	10.35	603.61	--	--	10.74	603.22	--	--	--	--
MW-A3	611.13	9.74	601.89	8.95	602.68	--	--	9.32	602.31	--	--	--	--
MW-B1	635.08	33.01	602.57	32.86	602.72	--	--	33.04	602.54	--	--	--	--
MW-B2	634.74	34.78	600.46	34.15	601.09	--	--	34.51	600.73	--	--	--	--
MW-B3	634.66	36.72	598.44	36.09	599.07	--	--	36.37	598.79	--	--	--	--
MW-B4	636.16	40.11	596.55	39.63	597.03	--	--	39.79	596.87	--	--	--	--
MW-B5	634.78	40.05	595.23	39.65	595.63	--	--	39.82	595.46	39.93	595.35	--	--
MW-B6	618.84	26.48	592.86	26.13	593.21	--	--	26.41	592.93	--	--	--	--
MW-B7	616.56	25.93	591.13	24.64	592.42	--	--	25.06	592.00	25.18	591.88	--	--
PZ-23(2)	603.88	12.79	591.57	12.76	591.60	--	--	13.11	591.25	--	--	--	--
PZ-24(2)	588.07	4.32	584.98	4.11	585.19	--	--	4.51	584.79	--	--	--	--
PZ-37	601.70	2.89	599.31	2.94	599.26	--	--	3.31	598.89	--	--	--	--
PZ-40(2)	590.92	8.32	583.08	7.46	583.94	--	--	8.91	582.49	--	--	--	--
RW-1	611.46	--	--	--	--	--	--	--	--	--	--	28.90	583.06
RW-2	615.69	--	--	--	--	--	--	--	--	--	--	33.40	582.79
RW-3	592.54	--	--	--	--	--	--	--	--	--	--	12.30	580.74
RW-4	589.85	--	--	--	--	--	--	--	--	--	--	11.18	579.17
RW-5	587.06	--	--	--	--	--	--	--	--	--	--	13.10	574.46
RW-6	590.21	--	--	--	--	--	--	--	--	--	--	9.60	581.11
RW-7	588.01	--	--	--	--	--	--	--	--	--	--	10.90	577.61
RW-5	587.06	--	--	--	--	--	--	--	--	--	--	13.10	574.46
RW-6	590.21	--	--	--	--	--	--	--	--	--	--	9.60	581.11
RW-7	588.01	--	--	--	--	--	--	--	--	--	--	10.90	577.61

Notes:

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Elevation in feet relative to Plant Datum (NGVD 29).

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Table 2
Summary of Groundwater Elevation Data – February 2017 - April 2020
JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	October 2017		February 2018		April 2018		June 2018		July 2018	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background											
JHC-MW-15023	620.48	--	--	--	--	16.18	604.80	16.52	604.46	--	--
JHC-MW-15024	617.12	--	--	--	--	11.50	606.12	11.62	606.00	--	--
JHC-MW-15025	617.67	--	--	--	--	10.79	607.38	10.88	607.29	--	--
JHC-MW-15026	618.54	--	--	--	--	12.78	606.26	12.52	606.52	--	--
JHC-MW-15027	617.80	--	--	--	--	13.14	605.16	12.80	605.50	--	--
JHC-MW-15028	614.30	--	--	--	--	11.98	602.82	17.30	597.50	--	--
Landfill											
JHC-MW-15017	617.11	--	--	--	--	13.85	603.76	13.80	603.81	--	--
JHC-MW-15018	617.52	--	--	--	--	14.65	603.37	14.55	603.47	--	--
JHC-MW-15019	613.36	--	--	--	--	11.05	602.81	10.91	602.95	--	--
JHC-MW-15022	624.29	--	--	--	--	28.11	596.68	29.10	595.69	--	--
JHC-MW-15031	636.37	--	--	--	--	42.40	594.47	42.21	594.66	--	--
JHC-MW-15032	614.79	--	--	--	--	16.22	599.07	16.35	598.94	--	--
JHC-MW-15033	621.49	--	--	--	--	20.84	601.15	21.07	600.92	--	--
JHC-MW-15034	616.47	--	--	--	--	14.55	602.42	14.83	602.14	--	--
JHC-MW-15035	634.78	--	--	--	--	39.52	595.76	39.42	595.86	--	--
JHC-MW-15036	618.84	--	--	--	--	26.13	593.21	26.00	593.34	--	--
JHC-MW-15037	616.56	--	--	--	--	24.73	592.33	24.60	592.46	--	--
HMP											
MW-1	614.14	11.86	602.78	10.88	603.76	9.79	604.85	--	--	10.48	604.16
MW-3	617.49	12.46	605.53	10.92	607.07	10.09	607.90	--	--	10.70	607.29
MW-4	635.19	32.14	603.55	30.50	605.19	29.68	606.01	--	--	30.41	605.28
MW-5	615.29	12.35	603.44	10.37	605.42	9.36	606.43	--	--	10.52	605.27
MW-08	618.25	29.36	589.39	28.90	589.85	28.73	590.02	28.65	590.10	28.90	589.85
MW-08B	618.60	29.65	589.45	29.17	589.93	29.07	590.03	28.95	590.15	29.18	589.92
MW-08C	618.93	29.95	589.48	29.47	589.96	29.37	590.06	29.25	590.18	29.49	589.94
MW-09B	608.74	21.52	587.72	21.01	588.23	20.89	588.35	--	--	20.96	588.28
MW-09C	608.03	26.80	581.73	20.27	588.26	20.14	588.39	--	--	20.52	588.01
MW-09D	607.96	20.60	587.86	20.08	588.38	19.94	588.52	--	--	20.34	588.12
MW-10B	602.88	12.23	591.15	11.26	592.12	11.97	591.41	--	--	12.49	590.89
MW-11A	590.54	10.66	580.38	10.68	580.36	10.43	580.61	9.45	581.59	9.86	581.18
MW-12	591.13	9.59	582.04	9.05	582.58	8.31	583.32	--	--	9.97	581.66
MW-13	595.87	10.62	585.75	9.47	586.90	9.15	587.22	9.93	586.44	10.51	585.86
MW-14	590.73	9.71	581.52	10.01	581.22	9.59	581.64	13.11	578.12	9.52	581.71
MW-15	593.75	13.32	580.93	13.71	580.54	13.29	580.96	--	--	12.95	581.30

Notes:
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Elevation in feet relative to Plant Datum (NGVD 29).
TOC: Top of well casing.
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(2) - Monitoring well was resurveyed in second Quarter 2018. Previous Top of casing for PZ-23 was 603.37, for PZ-24 was 588.31, and for PZ-40 was 590.41.

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Well Location	TOC Elevation (ft)	October 2017		February 2018		April 2018		June 2018		July 2018	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
HMP contd.											
MW-A1	613.57	12.26	601.81	10.52	603.55	9.81	604.26	--	--	10.07	604.00
MW-A2	613.46	10.66	603.30	10.82	603.14	10.12	603.84	--	--	10.29	603.67
MW-A3	611.13	10.24	601.39	9.41	602.22	8.73	602.90	--	--	8.57	603.06
MW-B1	635.08	33.59	601.99	32.95	602.63	32.95	602.63	--	--	33.12	602.46
MW-B2	634.74	35.32	599.92	34.49	600.75	34.01	601.23	--	--	34.51	600.73
MW-B3	634.66	37.23	597.93	36.45	598.71	36.01	599.15	--	--	36.22	598.94
MW-B4	636.16	40.61	596.05	39.92	596.74	39.50	597.16	--	--	39.60	597.06
MW-B5	634.78	40.61	594.67	39.94	595.34	39.52	595.76	--	--	39.67	595.61
MW-B6	618.84	27.04	592.30	26.39	592.95	26.11	593.23	--	--	26.28	593.06
MW-B7	616.56	25.69	591.37	24.96	592.10	24.75	592.31	--	--	24.93	592.13
PZ-23(2)	603.88	13.22	591.14	13.15	591.21	13.31	591.05	13.29	591.09	13.76	590.62
PZ-24(2)	588.07	5.72	583.58	4.44	584.86	4.16	585.14	4.90	583.67	5.92	582.65
PZ-37	601.70	3.19	599.01	3.19	599.01	3.41	598.79	--	--	3.69	598.51
PZ-40(2)	590.92	9.88	581.52	8.28	583.12	7.46	583.96	8.32	583.10	9.39	582.03
RW-1	611.46	--	--	28.97	582.99	28.75	583.24	--	--	28.71	583.25
RW-2	615.69	--	--	33.55	582.64	33.31	582.91	--	--	32.94	583.25
RW-3	592.54	--	--	12.24	580.80	12.27	580.80	--	--	12.16	580.88
RW-4	589.85	--	--	14.11	576.24	13.16	577.22	--	--	11.21	579.14
RW-5	587.06	--	--	--	--	13.83	573.76	--	--	11.61	575.95
RW-6	590.21	--	--	12.22	578.49	11.85	578.87	--	--	11.60	579.11
RW-7	588.01	--	--	10.71	577.80	9.83	578.69	--	--	8.45	580.06
RW-5	587.06	--	--	--	--	13.83	573.76	--	--	11.61	575.95
RW-6	590.21	--	--	12.22	578.49	11.85	578.87	--	--	11.60	579.11
RW-7	588.01	--	--	10.71	577.80	9.83	578.69	--	--	8.45	580.06

Notes:

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Well Location	TOC Elevation (ft)	October 2018		November 2018		February 2019		April 2019	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background									
JHC-MW-15023	620.48	--	--	16.78	604.20	--	--	15.90	605.08
JHC-MW-15024	617.12	--	--	11.92	605.70	--	--	11.05	606.57
JHC-MW-15025	617.67	--	--	11.10	607.07	--	--	9.15	608.03
JHC-MW-15026	618.54	--	--	12.85	606.19	--	--	12.13	606.91
JHC-MW-15027	617.80	--	--	13.26	605.04	--	--	12.61	605.69
JHC-MW-15028	614.30	--	--	12.98	601.82	--	--	12.58	602.22
Landfill									
JHC-MW-15017	617.11	--	--	14.35	603.26	--	--	14.21	603.40
JHC-MW-15018	617.52	--	--	15.11	602.91	--	--	14.93	603.09
JHC-MW-15019	613.36	--	--	11.54	602.32	--	--	11.30	602.56
JHC-MW-15022	624.29	--	--	28.39	596.40	--	--	28.01	596.78
JHC-MW-15031	636.37	--	--	42.82	594.05	--	--	42.53	594.34
JHC-MW-15032	614.79	--	--	16.56	598.73	--	--	16.11	599.18
JHC-MW-15033	621.49	--	--	21.29	600.70	--	--	20.72	601.27
JHC-MW-15034	616.47	--	--	15.07	601.90	--	--	14.88	602.09
JHC-MW-15035	634.78	--	--	40.10	595.18	--	--	39.82	595.46
JHC-MW-15036	618.84	--	--	26.42	592.92	--	--	26.12	593.22
JHC-MW-15037	616.56	--	--	24.95	592.11	--	--	24.70	592.36
HMP									
MW-1	614.14	9.99	604.65	--	--	10.37	604.27	10.26	604.38
MW-3	617.49	10.14	607.85	--	--	10.05	607.94	9.67	608.32
MW-4	635.19	30.11	605.58	--	--	29.95	605.74	29.52	606.17
MW-5	615.29	9.98	605.81	--	--	9.60	606.19	9.28	606.51
MW-08	618.25	29.95	588.80	28.78	589.97	28.98	589.77	28.83	589.92
MW-08B	618.60	29.20	589.90	29.18	589.92	29.25	589.85	29.10	590.00
MW-08C	618.93	29.50	589.93	29.48	589.95	29.57	589.86	29.41	590.02
MW-09B	608.74	21.48	587.76	21.48	587.76	21.50	587.74	21.25	587.99
MW-09C	608.03	23.10	585.43	20.74	587.79	20.75	587.78	20.51	588.02
MW-09D	607.96	20.53	587.93	20.57	587.89	20.56	587.90	20.31	588.15
MW-10B	602.88	13.46	589.92	13.66	589.72	13.58	589.80	13.50	589.88
MW-11A	590.54	10.12	580.92	10.50	580.54	10.15	580.89	9.59	581.45
MW-12	591.13	8.60	583.03	--	--	8.33	583.30	8.52	583.11
MW-13	595.87	9.86	586.51	10.48	585.89	9.69	586.68	10.20	586.17
MW-14	590.73	9.30	581.93	9.62	581.61	9.64	581.59	9.40	581.83
MW-15	593.75	13.07	581.18	13.23	581.02	12.97	581.28	12.51	581.74

Notes:
Survey conducted by Nederveld, November 2015 and October 2018.
Elevation in feet relative to Plant Datum (NGVD 29).
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
ft BGS: Feet below ground surface.
(1) - Monitoring well decommissioned on June 14, 2018.
(2) - Monitoring well was resurveyed in second Quarter 2018. Previous Top of casing for PZ-23 was 603.37, for PZ-24 was 588.31, and for PZ-40 was 590.41.

Table 2
Summary of Groundwater Elevation Data – February 2017 - April 2020
JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	October 2018		November 2018		February 2019		April 2019	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
HMP contd.									
MW-A1	613.57	9.89	604.18	--	--	10.49	603.58	10.42	603.65
MW-A2	613.46	10.20	603.76	--	--	10.79	603.17	10.69	603.27
MW-A3	611.13	8.98	602.65	--	--	9.35	602.28	9.07	602.56
MW-B1	635.08	33.66	601.92	--	--	34.35	601.23	34.32	601.26
MW-B2	634.74	34.70	600.54	--	--	35.52	599.72	35.41	599.83
MW-B3	634.66	36.39	598.77	--	--	37.15	598.01	36.93	598.23
MW-B4	636.16	40.11	596.55	--	--	40.32	596.34	39.99	596.67
MW-B5	634.78	40.11	595.17	--	--	40.15	595.13	39.85	595.43
MW-B6	618.84	26.41	592.93	--	--	26.42	592.92	26.20	593.14
MW-B7	616.56	24.96	592.10	--	--	24.90	592.16	24.75	592.31
PZ-23(2)	603.88	15.00	589.38	13.64	590.74	14.47	589.91	13.54	590.84
PZ-24(2)	588.07	7.25	581.32	5.10	583.47	4.73	583.84	4.78	583.79
PZ-37	601.70	3.25	598.95	--	--	3.70	598.50	3.56	598.64
PZ-40(2)	590.92	7.95	583.47	8.30	583.12	7.71	583.71	8.14	583.28
RW-1	611.46	28.76	583.20	--	--	28.74	583.22	28.50	583.46
RW-2	615.69	34.21	581.98	33.35	582.84	33.15	583.04	32.86	583.33
RW-3	592.54	12.50	580.54	14.35	578.69	11.19	581.85	10.84	582.20
RW-4	589.85	13.15	577.20	13.15	577.20	11.88	578.47	10.52	579.83
RW-5	587.06	12.07	575.49	12.10	575.46	12.47	575.09	12.00	575.56
RW-6	590.21	11.61	579.10	11.75	578.96	11.05	579.66	10.62	580.09
RW-7	588.01	9.23	579.28	9.55	578.96	9.08	579.43	8.34	580.17
RW-5	587.06	12.07	575.49	12.10	575.46	12.47	575.09	12.00	575.56
RW-6	590.21	11.61	579.10	11.75	578.96	11.05	579.66	10.62	580.09
RW-7	588.01	9.23	579.28	9.55	578.96	9.08	579.43	8.34	580.17

Notes:

Survey conducted by Nederveld, November 2015 and October 2018.

Elevation in feet relative to Plant Datum (NGVD 29).

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ft BTOC: Feet below top of well casing.

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Table 2
Summary of Groundwater Elevation Data – February 2017 - April 2020
JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	August 2019		October 2019		February 2020		April 2020	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
Background									
JHC-MW-15023	620.48	17.20	603.78	16.35	604.63	15.41	605.57	15.50	605.48
JHC-MW-15024	617.12	12.09	605.53	11.65	605.97	10.32	607.30	10.42	607.20
JHC-MW-15025	617.67	11.15	607.02	10.58	607.59	9.33	608.84	9.43	608.74
JHC-MW-15026	618.54	12.71	606.33	12.38	606.66	11.15	607.89	11.11	607.93
JHC-MW-15027	617.80	13.01	605.29	12.92	605.38	11.59	606.71	11.37	606.93
JHC-MW-15028	614.30	12.80	602.00	12.50	602.30	11.78	603.02	12.01	602.79
Landfill									
JHC-MW-15017	617.11	14.50	603.11	14.08	603.53	--	--	13.55	604.06
JHC-MW-15018	617.52	15.20	602.82	14.93	603.09	--	--	14.30	603.72
JHC-MW-15019	613.36	11.57	602.29	11.50	602.36	--	--	10.72	603.14
JHC-MW-15022	624.29	28.50	596.29	28.22	596.57	--	--	27.78	597.01
JHC-MW-15031	636.37	42.69	594.18	42.85	594.02	--	--	42.34	594.53
JHC-MW-15032	614.79	16.88	598.41	16.21	599.08	--	--	15.81	599.48
JHC-MW-15033	621.49	21.69	600.30	20.92	601.07	--	--	20.39	601.60
JHC-MW-15034	616.47	15.48	601.49	14.65	602.32	--	--	14.05	602.92
JHC-MW-15035	634.78	40.00	595.28	40.28	595.00	--	--	39.61	595.67
JHC-MW-15036	618.84	26.39	592.95	26.40	592.94	--	--	25.93	593.41
JHC-MW-15037	616.56	24.91	592.15	24.85	592.21	--	--	24.47	592.59
HMP									
MW-1	614.14	10.50	604.14	9.91	604.73	9.28	605.36	9.14	605.50
MW-3	617.49	10.28	607.71	9.78	608.21	8.54	609.45	8.61	609.38
MW-4	635.19	30.28	605.41	29.89	605.80	28.58	607.11	28.63	607.06
MW-5	615.29	10.38	605.41	9.63	606.16	8.51	607.28	8.65	607.14
MW-08	618.25	28.95	589.80	28.93	589.82	28.64	590.11	28.67	590.08
MW-08B	618.60	29.21	589.89	29.20	589.90	--	--	28.99	590.11
MW-08C	618.93	29.54	589.89	29.50	589.93	29.23	590.20	29.26	590.17
MW-09B	608.74	21.61	587.63	30.05	579.19	22.23	587.01	21.20	588.04
MW-09C	608.03	20.88	587.65	20.95	587.58	20.48	588.05	19.56	588.97
MW-09D	607.96	20.69	587.77	20.76	587.70	20.31	588.15	20.27	588.19
MW-10B	602.88	13.99	589.39	14.01	589.37	13.45	589.93	13.45	589.93
MW-11A	590.54	9.40	581.64	10.44	580.60	9.35	581.69	9.06	581.98
MW-12	591.13	8.85	582.78	8.28	583.35	8.38	583.25	8.23	583.40
MW-13	595.87	10.52	585.85	--	--	10.15	586.22	10.09	586.28
MW-14	590.73	8.35	582.88	8.45	582.78	8.45	582.78	8.13	583.10
MW-15	593.75	12.26	581.99	9.59	584.66	12.31	581.94	12.02	582.23

Notes:
Survey conducted by Nederveld, November 2015 and October 2018.
Elevation in feet relative to Plant Datum (NGVD 29).
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ft BTOC: Feet below top of well casing.
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Table 2
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JH Campbell
West Olive, Michigan

Well Location	TOC Elevation (ft)	August 2019		October 2019		February 2020		April 2020	
		Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)	Depth to Water (ft BTOC)	Groundwater Elevation (ft)
HMP contd.									
MW-A1	613.57	10.60	603.47	10.08	603.99	9.55	604.52	9.61	604.46
MW-A2	613.46	10.80	603.16	10.45	603.51	9.80	604.16	9.83	604.13
MW-A3	611.13	9.26	602.37	9.23	602.40	8.32	603.31	8.45	603.18
MW-B1	635.08	34.60	600.98	34.20	601.38	33.56	602.02	34.35	601.23
MW-B2	634.74	35.66	599.58	35.45	599.79	34.72	600.52	34.95	600.29
MW-B3	634.66	37.11	598.05	37.23	597.93	36.40	598.76	36.61	598.55
MW-B4	636.16	40.20	596.46	40.49	596.17	39.61	597.05	39.73	596.93
MW-B5	634.78	40.05	595.23	40.30	594.98	39.53	595.75	39.61	595.67
MW-B6	618.84	26.36	592.98	26.38	592.96	25.92	593.42	25.93	593.41
MW-B7	616.56	24.95	592.11	24.83	592.23	24.44	592.62	24.47	592.59
PZ-23(2)	603.88	14.15	590.23	13.64	590.74	13.63	590.75	13.64	590.74
PZ-24(2)	588.07	5.56	583.01	4.67	583.90	4.83	583.74	4.66	583.91
PZ-37	601.70	4.72	597.48	3.44	598.76	3.76	598.44	3.95	598.25
PZ-40(2)	590.92	8.61	582.81	7.35	584.07	7.59	583.83	7.51	583.91
RW-1	611.46	29.12	582.84	30.85	581.11	30.36	581.60	30.26	581.70
RW-2	615.69	36.54	579.65	35.86	580.33	34.95	581.24	32.80	583.39
RW-3	592.54	13.88	579.16	12.14	580.90	13.39	579.65	13.34	579.70
RW-4	589.85	11.56	578.79	23.75	566.60	11.40	578.95	11.93	578.42
RW-5	587.06	12.53	575.03	11.45	576.11	10.66	576.90	10.12	577.44
RW-6	590.21	14.36	576.35	13.18	577.53	13.26	577.45	12.30	578.41
RW-7	588.01	11.28	577.23	10.81	577.70	9.84	578.67	9.45	579.06
RW-5	587.06	12.53	575.03	11.45	576.11	10.66	576.90	10.12	577.44
RW-6	590.21	14.36	576.35	13.18	577.53	13.26	577.45	12.30	578.41
RW-7	588.01	11.28	577.23	10.81	577.70	9.84	578.67	9.45	579.06

Notes:

Survey conducted by Nederveld, November 2015 and October 2018.

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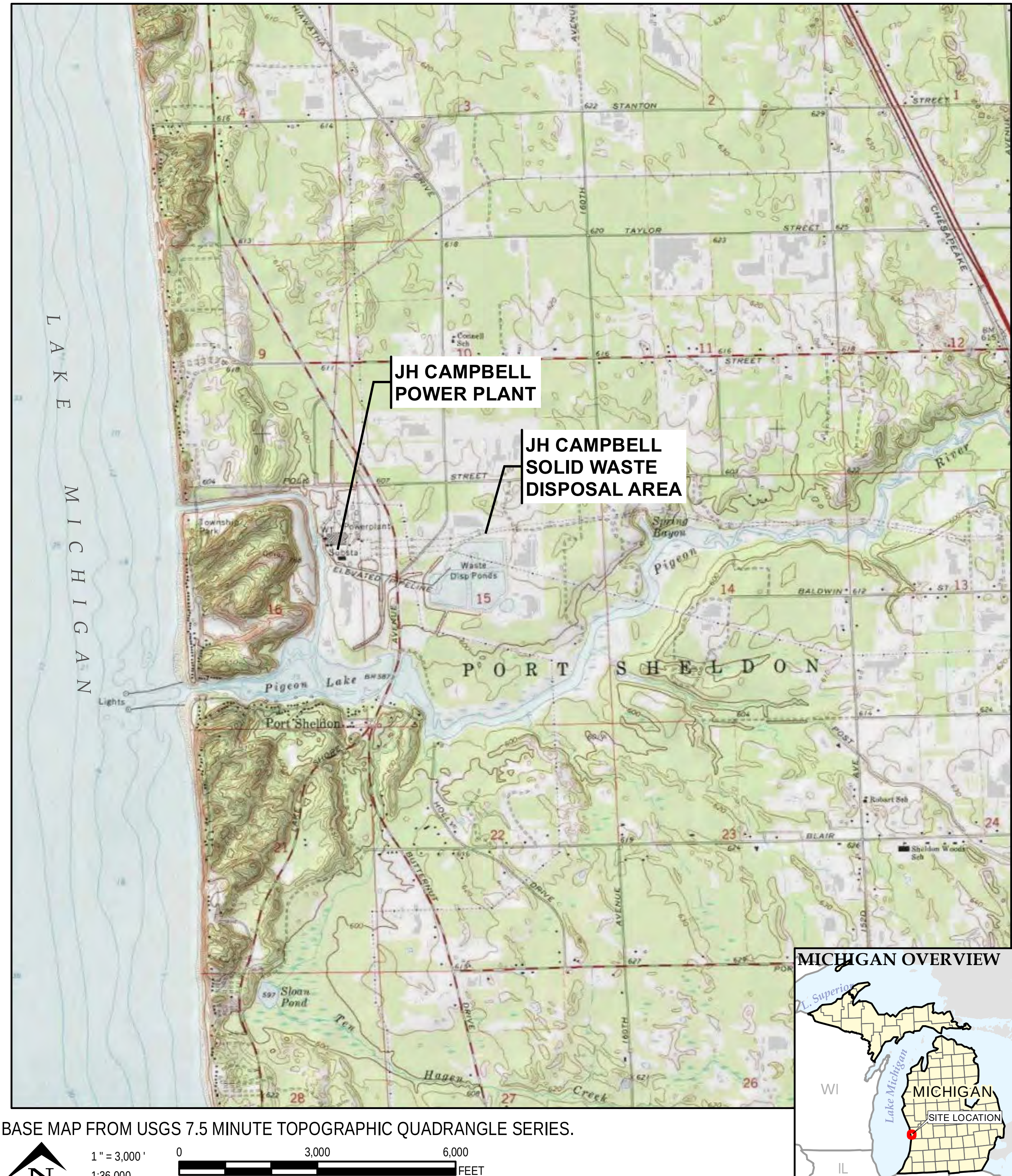
Figures



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

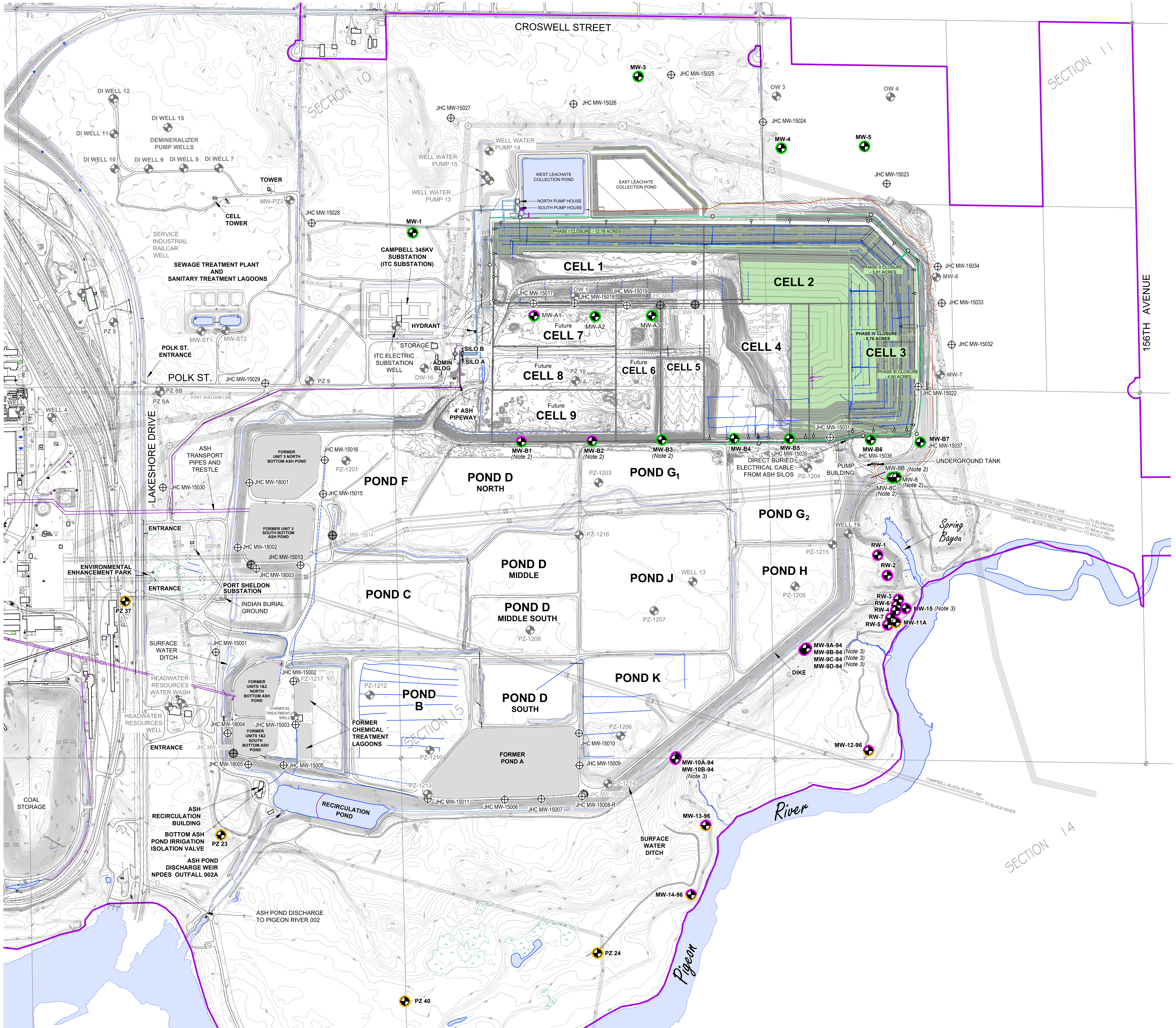
N

1 " = 3,000 '
1:36,000

0 3,000 6,000 FEET

TRC 1540 Eisenhower Place Ann Arbor, MI 48108-3284 Phone: 734.971.7080 www.trccompanies.com	PROJECT: **CONSUMERS ENERGY COMPANY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN**	DRAWN BY: S. MAJOR CHECKED BY: B. YELEN APPROVED BY: S. HOLMSTROM DATE: JANUARY 2020
TRC - GIS	TITLE: **SITE LOCATION MAP**	PROJ. NO.: 322174 FILE: 322174-001-022.mxd **FIGURE 1**

E:\ConsumersEnergy\CCR_GW\2017_269767\322174-001-022.mxd -- Saved By: SMAJOR on 1/24/2020, 08:49:03 AM



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SECTION LINE
- RAILROAD TRACKS
- CELL BOUNDARY
- FENCELINE
- DITCH
- UNPAVED ROAD OR DRIVE
- OVERHEAD POWER LINES
- ELECTRIC LINE
- SANITARY PIPE
- UTILITY
- LEACHATE PIPE
- ASH PIPE
- PIPELINE
- IRRIGATION PIPE
- WATER
- FACILITY COVER
- WETLAND
- POLE
- MW-7 WELL
- JHC MW-15034 RCRA MONITORING PROGRAM WELL
- JHC MW-15004 DECOMMISSIONED RCRA MONITORING PROGRAM WELL
- MW-5 DRY ASH LANDFILL MONITORING WELL
- PZ-23 CELLS B-K HMP WELL
- RW-1 RAP MONITORING WELL
- P-4D RAP PIEZOMETER

NOTES

1. BASEMAP DEVELOPED FROM CONSUMERS ENERGY, "CAMPBASE.DWG", DATED 02/10/2014 AND NEDERVELD "CAMPBELL PLANT MONITORING WELLS-CCR MONITORING", DATED 11/25/2015. PROVIDED BY CONSUMERS ENERGY.
2. HMP SENTINAL WELL
3. RAP SENTINAL WELL

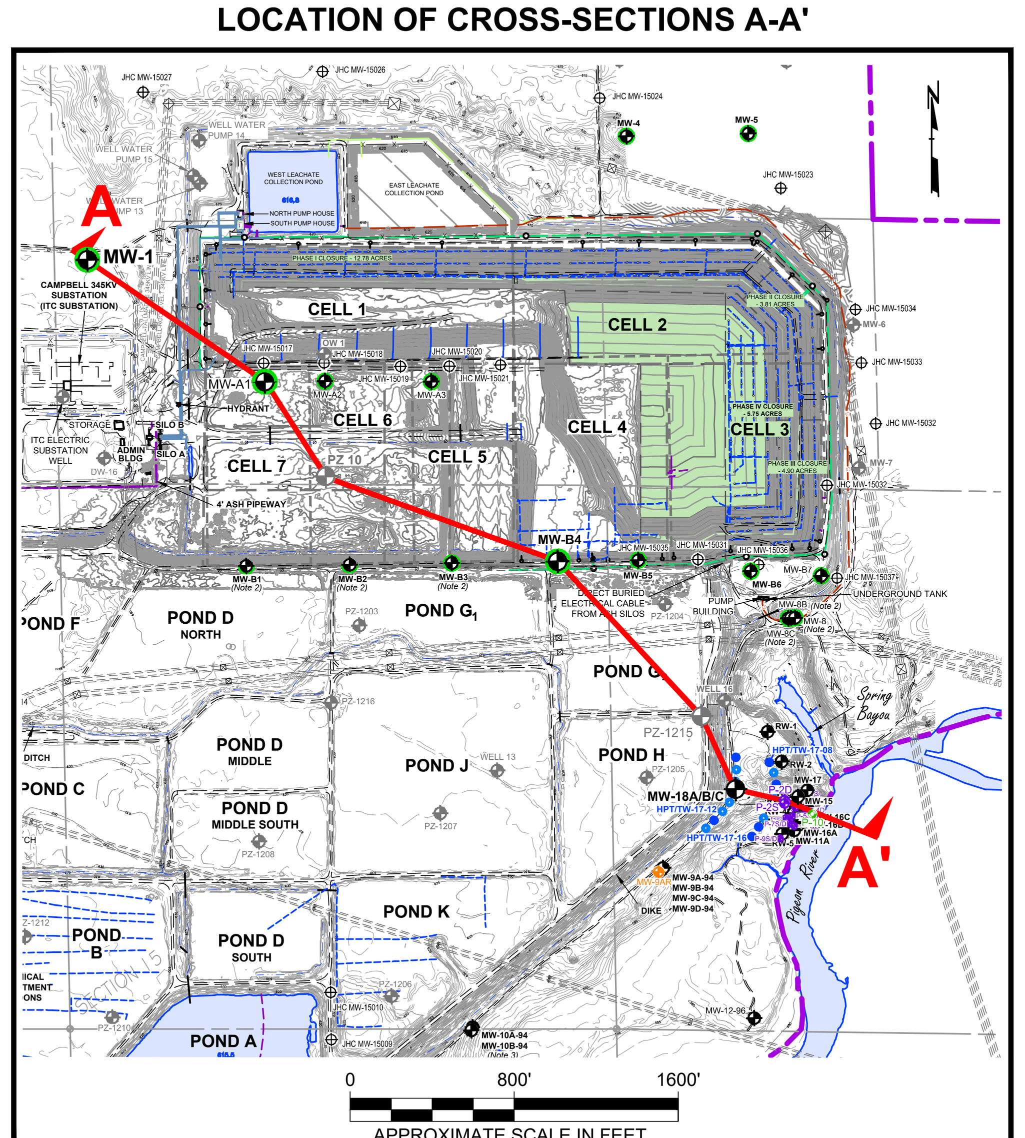
0 360' 720' 1080' 1440'
APPROXIMATE SCALE IN FEET

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	SITE FEATURES MAP
DRAWN BY: D.STEHLE	PROJ. NO.: 367390.0001.01.03
CHECKED BY: K.LOWERY	FIGURE 2
APPROVED BY: S.HOLMSTROM	
DATE: JULY 2020	
TRC	1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trccompanies.com
FILE NO.:	367390.0001.01.03.02 Hydro.dwg

DRAWING NAME: J:_TRC\Consumers\JH Campbell\367390\0001\01\03_Hydro Rpt\ 367390.0001.01.03.02 Hydro.dwg --- PLOT DATE: July 30, 2020 - 6:47AM --- LAYOUT: FIG02 Site Features

GENERALIZED GEOLOGIC CROSS-SECTION A-A'

LOCATION OF CROSS-SECTIONS A-A'



LEGEND

STRATIGRAPHIC BOUNDARY BASED ON NEAREST SOIL BORING OR MONITORING WELL (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER ELEVATION (SHOWING DRAWDOWN AT WELL SCREEN)

WELL

WELL SCREEN

END OF BORING

HPT BORING / TEMPORARY WELL (TRC 2018)

Lithology Key

- SAND
- SAND WITH GRAVEL
- CLAY
- SANDY CLAY
- SANDY SILT / SILTY SAND
- FILL

NOTE

1. STATIC WATER LEVEL REPRESENTS MAXIMUM GROUNDWATER ELEVATION OBSERVED BETWEEN FEBRUARY 2017 AND APRIL 2020.

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	GENERALIZED GEOLOGIC CROSS-SECTIONS A-A'
DRAWN BY:	D.STEHLE
CHECKED BY:	B.YELEN
APPROVED BY:	S.HOLMSTROM
DATE:	SEPTEMBER 2020
PROJ. NO.:	367390.0001.01.03
	FIGURE 3
FILE NO.:	367390.0001.01.03.03A Hydro.dwg

TRC

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Phone: 734.971.7080
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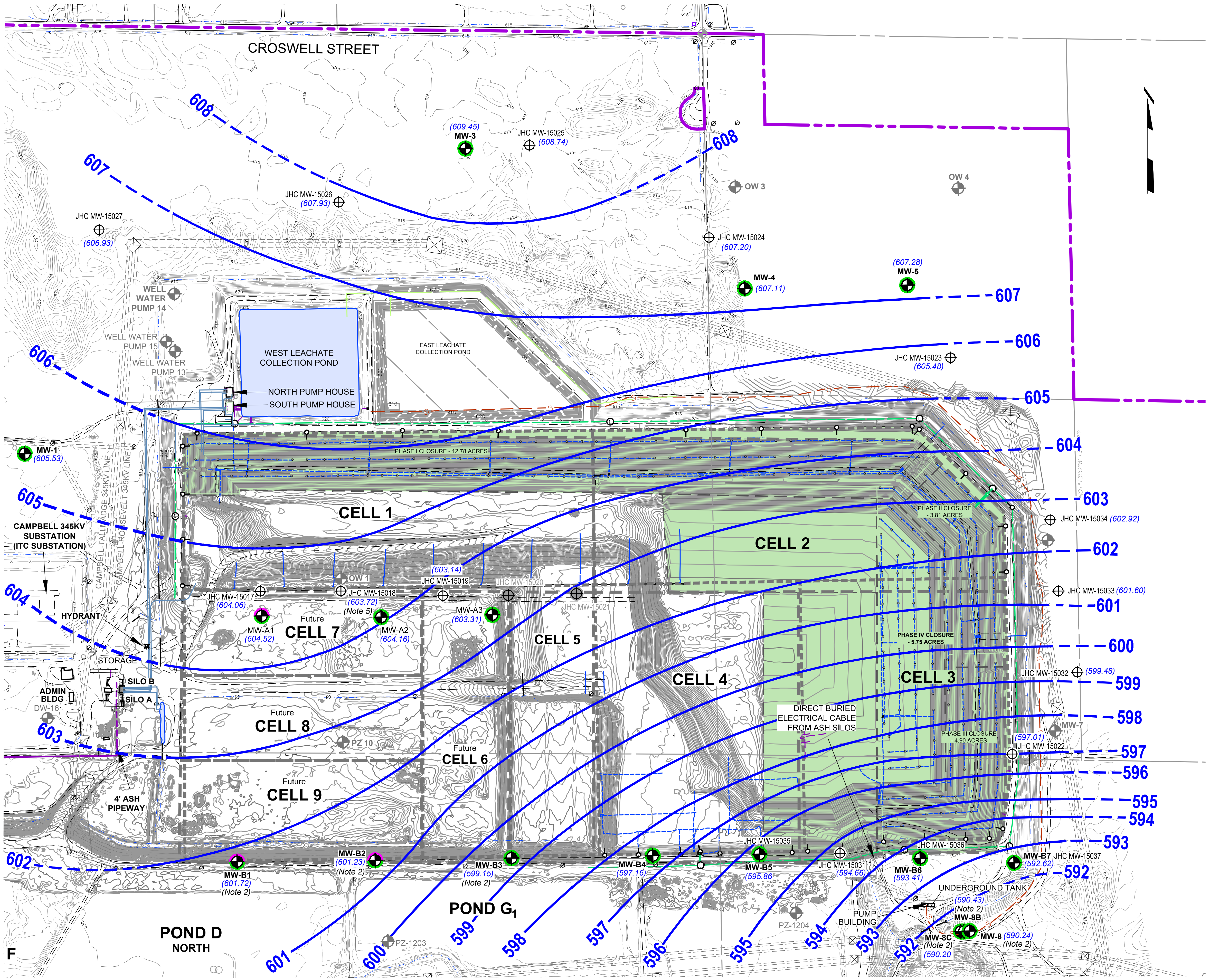

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SECTION LINE
- RAILROAD TRACKS
- CELL BOUNDARY
- FENCELINE
- DITCH
- UNPAVED ROAD OR DRIVE
- OVERHEAD POWER LINES
- ELECTRIC LINE
- SANITARY PIPE
- UTILITY
- LEACHATE PIPE
- ASH PIPE
- PIPELINE
- IRRIGATION PIPE
- WATER
- FACILITY COVER
- WETLAND
- POLE
- MW-7 — WELL
- JHC MW-15004 — RCRA MONITORING PROGRAM WELL
- JHC MW-15004 — DECOMMISSIONED RCRA MONITORING PROGRAM WELL
- MW-5 — DRY ASH LANDFILL HMP WELL
- PZ-23 — CELLS B-K HMP WELL
- RW-1 — RAP MONITORING WELL
- 600 — MAXIMUM GROUNDWATER CONTOUR LINE (DASHED WHERE INFERRED)
- (591.65) — GROUNDWATER ELEVATION

NOTES

1. BASEMAP DEVELOPED FROM CONSUMERS ENERGY, "CAMPBASE.DWG", DATED 02/10/2014 AND NEDERVELD "CAMPBELL PLANT MONITORING WELLS-CCR MONITORING", DATED 11/25/2015. PROVIDED BY CONSUMERS ENERGY.
2. HMP SENTINEL WELL
3. RAP SENTINEL WELL
4. STATIC WATER ELEVATIONS IN PLANT DATUM, NGVD 29.
5. NOT USED TO CONSTRUCT CONTOUR LINES.

0 360' 720'

APPROXIMATE SCALE IN FEET

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	GROUNDWATER CONTOUR MAP 2017-2020 MAXIMUM STATIC WATER ELEVATION
DRAWN BY: D.STEHLE	PROJ NO.: 367390.0001.01.03
CHECKED BY: B.YELEN	FIGURE 4
APPROVED BY: S.HOLMSTROM	
DATE: AUGUST 2020	

TRC

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Ann Arbor, MI 48108
Phone: 734.971.7080
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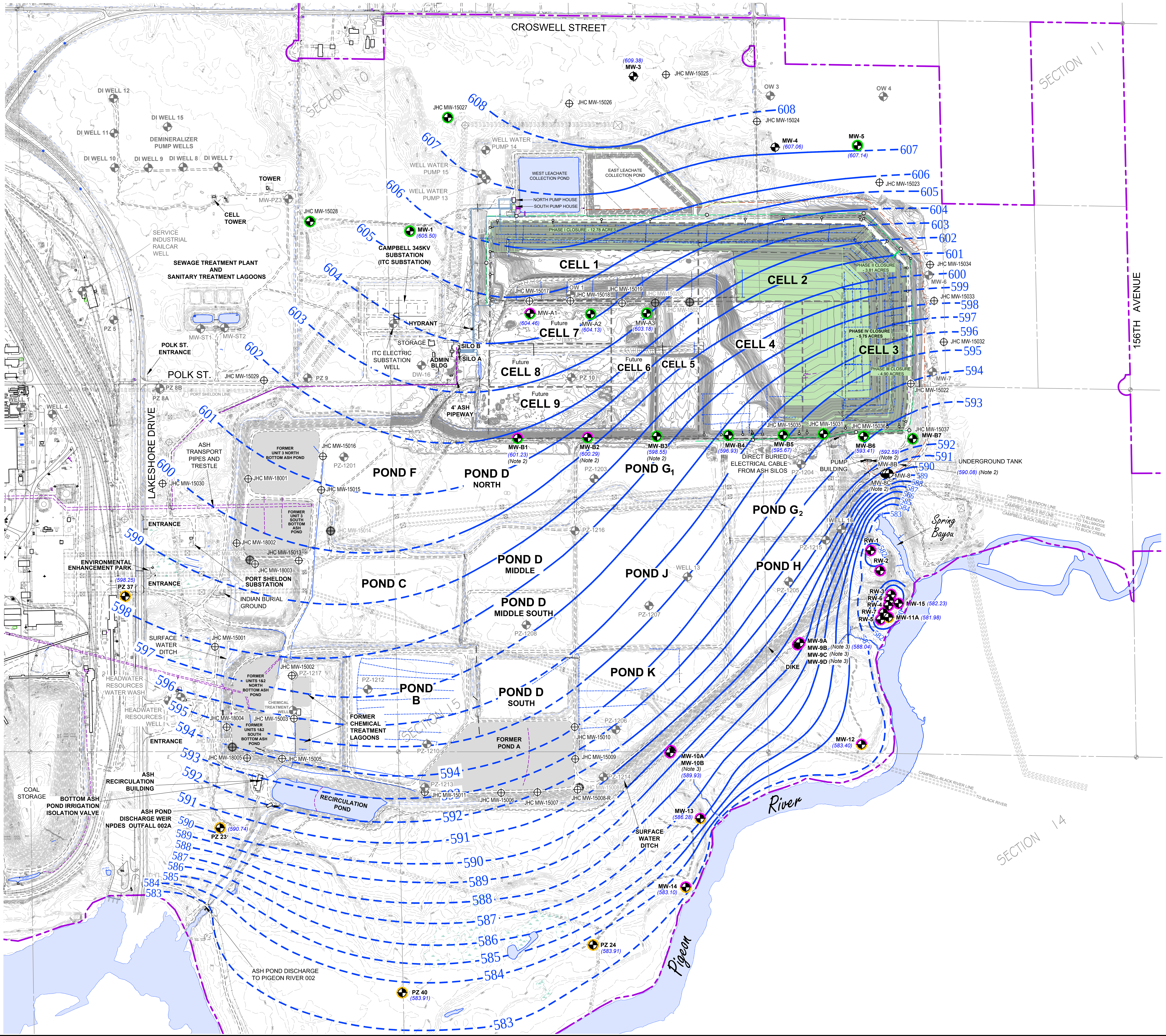
FILE NO.: 367390.0001.01.03.04 Hydro.dwg

11x17 — USER: DStehle — ATTACHED XREFS: Contours Misc; Contours Topo 2020-07-22 — ATTACHED IMAGES:
DRAWING NAME: J:_TRC\Consumers\JH Campbell\367390\0001\01\03\04 Hydro.dwg — PLOT DATE: August 21, 2020 - 11:26AM — LAYOUT: FIG04 2017-20 Static GW Elevs
Version: 2017-10-21



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SECTION LINE
- RAILROAD TRACKS
- CELL BOUNDARY
- FENCELINE
- DITCH
- UNPAVED ROAD OR DRIVE
- OVERHEAD POWER LINES
- ELECTRIC LINE
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- UTILITY
- LEACHATE PIPE
- ASH PIPE
- PIPELINE
- IRRIGATION PIPE
- WATER
- FACILITY COVER
- WETLAND
- POLE
- MW-1 MONITORING WELL
- MW-7 WELL
- JHC MW-15034 RCRA MONITORING PROGRAM WELL
- JHC MW-15004 DECOMMISSIONED RCRA MONITORING PROGRAM WELL
- MW-5 DRY ASH LANDFILL HMP MONITORING WELL
- PZ-23 CELLS B-K HMP WELL
- RW-1 RAP MONITORING WELL
- 607 GROUNDWATER CONTOUR LINE (DASHED WHERE INFERRED)
- (607.06) GROUNDWATER ELEVATION

NOTES

1. BASEMAP DEVELOPED FROM CONSUMERS ENERGY, "CAMPBASE.DWG", DATED 02/10/2014 AND NEDERVELD "CAMPBELL PLANT MONITORING WELLS-CCR MONITORING", DATED 11/25/2015. PROVIDED BY CONSUMERS ENERGY.
2. HMP SENTINAL WELL
3. RAP SENTINEL WELL
4. STATIC WATER ELEVATIONS IN PLANT DATUM, NGVD 29.

0 360' 720' 1080' 1440'

APPROXIMATE SCALE IN FEET

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	GROUNDWATER CONTOUR MAP APRIL 2020
DRAWN BY: D.STEHLE	PROJ. NO.: 367390.0001.01.03
CHECKED BY: B.YELEN	
APPROVED BY: S.HOLMSTROM	FIGURE 5
DATE: AUGUST 2020	

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
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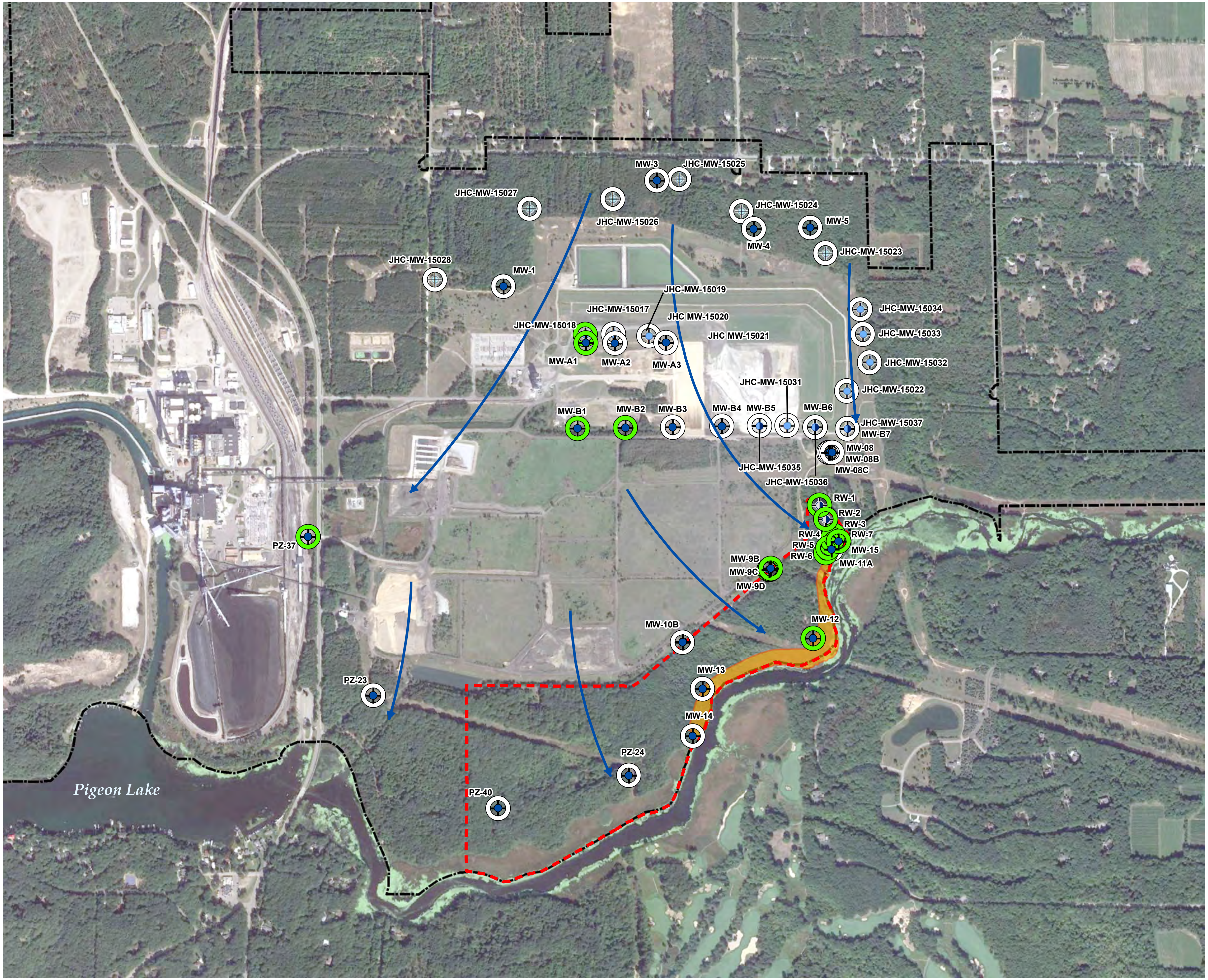
FILE NO.: 367390.0001.01.03.05 Hydro.dwg

DRAWING NAME: J:_TRC\Consumers\JH Campbell\367390\0001\01\03_Hydro Rpt\367390.0001.01.03.05 Hydro.dwg --- PLOT DATE: August 24, 2020 - 9:27AM --- LAYOUT: FIG05 GW Contour Map April 2020



LEGEND

- BACKGROUND MONITORING WELL
- DOWNGRADIENT LANDFILL MONITORING WELL
- DOWNGRADIENT LANDFILL MONITORING WELL AND HMP WELL
- HMP WELL
- RAP WELL
- NO EXCEEDANCES
- ONE OR MORE EXCEEDANCES
- APPROXIMATE DRINKING WATER RESTRICTED AREA
- SITE-SPECIFIC MIXING ZONE AREA FOR SELENIUM
  - Se CHRONIC GSI CRITERIA = 47 ug/L
  - Se ACUTE GSI CRITERIA = 120 ug/L
- PROPERTY BOUNDARY
- GROUNDWATER FLOW DIRECTION

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS BASED ON SURVEY DATA THROUGH 12/07/2018.
3. GROUNDWATER CONCENTRATIONS INCLUDED IN APPENDIX D OF THE DRY ASH LANDFILL HYDROGEOLOGICAL REPORT (TRC, AUGUST 2020) SHOWN IN COMPARISON TO MICHIGAN PART 201 GENERIC DRINKING WATER CLEANUP CRITERIA, DECEMBER 30, 2013.

0 1,500 3,000 Feet

1 " = 1,000 '
1:12,000

PROJECT:
CONSUMERS ENERGY COMPANY
JH CAMPBELL POWER PLANT
WEST OLIVE, MICHIGAN

TITLE:
MICHIGAN PART 201 DRINKING WATER CRITERIA EXCEEDANCES

DRAWN BY:	A. HORRIE	PROJ NO.:	322174-001
CHECKED BY:	K. LOWERY	**FIGURE 6**	
APPROVED BY:	S. HOLMSTROM		
DATE:	AUGUST 2020		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

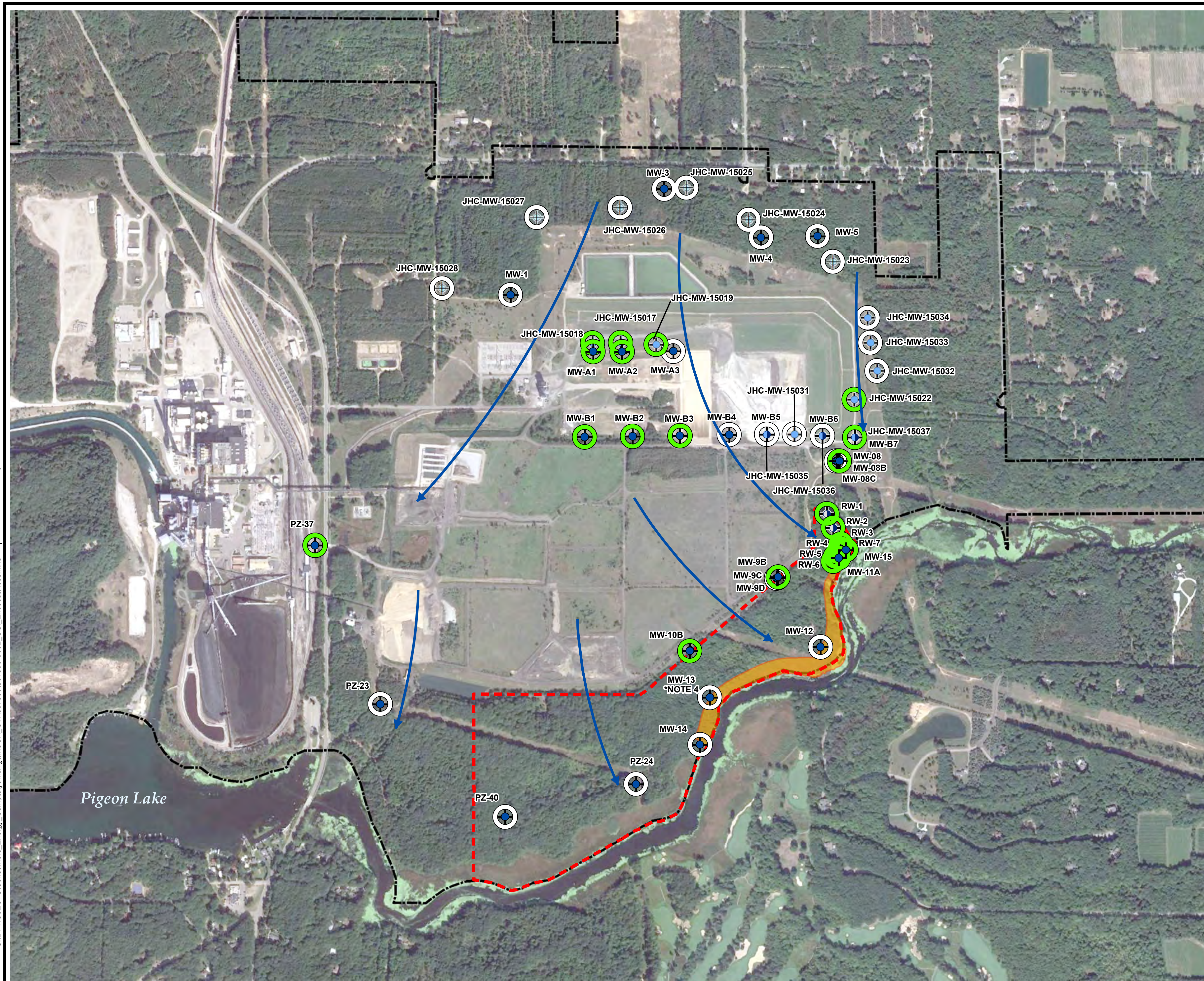
FILE NO.: 367390-0002_DW_Exceedances.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 8/25/2020, 09:33:52 AM by AHORRIE -- LAYOUT: ANSI B(11"x17")
Path: S:\1-PROJECTS\Consumers_Energy_Company\Michigan\CCR_GW\367390\367390-0002_DW_Exceedances.mxd

TRC - GIS



LEGEND

- BACKGROUND MONITORING WELL
- DOWNGRADIENT LANDFILL MONITORING WELL
- DOWNGRADIENT LANDFILL MONITORING WELL AND HMP WELL
- HMP WELL
- RAP WELL
- NO EXCEEDANCES
- ONE OR MORE EXCEEDANCES
- APPROXIMATE DRINKING WATER RESTRICTED AREA
- SITE-SPECIFIC MIXING ZONE AREA FOR SELENIUM
  - Se CHRONIC GSI CRITERIA = 47 ug/L
  - Se ACUTE GSI CRITERIA = 120 ug/L
- PROPERTY BOUNDARY
- GROUNDWATER FLOW DIRECTION

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS BASED ON SURVEY DATA THROUGH 12/07/2018.
3. GROUNDWATER CONCENTRATIONS INCLUDED IN APPENDIX D OF THE DRY ASH LANDFILL HYDROGEOLOGICAL REPORT (TRC, AUGUST 2020) SHOWN IN COMPARISON TO MICHIGAN PART 201 GENERIC GROUNDWATER SURFACE WATER INTERFACE (GSI) CLEANUP CRITERIA, DECEMBER 30, 2013, UPDATED JUNE 25, 2018.
4. CONCENTRATIONS ARE BELOW SITE-SPECIFIC MIXING ZONE VALUE.

0 1,000 2,000 Feet

1 " = 1,000 '

1:12,000

PROJECT:

CONSUMERS ENERGY COMPANY
JH CAMPBELL POWER PLANT
WEST OLIVE, MICHIGAN

TITLE:

MICHIGAN PART 201
GROUNDWATER SURFACE WATER INTERFACE
CRITERIA EXCEEDANCES

DRAWN BY:	A. HORRIE	PROJ NO.:	322174-001
CHECKED BY:	K. LOWERY		
APPROVED BY:	S. HOLMSTROM	**FIGURE 7**	
DATE:	AUGUST 2020		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 367390-0001_GSI_Exceedances.mxd

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 8/24/2020, 11:32:27 AM by AHORRIE -- LAYOUT: ANSI B(11"x17")
Path: S:\1-PROJECTS\Consumers_Energy_Company\Michigan\CCR_GW\367390\367390-0001_GSI_Exceedances.mxd

Appendix A
Soil Boring Logs and Well Construction Diagrams

Date Start: 9/18/15	**Northing:** 517781.423
Date Finish: 9/18/15	**Easting:** 12633905.01
Drilling Company: Mateco Drilling	**Casing Elevation:** 627.297
Driller's Name: John Pitsch	**Borehole Depth (ft. bgs.):** 40.0
Drilling Method: Air Knife/Sonic	**Surface Elevation:** 624.367
Sampling Method: Continuous	**Descriptions By:** A. Westhuis
Rig Type: Sonic	
Water Level Start (ft. bgs.): 29.0	
Water Level Finish (ft. btoc.): 33.26	

Well/Boring ID: **JHC MW-15005**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 70 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	625									TOC = 627.297 (ft. above msl)
0								(0.0 - 0.3') Grass, Topsoil.		Concrete (0.0-1.0' bgs)
								(0.3 - 10.0') ASH and SAND, fine to medium; trace granules, subrounded; moist; soft to stiff; poorly sorted; brown (10YR 5/3) to dark grayish brown (10YR 4/2). NOTE: Fill material.		
	620									
5		1	0.0-10.0'	10	NA					
	615									
10								(10.0 - 11.0') ASH; well sorted; medium stiff to stiff; moist; dark gray (10YR 4/1). NOTE: Fill material.		
								(11.0 - 13.0') SAND, medium, little to some fine sand, subrounded; trace silt; well sorted; dry; brown (10YR 5/3) to yellowish brown (10YR 5/4).		Bentonite/Cement Grout (1.0-23.0' bgs)
								(13.0 - 16.0') SAND, medium; little fine sand, subrounded; trace silt; well sorted; dry; very pale brown (10YR 7/4).		2" PVC Well Casing (-3.0-27.0' bgs)
	610									
15		2	10.0-20.0'	6	NA					
								(16.0 - 19.5') SAND, medium; trace fine, subrounded; trace silt; dry; light yellowish brown (10YR 6/4).		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 29.0' bgs during drilling.
Water level at development encountered at 33.26' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 595.77 feet

Date Start: 9/18/15 **Date Finish:** 9/18/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 29.0 **Water Level Finish (ft. btoc.):** 33.26	**Northing:** 517781.423 **Easting:** 12633905.01 **Casing Elevation:** 627.297 **Borehole Depth (ft. bgs.):** 40.0 **Surface Elevation:** 624.367 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15005** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 70 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	605							(19.5 - 19.8') SAND, medium; trace fine, subrounded; little to some silt; moist, brown (10YR 4/3).		
20								(19.8 - 29.0') SAND, medium, trace fine, subrounded; trace silt; well sorted; dry; very pale brown (10YR 7/4).		
	600									Bentonite Pellets (23.0-25.0' bgs)
25		3	20.0-30.0'	6	NA					
	595							(29.0 - 31.0') SAND, medium, little fine, trace coarse, subrounded; trace silt; well sorted; wet; pale brown (10YR 6/3).		
30									▼	
								(31.0 - 33.0') SAND, medium to coarse, little fine, subrounded; trace silt; well sorted; wet; pale brown (10YR 6/3).		Sand Pack K&E WP1 (25.0-40.0' bgs) 2" PVC 10 Slot Well Screen (27.0-37.0 bgs)
								(33.0 - 40.0') SAND, fine, some medium, subrounded; well sorted; wet; pale brown (10YR 6/3).		
	590									
35		4	30.0-40.0'	9	NA					
	585									Sand Pack K&E WP1 (37-40' bgs)
40								End of boring at 40.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 29.0' bgs during drilling.
Water level at development encountered at 33.26' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 595.77 feet

Date Start: 9/21/15
Date Finish: 9/21/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.28

Northing: 517540.502
Easting: 12635742.72
Casing Elevation: 627.697

Borehole Depth (ft. bgs.): 40.0
Surface Elevation: 624.817

Descriptions By: A. Westhuis

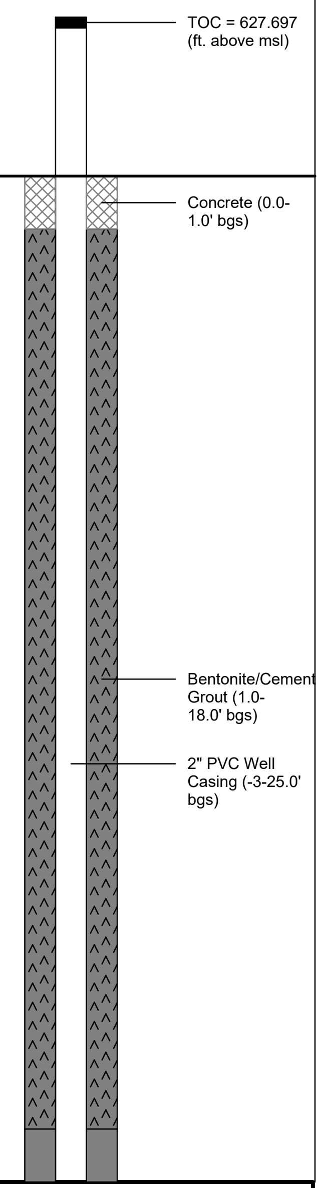
Well/Boring ID: **JHC MW-15007**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 75 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	0							(0.0 - 0.3') Grass, Topsoil.		
								(0.3 - 10.0') SAND, fine to medium, subrounded; trace silt; well sorted; dry to moist; light brownish gray (10YR 6/2).		
5	-5	1	0.0-10.0'	10	NA					
10	-10							(10.0 - 17.0') SAND, fine, trace to little medium, subrounded; little silt; well sorted; dry; light yellowish brown (10YR 6/4).		
15	-15	2	10.0-20.0'	8	NA					
								(17.0 - 17.5') SAND, very fine to fine, subrounded; little to some silt; well sorted; dry; very pale brown (10YR 7/3).		
								(17.5 - 40.0') SAND, fine to medium, subrounded; trace silt; well sorted; dry to moist; brownish yellow (10YR 6/6).		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 21.0' bgs during drilling.
Water level at development was 29.28' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.22 feet

Date Start: 9/21/15
Date Finish: 9/21/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.28

Northing: 517540.502
Easting: 12635742.72
Casing Elevation: 627.697

Borehole Depth (ft. bgs.): 40.0
Surface Elevation: 624.817

Descriptions By: A. Westhuis

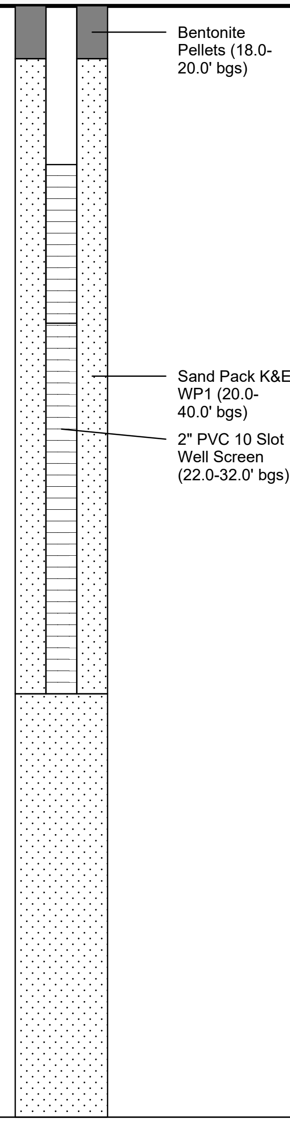
Well/Boring ID: JHC MW-15007

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 75 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
20	-20							NOTE: Wet at 21.0' bgs.		
25	-25	3	20.0-30.0'	5	NA					
30	-30									
35	-35	4	30.0-40.0'	5	NA					
40	-40							End of boring at 40.0' bgs.		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 21.0' bgs during drilling.
Water level at development was 29.28' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.22 feet

Date Start: 9/25/15
Date Finish: 9/28/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 23.92
Water Level Finish (ft. btoc.): 28.57

Northing: 519715.111
Easting: 12634186.63
Casing Elevation: 635.202

Borehole Depth (ft. bgs.): 40.0
Surface Elevation: 632.462

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15015

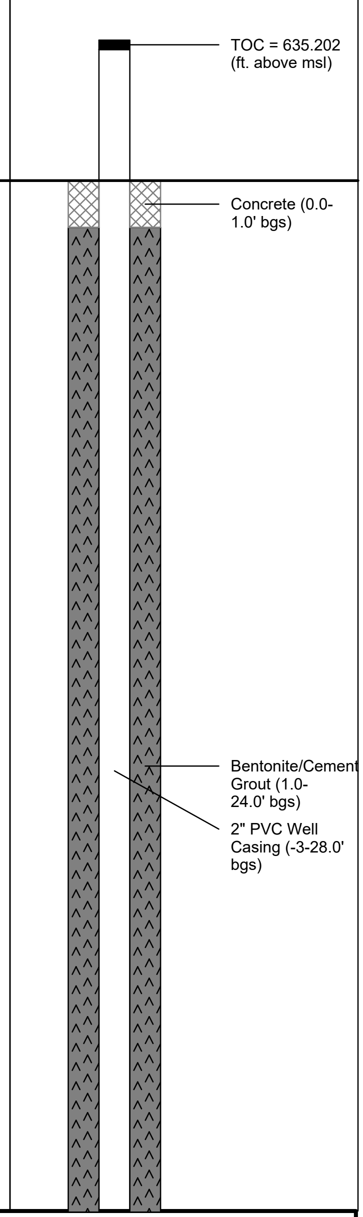
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 75 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	635								
0								(0.0 - 0.3') Grass, Topsoil.	
	630							(0.3 - 10.0') ASH; some sand, very fine to fine, trace medium, subrounded; well sorted; moist; medium stiff; gray (10YR 5/1). NOTE: Fill material.	
5		1	0.0-10.0'	5.0	NA				
	625								
10								(10.0 - 15.0') SAND, fine, little medium; subrounded; trace to little silt; well sorted; moist to wet; light brownish gray (10YR 6/2).	
	620								
15		2	10.0-20.0'	7.0	NA			(15.0 - 35.0') SAND, fine, little medium, subrounded; trace silt; well sorted; moist to wet; very pale brown (10YR 7/4).	
	615								
20									

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 23.92' bgs.
Water level at development was 28.57' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 607.68 feet

Date Start: 9/25/15
Date Finish: 9/28/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 23.92
Water Level Finish (ft. btoc.): 28.57

Northing: 519715.111
Easting: 12634186.63
Casing Elevation: 635.202

Borehole Depth (ft. bgs.): 40.0
Surface Elevation: 632.462

Descriptions By: A. Westhuis

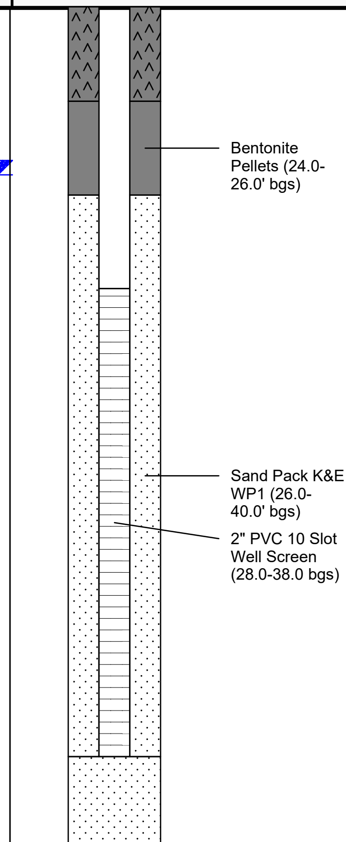
Well/Boring ID: **JHC MW-15015**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 75 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	610							NOTE: Wet at 23.92' bgs.		
25	605	3	20.0-30.0'	8.0	NA					
30	600									
35	595	4	30.0-40.0'	8.0	NA			(35.0 - 40.0') SAND, very fine to fine, subrounded; trace silt; well sorted; wet; pale brown (10YR 6/3).		
40								End of boring at 40.0' bgs.		



Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 23.92' bgs.
Water level at development was 28.57' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 607.68 feet

Date Start: 9/29/15
Date Finish: 9/29/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 12.0
Water Level Finish (ft. btoc.): 15.56

Northing: 521074.309
Easting: 12635685.32
Casing Elevation: 616.607

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 613.691

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15017**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									TOC = 616.607 (ft. above msl)
0								(0.0 - 0.3') Grass, Topsoil.		Concrete (0.0-1.0' bgs)
								(0.3 - 10.0') SAND, fine to medium, subrounded; trace silt; poorly sorted; dry; yellowish brown (10YR 4/3).		
	610									Bentonite/Cement Grout (1.0-6.0' bgs)
5		1	0.0-10.0'	4.0	NA					2" PVC Well Casing (-3-10.0' bgs)
										Bentonite Pellets (6.0-8.0' bgs)
	605									
10								(10.0 - 18.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10YR 6/3). NOTE: Wet at 12.0'.		
	600									Sand Pack K&E WP1 (8.0-20.0' bgs)
15		2	10.0-20.0'	7.0	NA					2" PVC 10 Slot Well Screen (10.0-20.0 bgs)
	595							(18.0 - 20.0') SAND, medium, little fine, subrounded; trace silt; well sorted; wet; pale brown (10YR 6/3). NOTE: Little small pebbles, subrounded.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs.
Water level at development was 15.56' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 596.00 feet

Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** 15.56	**Northing:** 521074.309 **Easting:** 12635685.32 **Casing Elevation:** 616.607 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 613.691 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15017** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
20										
								End of boring at 20.0' bgs.		

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs.
Water level at development was 15.56' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 596.00 feet

Date Start: 9/29/15
Date Finish: 9/29/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 12.0
Water Level Finish (ft. btoc.): 16.29

Northing: 521075.536
Easting: 12635979.61
Casing Elevation: 617.022

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 614.262

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15018

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									TOC Elevation = 617.022 (ft. above msl)
0								(0.0 - 0.3') Grass, Topsoil.		Concrete (0.0-1.0' bgs)
								(0.3 - 1.0') ASH and SAND, very fine to fine, well sorted; dry; light gray (10YR 7/2). NOTE: Fill material.		
								(1.0 - 10.0') SAND, fine, subrounded; well sorted; dry; brownish yellow (10YR 6/6).		Bentonite/Cement Grout (1.0-6.0' bgs)
	610									2" PVC Well Casing (-3-10.0' bgs)
5		1	0.0-10.0'	3.0	NA					Bentonite Pellets (6.0-8.0' bgs)
	605									
10								(10.0 - 17.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; very pale brown (10YR 7/3).		
								NOTE: Wet at 12.0' bgs.		
	600									Sand Pack K&E WP1 (8.0-20.0' bgs)
15		2	10.0-20.0'	7.0	NA					2" PVC 10 Slot Well Screen (10.0-20.0 bgs)
								(17.0 - 20.0') SAND, medium, little fine, subrounded; trace granules; subrounded; trace silt; well sorted; wet; very pale brown (10YR 7/4).		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
Water level at development was 16.29' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 600.45 feet

Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** 16.29	**Northing:** 521075.536 **Easting:** 12635979.61 **Casing Elevation:** 617.022 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 614.262 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15018** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	595									
20								End of boring at 20.0' bgs.		

ARCADIS Design & Consultancy for natural and built assets

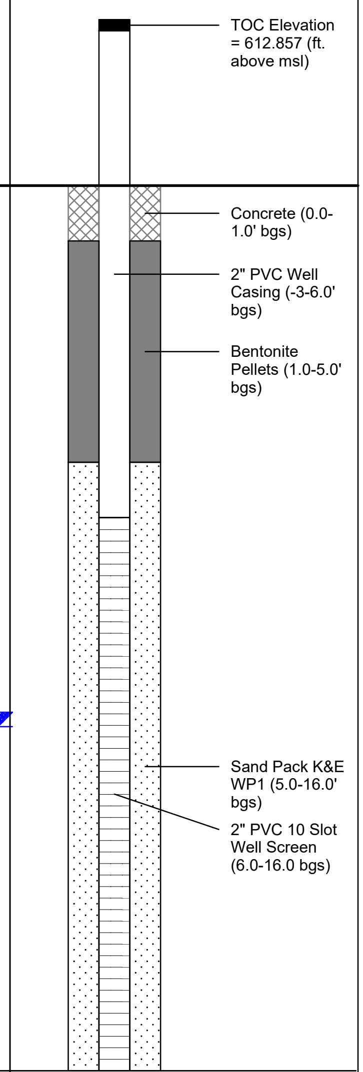
Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
Water level at development was 16.29' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 600.45 feet

Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 8.5 **Water Level Finish (ft. btoc.):** 12.78	**Northing:** 521058.673 **Easting:** 12636352 **Casing Elevation:** 612.857 **Borehole Depth (ft. bgs.):** 16.0 **Surface Elevation:** 609.812 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15019** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy, light rain

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	610							(0.0 - 0.3') Grass, Topsoil.	
		1	0.0-10.0'	4.0	NA			(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; dark yellowish brown (10YR 4/4). NOTE: Wet at 8.5' bgs.	
5	605								
10	600							(10.0 - 12.0') SAND, fine, subrounded; little silt; well sorted; wet; brown (10YR 4/3).	
		2	10.0-16.0'	7.0	NA			(12.0 - 16.0') SAND, fine, subrounded; trace silt; well sorted; wet; brownish yellow (10YR 6/6).	
15	595								
								End of boring at 16.0' bgs.	

Well/Boring Construction



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Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 8.5' bgs during drilling.
Water level at development was 12.78' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.87 feet

Date Start: 9/30/15
Date Finish: 9/30/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.39

Northing: 520479.719
Easting: 12638430.24
Casing Elevation: 623.792

Borehole Depth (ft. bgs.): 33.0
Surface Elevation: 620.917

Descriptions By: A. Westhuis

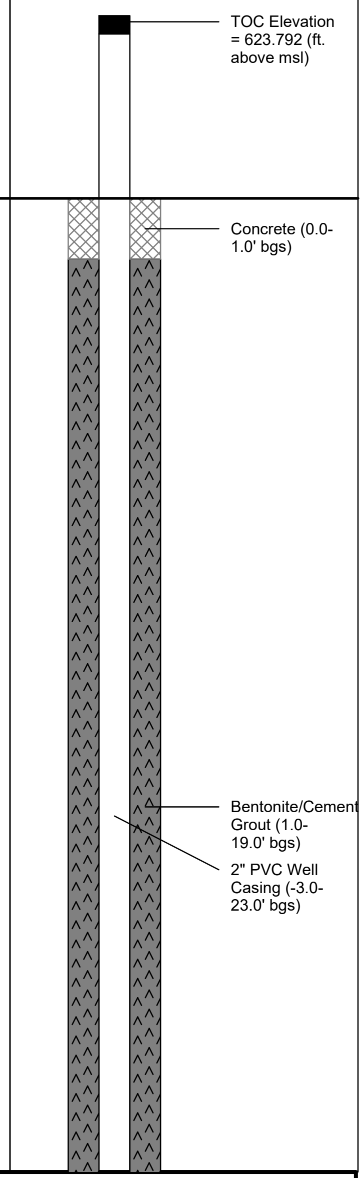
Well/Boring ID: **JHC MW-15022**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0								(0.0 - 0.3') TOPSOIL; grass.		
	620							(0.3 - 10.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry to moist; dark yellowish brown (10 YR 4/6).		
5	615	1	0-10'	5	NA					
10	610							(10.0 - 21.0') SAND, fine, subrounded; little very fine sand; trace granules, subrounded; trace silt; well sorted; moist to wet; yellowish brown (10 YR 5/6).		
15	605	2	10-20'	4	NA					



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Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 29.39' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 594.34 feet

Date Start: 9/30/15
Date Finish: 9/30/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.39

Northing: 520479.719
Easting: 12638430.24
Casing Elevation: 623.792

Borehole Depth (ft. bgs.): 33.0
Surface Elevation: 620.917

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15022

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
20	600									Bentonite Pellets (19.0-21.0' bgs)
25	595	3	20-30'	5	NA			(21.0 - 29.0') SAND, fine to medium, subrounded; trace granules, subrounded; well sorted; wet; yellowish brown (10 YR 5/4).		Sand Pack K&E WP1 (21.0-33.0' bgs); 2" PVC 10 Slot Well Screen (23.0-33.0' bgs)
30	590	4	30-33'	3	NA			(29.0 - 33.0') SAND, very fine to fine, subrounded; trace silt; well sorted; wet; yellowish brown (10 YR 5/4).		
35	585							End of boring at 33.0' bgs.		

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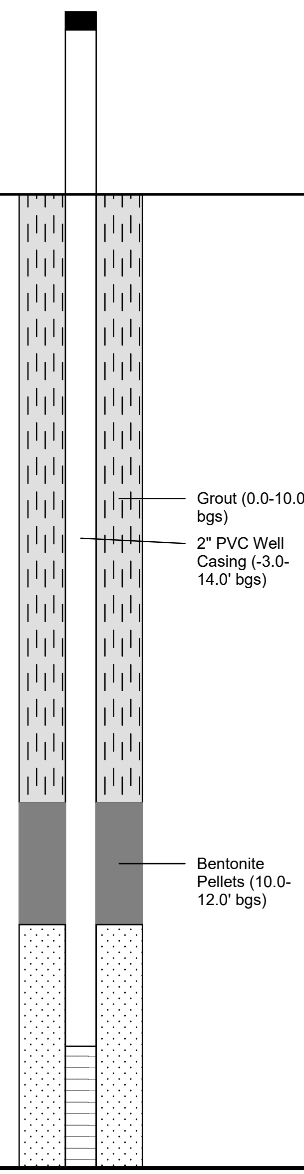
Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 29.39' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 594.34 feet

Date Start: 10/1/15 **Date Finish:** 10/1/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** NA **Water Level Finish (ft. btoc.):** NA	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth (ft. bgs.):** 25.0 **Surface Elevation:** NA **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC-MW-15023** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	0							(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 10.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3). Note: Trace wood fragments from 7.0 to 10.0' bgs.		
5	-5	1	0-10'	10	NA					
10	-10							(10.0 - 16.0') SAND, very fine to fine, subrounded; trace to little silt; well sorted; dry to moist; brownish yellow (10 YR 6/8).		
15	-15	2	10-20'	8	NA					



Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
No odor or staining observed.

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Date Start: 10/1/15
Date Finish: 10/1/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: NA

Descriptions By: A. Westhuis

Well/Boring ID: **JHC-MW-15023**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
								(16.0 - 17.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist; yellow (10 YR 7/6).		
								(17.0 - 18.0') SAND, fine, subrounded; trace silt; well sorted; moist; brownish yellow (10 YR 6/6).		Sand Pack K&E WP1 (12.0-25.0' bgs)
20	-20							(18.0 - 21.0') SAND, very fine; little fine sand, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).		2" PVC 10 Slot Well Screen (14.0-24.0' bgs)
		3	20-25'	4	NA			(21.0 - 25.0') SAND, medium; trace fine sand, subangular; trace granules, subangular; poorly sorted; wet; pale brown (10 YR 6/3).		
25	25							End of boring at 25.0' bgs.		
30	-30									
35	-35									

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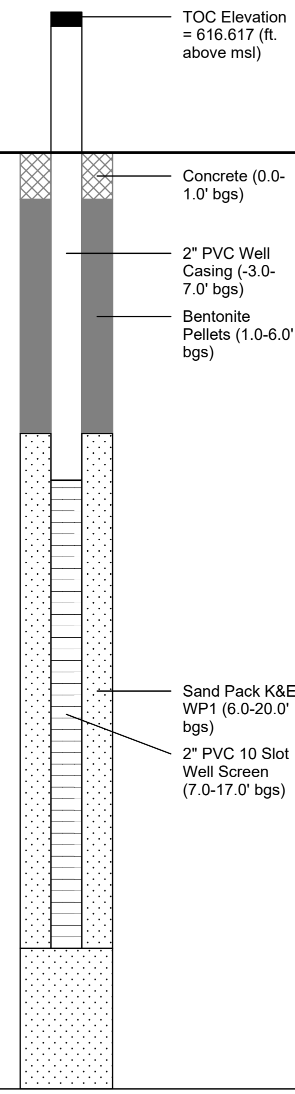
Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
No odor or staining observed.

Date Start: 10/1/15 **Date Finish:** 10/1/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 10.0 **Water Level Finish (ft. btoc.):** NA	**Northing:** 522366.013 **Easting:** 12637322.68 **Casing Elevation:** 616.617 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 613.787 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15024** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									
0								(0.0 - 0.3') TOPSOIL; grass.		
5	610	1	0-10'	4	NA			(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; brownish yellow (10 YR 6/6). NOTE: Wet at 10.0' bgs.		
10	605									
15	600	2	10-20'	9	NA			(10.0 - 20.0') SAND, fine to medium, subrounded; trace to little very fine sand; trace silt; well sorted; wet; pale brown (10 YR 6/3).		
20	595							End of boring at 20.0' bgs.		



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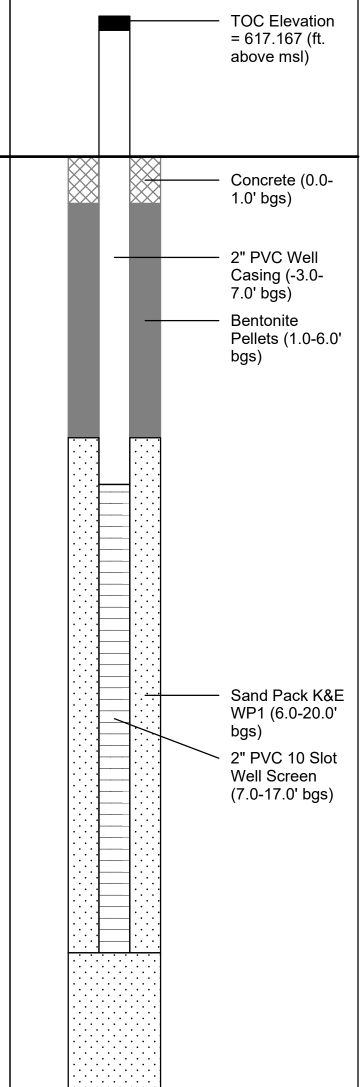
Remarks: bgs= below ground surface.

Air knife to 10.0' bgs.
Groundwater encountered at 10.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 602.24 feet above mean sea level.

Date Start: 10/1/15 **Date Finish:** 10/1/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** NA	**Northing:** 522702.978 **Easting:** 12636668.15 **Casing Elevation:** 617.167 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 614.137 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15025** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	615								
0		1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 5.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
5	610							(5.0 - 12.0') SAND, fine, subrounded; trace silt; well sorted; dry; brownish yellow (10 YR 6/6). Note: Color change to brownish yellow (10YR 6/8) at 6.0' bgs.	
10	605	2	10-20'	8	NA			(12.0 - 15.0') SAND, fine, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).	
15	600							(15.0 - 16.0') SAND, fine to medium, subrounded; trace coarse sand, subrounded; trace granules, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).	
								(16.0 - 20.0') SAND, very fine to fine, subrounded; little silt; well sorted; wet; pale brown (10 YR 6/3).	
20	595							End of boring at 20.0' bgs.	

Well/Boring Construction



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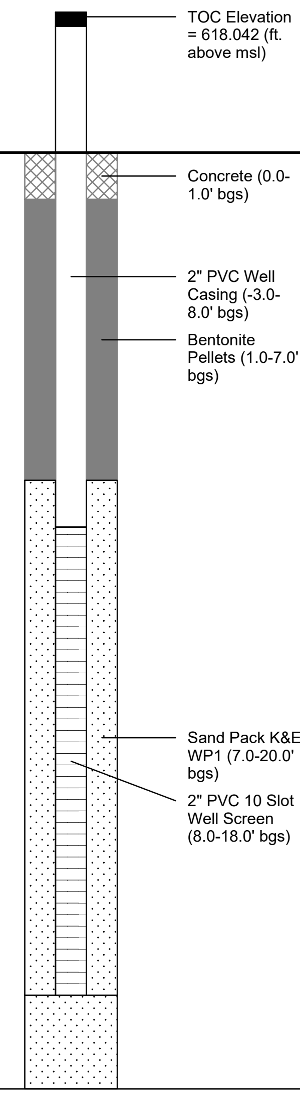
Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 603.36 feet above mean sea level.

Date Start: 10/2/15 **Date Finish:** 10/2/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** NA	**Northing:** 522495.091 **Easting:** 12635971.82 **Casing Elevation:** 618.042 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 615.087 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15026** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 45F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	615							(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 3.0') SAND, fine, subrounded; trace medium sand, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		
								(3.0 - 8.0') SAND, fine, subrounded; trace silt; well sorted; dry; brownish yellow (10 YR 6/6).		
5	610	1	0-10'	10	NA					
								(8.0 - 12.0') SAND, fine, subrounded; little very fine sand, subrounded; trace silt; well sorted; dry; pale brown (10 YR 6/3) to brownish yellow (10YR 6/6).		
10	605									
								(12.0 - 20.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).		
15	600	2	10-20'	6	NA					
20	595							End of boring at 20.0' bgs.		



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Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 602.32 feet above mean sea level.

Date Start: 10/2/15 **Date Finish:** 10/2/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 13.0 **Water Level Finish (ft. btoc.):** 15.85	**Northing:** 522394.86 **Easting:** 1235097.51 **Casing Elevation:** 617.302 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 614.767 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15027** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 50F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									TOC Elevation = 617.302 (ft. above msl)
0		1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass.		Concrete (0.0-1.0' bgs)
								(0.3 - 2.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; dark yellowish brown (10 YR 4/6).		2" PVC Well Casing (-3.0-10.0' bgs)
								(2.0 - 6.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		Bentonite Pellets (1.0-8.0' bgs)
5	610							(6.0 - 16.0') SAND, fine, subrounded; trace silt; well sorted; dry; yellow (10YR 7/6). Note: Wet at 13.0' bgs.		
10	605	2	10-20'	8	NA					Sand Pack K&E WP1 (8.0-20.0' bgs)
15	600							(16.0 - 20.0') SAND, fine; trace medium sand, subrounded; well sorted; wet; pale brown (10 YR 6/3).		2" PVC 10 Slot Well Screen (10.0-20.0' bgs)
20	595							End of boring at 20.0' bgs.		

Remarks: bgs= below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 13.0' bgs during drilling.
Water level at development was 15.85' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 601.04 feet

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Date Start: 10/2/15 **Date Finish:** 10/2/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Air knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 9.0 **Water Level Finish (ft. btoc.):** 14.38	**Northing:** 521646.198 **Easting:** 12634105.34 **Casing Elevation:** 613.8 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 611.025 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15028** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0							(0.0 - 0.3') TOPSOIL; grass.		TOC Elevation = 613.80 (ft. above msl)
610							(0.3 - 5.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; yellowish (10 YR 7/8).		Concrete (0.0-1.0' bgs) Bentonite/Cement Grout (1.0-4.0' bgs) 2" PVC Well Casing (-3.0-8.0' bgs)
5	1	0-10'	10	NA					Bentonite Pellets (4.0-6.0' bgs)
605							(5.0 - 9.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; pale brown (10 YR 6/3).		
10							(9.0 - 20.0') SAND, medium; trace to little very fine to fine sand, subrounded; trace silt; poorly sorted; moist to wet; pale brown (10 YR 6/3).		
600								▼	Sand Pack K&E WP1 (6.0-20.0' bgs) 2" PVC 10 Slot Well Screen (8.0-18.0' bgs)
15	2	10-20'	9	NA					
595									
20							End of boring at 20.0' bgs.		
590									

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Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 9.0' bgs during drilling.
Water level at development was 14.38' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 599.00 feet

Date Start: 10/5/15
Date Finish: 10/5/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 5.0
Water Level Finish (ft. btoc.): 7.99

Northing: 519760.827
Easting: 12633044.37
Casing Elevation: 607.167

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 604.047

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15030**

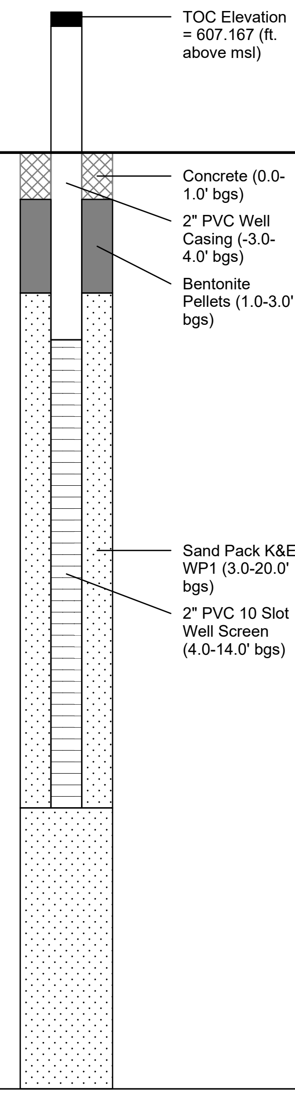
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, Light Rain, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	605								
0								(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; dark brown (10 YR 3/3) to very pale brown (10YR 7/3).	
	600								
5		1	0-10'	3	NA			NOTE: Wet at 5.0' bgs.	▼
	595								
10								(10.0 - 20.0') SAND, fine, subrounded; little medium sand, subrounded; trace silt; well sorted; wet; very pale brown (10 YR 7/3) to light gray (10YR 7/2).	
	590								
15		2	10-20'	6	NA				
	585								
20								End of boring at 20.0' bgs.	

Well/Boring Construction



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Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 5.0' bgs during drilling.
Water level at development was 7.99' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 599.65 feet

Date Start: 10/5/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): 43.20

Northing: 520118.003
Easting: 12637801.51
Casing Elevation: 635.872

Borehole Depth (ft. bgs.): 45.0
Surface Elevation: 632.937

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15031**

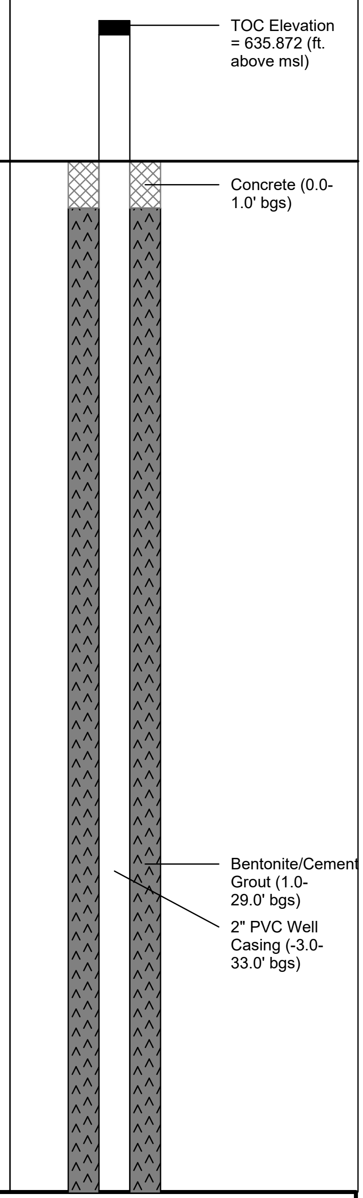
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	635								
0								(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 2.0') SAND, fine, subrounded; trace silt; well sorted; dry; dark grayish brown (10 YR 4/2).	
	630							(2.0 - 5.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
5		1	0-10'	10	NA			(5.0 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; pale brown (10 YR 6/3).	
	625								
10								(10.0 - 19.0') SAND, fine, subrounded; trace silt; well sorted; moist; brown (10 YR 5/3).	
	620								
15		2	10-20'	6	NA				
	615								
								(19.0 - 25.0') SAND, fine, subrounded; trace medium sand, subrounded; trace silt; well sorted; moist; yellowish brown (10 YR 5/4).	
20									

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

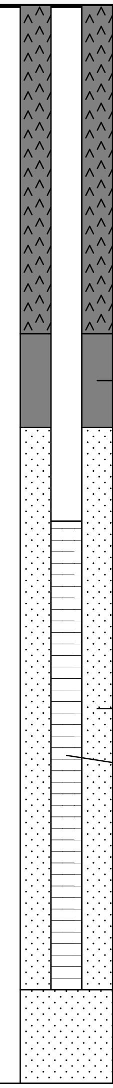
Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 36.0' bgs during drilling.
Water level at development was 43.20' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 592.53 feet

Date Start: 10/5/15 **Date Finish:** 10/6/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 36.0 **Water Level Finish (ft. btoc.):** 43.20	**Northing:** 520118.003 **Easting:** 12637801.51 **Casing Elevation:** 635.872 **Borehole Depth (ft. bgs.):** 45.0 **Surface Elevation:** 632.937 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15031** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Cloudy, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	610								
25		3	20-30'	8	NA			(25.0 - 36.0') SAND, very fine to fine, subrounded; trace silt; well sorted; very pale brown (10 YR 7/3).	
	605								
30									
	600								
35		4	30-40'	8	NA				
								(36.0 - 45.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; pale brown (10 YR 6/3). NOTE: Wet at 36.0' bgs.	
	595								
40									
	590	5	40-45'	5	NA				
45								End of boring at 45.0' bgs.	
	585								

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 36.0' bgs during drilling.
Water level at development was 43.20' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 592.53 feet

Date Start: 10/6/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 16.0
Water Level Finish (ft. btoc.): 17.88

Northing: 520779.281
Easting: 12638667.93
Casing Elevation: 614.287

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: 611.322

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15032**

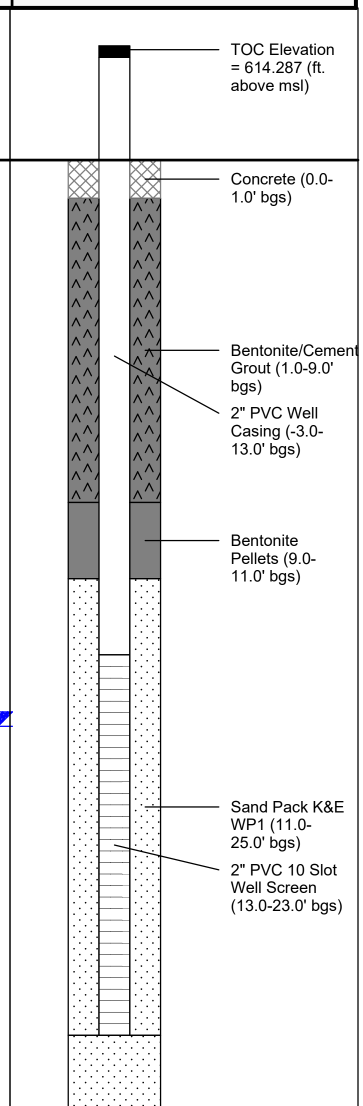
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	615								
0								(0.0 - 0.3') TOPSOIL; grass.	
	610							(0.3 - 2.5') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3).	
								(2.5 - 11.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
5	605	1	0-10'	10	NA				
10	600							(11.0 - 21.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).	
15	595	2	10-20'	7	NA			NOTE: Wet at 16.0' bgs.	16.0
20	590	3	20-25'	5	NA			(21.0 - 25.0') SAND, fine to medium, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).	
25	585							End of boring at 25.0' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 16.0' bgs during drilling.
Water level at development was 17.88' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 595.41 feet

Date Start: 10/6/15 **Date Finish:** 10/6/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 19.0 **Water Level Finish (ft. btoc.):** 22.93	**Northing:** 521075.809 **Easting:** 12638598.12 **Casing Elevation:** 620.987 **Borehole Depth (ft. bgs.):** 30.0 **Surface Elevation:** 618.082 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15033** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Cloudy, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0–10	620–610	1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass. (0.3 - 0.8') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3). (0.8 - 2.0') SAND, fine, subrounded; trace silt; well sorted; dry; yellowish brown (10 YR 5/6). (2.0 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		
10–20	605–600	2	10-20'	6	NA			(10.0 - 20.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist; yellowish brown (10 YR 5/4). NOTE: Wet at 19.0' bgs.	19.0	
20–30	595–590	3	20-30'	6	NA			(20.0 - 30.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; moist to wet; very pale brown (10 YR 6/3).		
30								End of boring at 30.0' bgs.		

Well/Boring Construction:
- TOC Elevation = 620.987 (ft. above msl)
- Concrete (0.0-1.0' bgs)
- Bentonite/Cement Grout (1.0-12.0' bgs)
- 2" PVC Well Casing (-3.0-16.0' bgs)
- Bentonite Pellets (12.0-14.0' bgs)
- Sand Pack K&E WP1 (14.0-30.0' bgs)
- 2" PVC 10 Slot Well Screen (16.0-26.0' bgs)

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 19.0' bgs during drilling.
Water level at development was 22.93' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 598.05 feet

Date Start: 10/6/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 13.0
Water Level Finish (ft. btoc.): 16.87

Northing: 521335.834
Easting: 12638568.9
Casing Elevation: 615.972

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: 612.902

Descriptions By: A. Westhuis

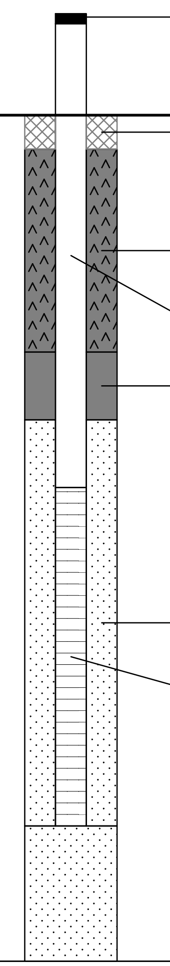
Well/Boring ID: JHC MW-15034

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	612.9	1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 0.8') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3).		
								(0.8 - 1.5') SAND, fine, subrounded; trace silt; well sorted; dry; yellowish brown (10 YR 5/6).		
								(1.5 - 13.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		
10		2	10-20'	5	NA					
13								(13.0 - 25.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).	13.0	
20		3	20-25'	5	NA					
25								End of boring at 25.0' bgs.		



Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 16.87' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.07 feet

ARCADIS Design & Consultancy for natural and built assets

Date Start: 3/14/01
Date Finish: 3/14/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 634.89

Borehole Depth (ft. bgs.): 43.5
Surface Elevation: NA

Descriptions By: Rebecca J. Koepke

Well/Boring ID: **JHC MW-15035**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	625									TOC = 634.89 (ft. above msl)
0								(0.0 - 0.5') SANDY ORGANIC SOIl, very dark brown, very fine to fine, loose, moist.		Concrete (0.0-1.0' bgs)
								(0.5 - 30.5') SAND, brownish yellow (10YR 6/8), poorly graded, fine, trace silt, round, loose, slightly moist.		
	620									
5		1	5.0-7.0'	0.9	NA					
	615									
10		2	10.0-12.0'	1.6	NA					
	610									
15		3	15.0-17.0'	1.6	NA					2" PVC Well Casing (-3.0-33.0' bgs)
										Bentonite Chips (1.0-31.0' bgs)
	605									
20								NOTE: Brownish yellow (10YR 6/6)		

Remarks: bgs = below ground surface
btoc = below top of casing

Groundwater encountered at 36.0' bgs during drilling.
No odor or staining observed.

Date Start: 3/14/01
Date Finish: 3/14/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 634.89
Borehole Depth (ft. bgs.): 43.5
Surface Elevation: NA
Descriptions By: Rebecca J. Koepke

Well/Boring ID: **JHC MW-15035**
Client: Consumers Energy
Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460
Weather Conditions: NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
		4	20.0-22.0'	1.8	NA					
25	600	5	25.0-27.0'	1.8	NA					
30	595	6	30.0-32.0'	1.3	NA			NOTE: Yellow (10YR 7/6) NOTE: Very pale brown (10YR 7/4)		
35	590	7	35.0-37.0'	1.8	NA			NOTE: Wet at 36.0' bgs	▼	Sand Pack Flat Rock #30 (31.0-43.5' bgs) 2" PVC 10 Slot Well Screen (33.0-43.0 bgs)
40	585									
45	580							End of boring at 43.5' bgs.		

Remarks: bgs = below ground surface
btoc = below top of casing

Groundwater encountered at 36.0' bgs during drilling.
No odor or staining observed.

ARCADIS Design & Consultancy for natural and built assets

Date Start: 3/13/01
Date Finish: 3/13/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 615.90

Borehole Depth (ft. bgs.): 30.5
Surface Elevation: NA

Descriptions By: Rebecca J. Koepke

Well/Boring ID: JHC MW-15036

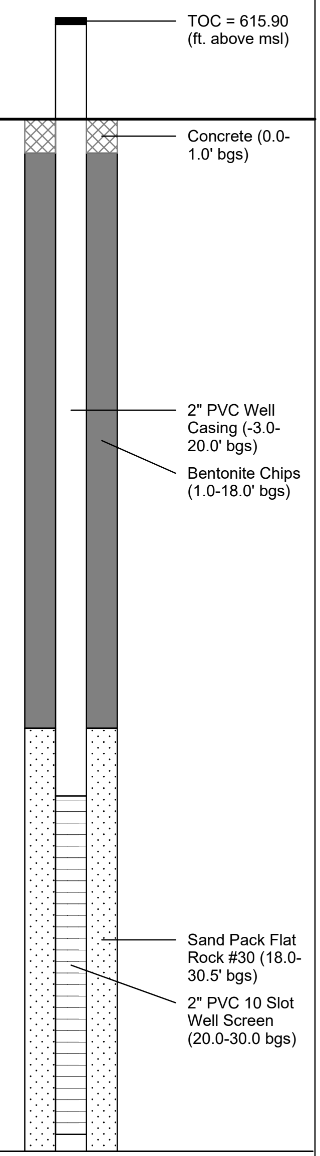
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	625								
0								(0.0 - 0.5') SANDY ORGANIC SOIl, very dark brown, very fine to fine, loose, moist.	
								(0.5 - 30.5') SAND, very pale brown (10YR 7/4), poorly graded, fine, trace silt, round, loose, slightly moist.	
5	620	1	5.0-7.0'	0.9	NA				
10	615	2	10.0-12.0'	1.6	NA			NOTE: Very fine.	
15	610	3	15.0-17.0'	1.6	NA			NOTE: Very pale brown (10YR 8/3), fine.	
20	605	4	20.0-22.0'	1.8	NA			NOTE: Fine to medium, moist.	
25	600	5	25.0-27.0'	1.8	NA				
30	595								
								End of boring at 30.5' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

No odor or staining observed.

Date Start: 8/29/01
Date Finish: 8/29/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 613.42

Borehole Depth (ft. bgs.): 28.5
Surface Elevation: NA

Descriptions By: Rebecca J. Koepke

Well/Boring ID: **JHC MW-15037**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: NA

DEPTH (feet bgs.) / ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
625									TOC = 613.42 (ft. above msl)
0	1	0.0-2.0'	1.5	NA			(0.0 - 1.0') SAND, semi compact, dark, organic, clayey, fine, moist.		Concrete (0.0-1.0' bgs)
							(1.0 - 2.0') SAND, loose, tan, fine, trace silt, moist.		
	2	2.0-4.0'	1.96	NA			(2.0 - 3.0') SAND, medium compact, light brown, fine, trace clay, moist.		
							(3.0 - 28.5') SAND, loose, tan, fine, trace silt, moist.		
620 / 5	3	4.0-6.0'	1.5	NA					
	4	6.0-8.0'	1.4	NA					
615 / 10	5	8.0-10.0'	1.0	NA					
	6	10.0-12.0'	1.2	NA					Bentonite Grout (1.0-20.0' bgs); 2" PVC Well Casing (-3.0-26.0' bgs)
	7	12.0-14.0'	1.5	NA					
610 / 15	8	14.0-16.0'	1.2	NA					
	9	16.0-18.0'	NA	NA					
605 / 20	10	18.0-20.0'	1.0	NA					
	11	20.0-22.0'	1.6	NA					Bentonite Pellets (20.0-21.0' bgs)
	12	22.0-24.0'	1.5	NA			NOTE: Wet at 22.0' bgs, grades to light brown.		
600 / 25	13	24.0-26.0'	1.5	NA					Sand Pack (21.0-28.5' bgs); 2" PVC 10 Slot Well Screen (23.0-28.0' bgs)
	14	26.0-28.0'	1.8	NA					
595 / 30							End of boring at 28.5' bgs.		

Remarks: bgs = below ground surface
btoc = below top of casing

Groundwater encountered at 22.0' bgs during drilling.
No odor or staining observed.

ARCADIS Design & Consultancy for natural and built assets

STS Consultants Ltd.

CLIENT
CONSUMERS POWER COMPANY

LOG OF BORING NUMBER MW-1

PROJECT NAME
CAMPBELL ASH STORAGE FACILITY EXPANSION

ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 611.9 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION BLOWS/FT.
	1	SS	Sandy topsoil, trace silt, roots and organics - dark brown - very loose to loose - moist. (SP)	1/6
	1A	SS		5
		HS	Fine sand, trace silt and roots - brown - loose - moist to saturated. (SP)	
	2	SS		5
5.0		HS		
	3	SS		7
		HS		
	4	SS		5
10.0		HS		
	5	SS		4
		HS		
		HS	Fine to medium sand, trace silt - brown - loose to medium dense - saturated. (SP)	
15.0	6	SS		14
		HS		
20.0				
	7	SS		9
22.0				

END OF BORING

Boring advanced with hollow stem augers.
Monitoring well installed. Screen set from 11.5 to 14.5 feet. See Monitor Well Installation Diagram for As-Built Details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 6.0 ft	WS OR WD WS	BORING STARTED 06/07/92	STS OFFICE Lansing-07
WL BCR	ACR	BORING COMPLETED 06/07/92	ENTERED BY DAP / SHEET NO. 1 OF 1
WL 7.61 ft @ 1 hr AB		RIG/FOREMAN CME/550	APP'D BY JSM / STS JOB NO. 72150A

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY

LOG OF BORING NUMBER: MW-2

PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION

ARCHITECT-ENGINEER:

SITE LOCATION: WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 615.9 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION BLOWS/FT.
	1	SS	Sandy topsoil, trace silt, roots and organics - dark brown - very loose to loose - moist. (SP)	2
	1A	SS		3
		HS	Fine sand, trace silt and roots - brown - very loose to loose - moist to saturated. (SP)	
	2	SS		4
5.0		HS		
	3	SS		6
		HS		
	4	SS		3
10.0		HS		
	5	SS		2
		HS		
15.0	6	SS		8
		HS		
		HS	Fine sand, trace silt - brown - medium dense - saturated. (SP)	
20.0	7	SS		15
22.0				

END OF BORING

Boring advanced with hollow stem augers.
Monitoring well installed. Screen set from 12.0 to 15.0 feet. See Monitor Well Installation Diagram for As-Built Details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 7.0 ft WS OR WD WS	BORING STARTED 06/11/92	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 06/11/92	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN CME550/BP	APP'D BY JSM	STS JOB NO. 72150A

STS Consultants Ltd.	CLIENT CONSUMERS POWER COMPANY	LOG OF BORING NUMBER MW-3
	PROJECT NAME CAMPBELL ASH STORAGE FACILITY EXPANSION	ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % × - - - - WATER CONTENT % ● - - - - LIQUID LIMIT % △
10 20 30 40 50

⊗ STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION BLOWS/FT.
						SURFACE ELEVATION 615.2 ft	
		1	SS			Sandy topsoil, trace silt, roots and organics - dark brown - very loose - moist. (SP)	1
		1A	SS			Fine sand, trace silt - brown - very loose to loose - moist to saturated. (SP)	2
			HS				
		2	SS				5
5.0			HS				
		3	SS				9
			HS				
		4	SS				4
10.0			HS				
		5	SS				8
			HS				
			HS			Fine to medium sand, trace silt - brown - medium dense - saturated. (SP)	
15.0		6	SS				15
			HS				
			HS			Fine sand, trace silt - brown - medium dense - saturated. (SP)	
20.0		7	SS				22
22.0							

END OF BORING

Boring advanced with hollow stem augers.
Monitoring well installed. Screen set from 12.0 to 15.0 feet. See Monitor Well Installation Diagram for As-Built Details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 6.5 ft	WS OR WD WS	BORING STARTED 06/08/92	STS OFFICE Lansing-07
WL BCR	ACR	BORING COMPLETED 06/08/92	ENTERED BY DAP / SHEET NO. 1 OF 1
WL 7.80 ft @ 0.5 hr AB		RIG/FOREMAN CME550/BP	APP'D BY JSM / STS JOB NO. 72150A

STS Consultants Ltd.

CLIENT
CONSUMERS POWER COMPANY

PROJECT NAME
CAMPBELL ASH STORAGE FACILITY EXPANSION

LOG OF BORING NUMBER MW-4

ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 633.3 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	SPT (BLOWS/FT.)
	1	SS	Sandy topsoil, trace silt, roots and organics - dark brown - very loose to loose - moist. (SP)	1/6
	1A	SS		2
		HS	Fine sand, trace silt and roots - brown - very loose to loose - moist to saturated. (SP)	
	2	SS		3
5.0		HS		
	3	SS		8
		HS		
	4	SS		7
10.0		HS		
	5	SS		9
		HS		
15.0	6	SS		8
		HS		
		HS	Fine sand - brown - loose to medium dense - saturated. (SP)	
20.0	7	SS		12
		HS		
25.0	8	SS		12
		HS		
30.0	9	SS		7
33.0		HS		

END OF BORING

Boring advanced with hollow stem augers.
Monitoring well installed. Screen set from 30.0 to 33.0 feet. See Monitor Well Installation Diagram for As-Built Details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 26.0 ft — WS OR WD: WS	BORING STARTED 06/06/92	STS OFFICE Lansing-07
WL BCR ACR	BORING COMPLETED 06/06/92	ENTERED BY DAP — SHEET NO. 1 OF 1
WL 27.33 ft AB	RIG/FOREMAN CME550/BP	APP'D BY JSM — STS JOB NO. 72150A

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY

LOG-OF-BORING NUMBER: MW-8

PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION

ARCHITECT-ENGINEER

SITE LOCATION: WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.² 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 616.5 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	SPT (BLOWS/FT)
	1	SS	Sandy topsoil, trace silt, roots and organics - dark brown - very loose to loose - moist. (SP)	1/6"
	1A	SS		4
		HS	Fine sand, trace silt and roots - brown - loose - moist to wet. (SP)	
	2	SS		6
5.0		HS		
	3	SS		7
		HS	Fine to medium sand, trace silt and roots - brown - loose to medium dense - moist to saturated. (SP)	
	4	SS		8
10.0		HS		
	5	SS		6
		HS		
15.0	6	SS		16
		HS		
20.0	7	SS		17
		HS		
25.0	8	SS		8
		HS		
30.0				
31.0			END OF BORING	

END OF BORING

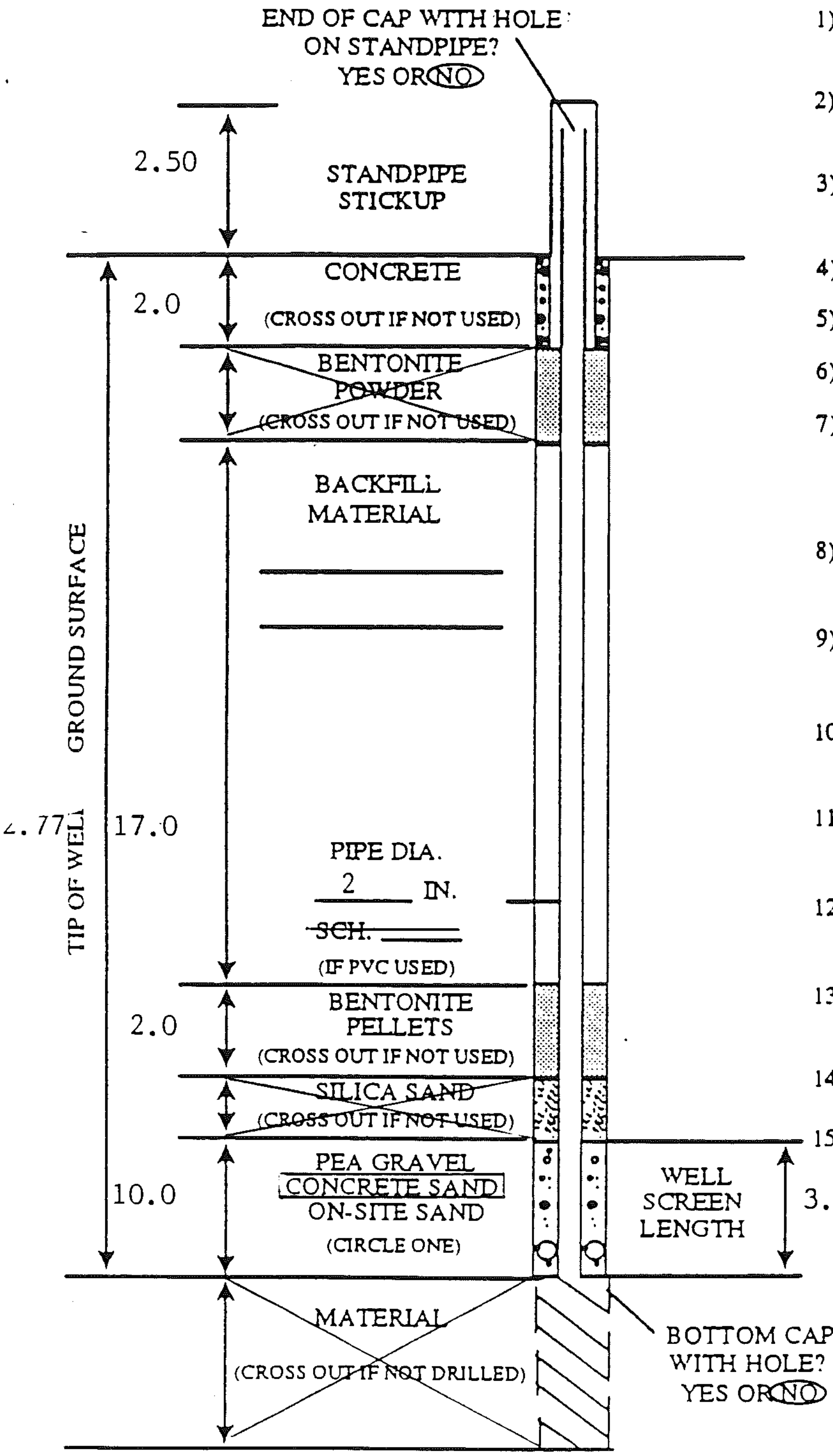
Boring advanced with hollow stem augers. Monitoring well installed. Screen set from 28.0 to 31.0 feet. See Monitor Well Installation Diagram for As-Built Details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 23.0 ft	WS OR WD: WD	BORING STARTED: 06/07/92	STS OFFICE: Lansing-07
WL BCR	ACR	BORING COMPLETED: 06/07/92	ENTERED BY: DAP / SHEET NO. 1 OF 1
WL 32.83 ft @ 1.0 hr AB		RIG/FOREMAN: CME550/BP	APP'D BY: JSM / STS JOB NO. 72150A

TS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE
PVC, GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, THREADED, OTHER ________

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE .010 - 10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED?
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ________

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 35 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
________ FT OR DRY

2) OTHER MEASUREMENTS:

DATE 6/20/92 , 26.39 FT FROM T. ST. PIPE
DATE 6/23/92 , 26.40 FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE

WELL NO. MW-8 DATE INSTALLED 6/7/92 DRILL RIG 550

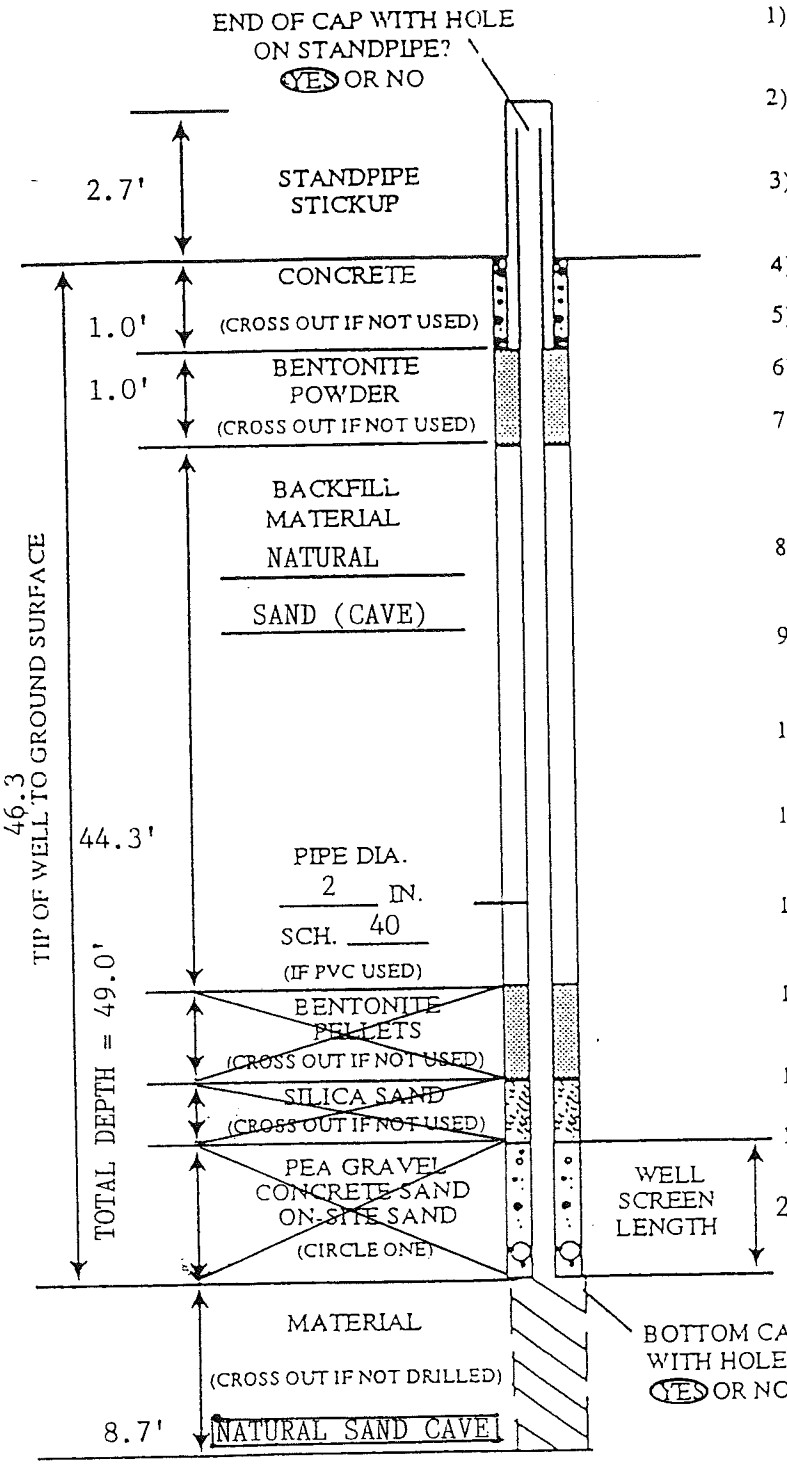
DRILLER BRUCE PENFIELD DRILL CREW DAVE R., DAVE D.

JOB/CLIENT CONSUMERS POWER COMPANY STS PROJECT NO. 72150A

(VERSION 1: 05/90 - M11DRAW"FIELDWELL")

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5' #10 Slot

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 35 GAL.

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
29.5 FT OR DRY
2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW 8B DATE INSTALLED 6/3/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW DEAN F. ZETTLER/JANEEN D. GROVE

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - MIIDRAW"FIELDWELL")

STS Consultants Ltd.

CLIENT	CONSUMERS POWER COMPANY
LOG OF BORING NUMBER	MW-8B
PROJECT NAME	JH CAMPBELL
ARCHITECT-ENGINEER	
SITE LOCATION	WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 616.5

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
0.0			PA			Medium sand, trace gravel, silt and roots - brown - medium dense - moist. (SP-TOPSOIL)
			PA			Medium sand, trace gravel and silt - brown - medium dense - moist. (SP) NOTE: Beach sand
10.0						
20.0						
30.0			PA			Medium sand, trace gravel and silt - brown - medium dense - saturated. (SP)
40.0						
50.0		1	BS			
			PA			
58.0						END OF BORING

See Well Installation Diagram for more details.

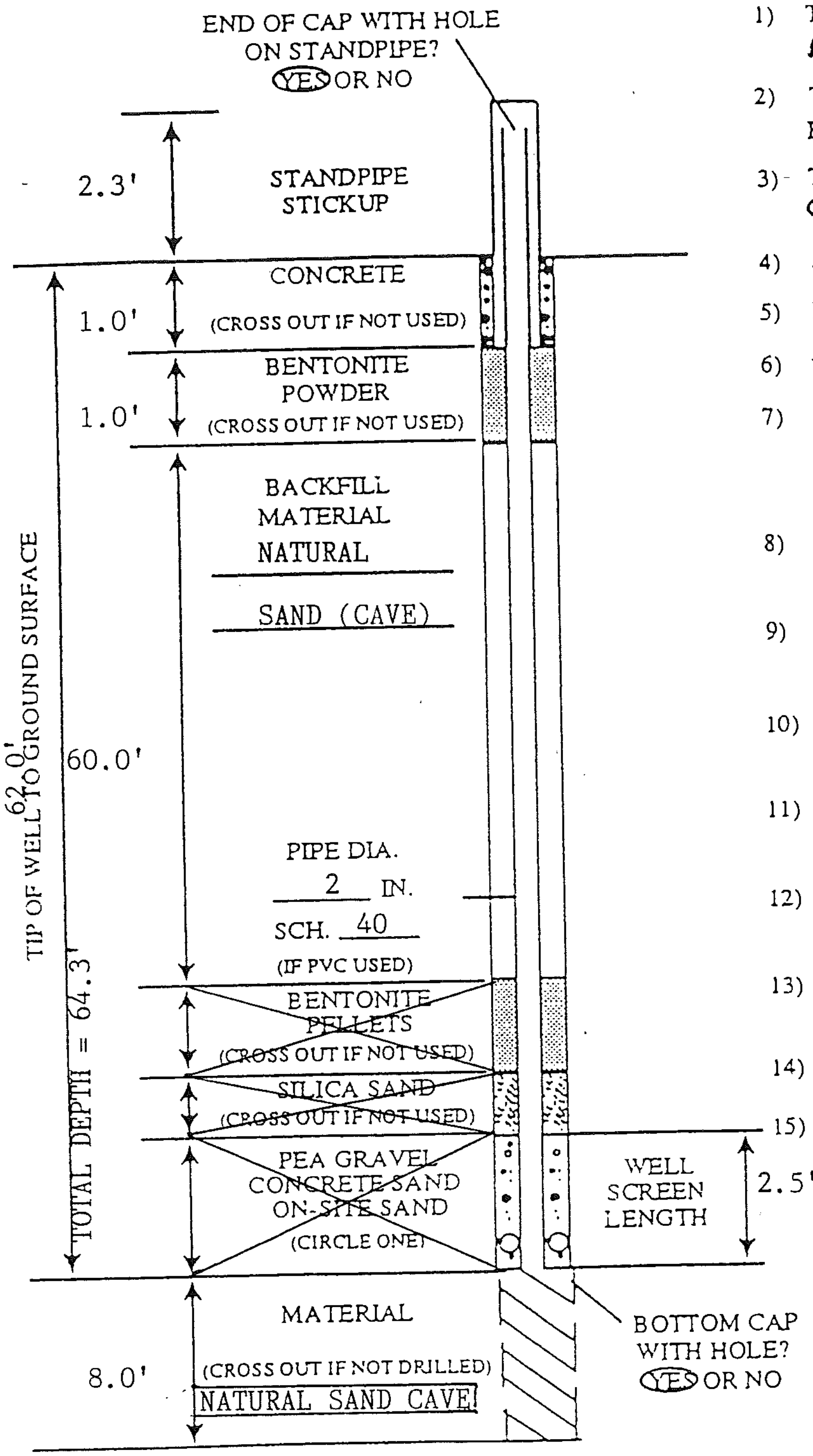
BS = Bulk Sample from soil cuttings.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 27 ft WS CR WD WD	BORING STARTED 06/03/94	STS OFFICE	Lansing-07
WL BCR ACR	BORING COMPLETED 06/03/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ________

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ________

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 45 GAL.

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
29 FT OR DRY

2) OTHER MEASUREMENTS:
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE

WELL NO. MW 8C DATE INSTALLED 6/6/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW GREGORY H. FOX/JANEEN D. GROVE

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - M11DRAW"FIELDWELL")

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER: MW-8C
PROJECT NAME: JH CAMPBELL	ARCHITECT-ENGINEER

SITE LOCATION: WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2}: 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %: 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT.: 10 20 30 40 50

SURFACE ELEVATION 616.5

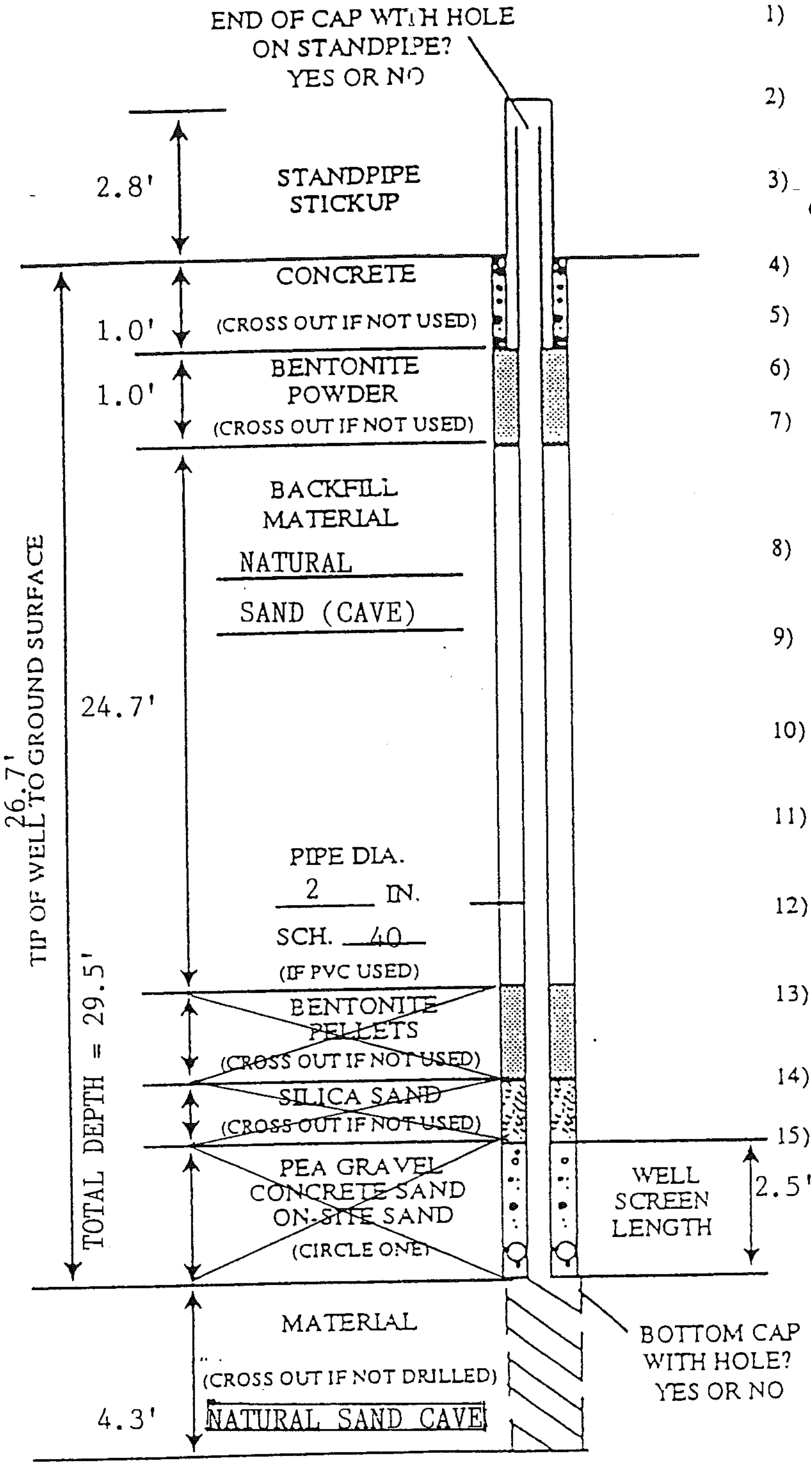
DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION BLOWS/FT.
			PA			Medium sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)	
10.0 / 20.0			PA			Medium sand, trace gravel and silt - brown - medium dense - moist. (SP)	
30.0 / 40.0 / 50.0 / 60.0			PA			Medium sand, trace gravel and silt - brown - medium dense - wet. (SP)	
70.0			PA			Silt and clay - gray - stiff. (CL-ML)	
72.0		1	SS				50
						END OF BORING See Well Installation Diagram for more details.	

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 27.5 ft — WS OR WD: WD	BORING STARTED 06/06/94	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 06/06/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 40 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
13 FT OR DRY

2) OTHER MEASUREMENTS:

DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW 9B DATE INSTALLED 6/7/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW DEAN F. ZETTLER

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - MIIDRAW"FIELDWELL")

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	MW-9B
PROJECT NAME	ARCHITECT-ENGINEER
JH CAMPBELL	

SITE LOCATION
WEST OLIVE, TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

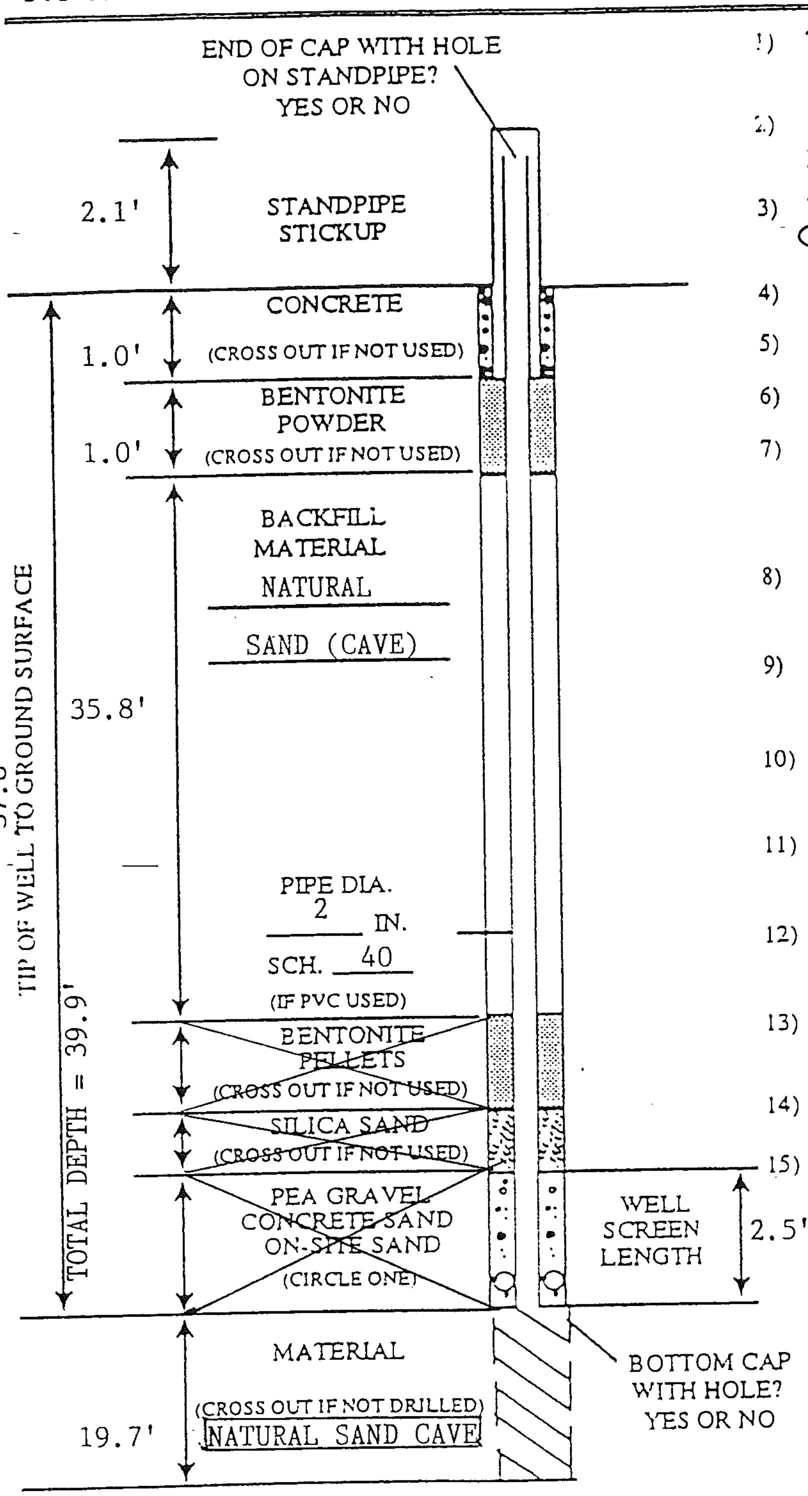
DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 608
			PA			Medium to coarse sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)
						Medium to coarse sand, trace gravel and silt - brown - medium dense - moist. (SP) NOTE: Beach Sand
5.0			PA			
10.0						Medium to coarse sand, trace gravel and silt - brown - medium dense - wet. (SP)
15.0						
20.0			PA			
25.0						
30.0						
31.0						END OF BORING See Well Installation Diagram for more details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 10 ft	WS OR WD WD	BORING STARTED 06/07/94	STS OFFICE Lansing-07	
WL BCR	ACR	BORING COMPLETED 06/07/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL		RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5; #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 35 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
12.5 FT OR DRY

2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW 9C DATE INSTALLED 6/2/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW DEAN F. ZETTLER

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - M11DRAW"FIELDWELL")

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	MW-9C
PROJECT NAME	ARCHITECT-ENGINEER
JH CAMPBELL	

SITE LOCATION
WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.[2] 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION BLOWS/FT.
10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
						SURFACE ELEVATION 608
			PA			Medium to coarse sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)
			PA			Medium to coarse sand, trace gravel and silt - brown - medium dense - moist. (SP) Note: Beach Sand
10.0						
			PA			Medium to coarse sand, trace gravel and silt - brown - medium dense - wet. (SP)
20.0						
30.0						
40.0						
50.0						
57.5		1	BS			Silty clay, trace sand - gray - very stiff - moist. (CL)

END OF BORING

See Well Installation Diagram for more details.

BS = Bulk Sample from soil cuttings.

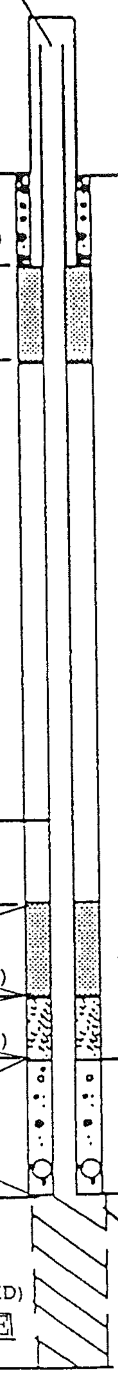
The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 10 ft WS OR WD WD	BORING STARTED 06/02/94	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 06/02/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM

END OF CAP WITH HOLE ON STANDPIPE? YES OR NO



2.4' STANDPIPE STICKUP

1.0' CONCRETE (CROSS OUT IF NOT USED)

1.0' BENTONITE POWDER (CROSS OUT IF NOT USED)

50.4' BACKFILL MATERIAL NATURAL SAND (CAVE)

PIPE DIA. 2 IN.

SCH. 40 (IF PVC USED)

~~BENTONITE PELLETS (CROSS OUT IF NOT USED)~~

~~SILICA SAND (CROSS OUT IF NOT USED)~~

~~PEA GRAVEL CONCRETE SAND ON-SITE SAND (CIRCLE ONE)~~

WELL SCREEN LENGTH 2.5'

TIP OF WELL TO GROUND SURFACE 52.4'

TOTAL DEPTH = 54.8'

5.6' MATERIAL (CROSS OUT IF NOT DRILLED) NATURAL SAND CAVE

BOTTOM CAP WITH HOLE? YES OR NO

1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH ~~THREADED~~, OTHER ________

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ________

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 25 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT? 13 FT OR DRY
2) OTHER MEASUREMENTS:
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE
DATE ________ , ________ FT FROM T. ST. PIPE

WELL NO. MW 9D DATE INSTALLED 6/6/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW GREGORY H. FOX

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - M11DRAW"FIELDWELL")

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	MW-9D
PROJECT NAME: JH CAMPBELL	ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 608

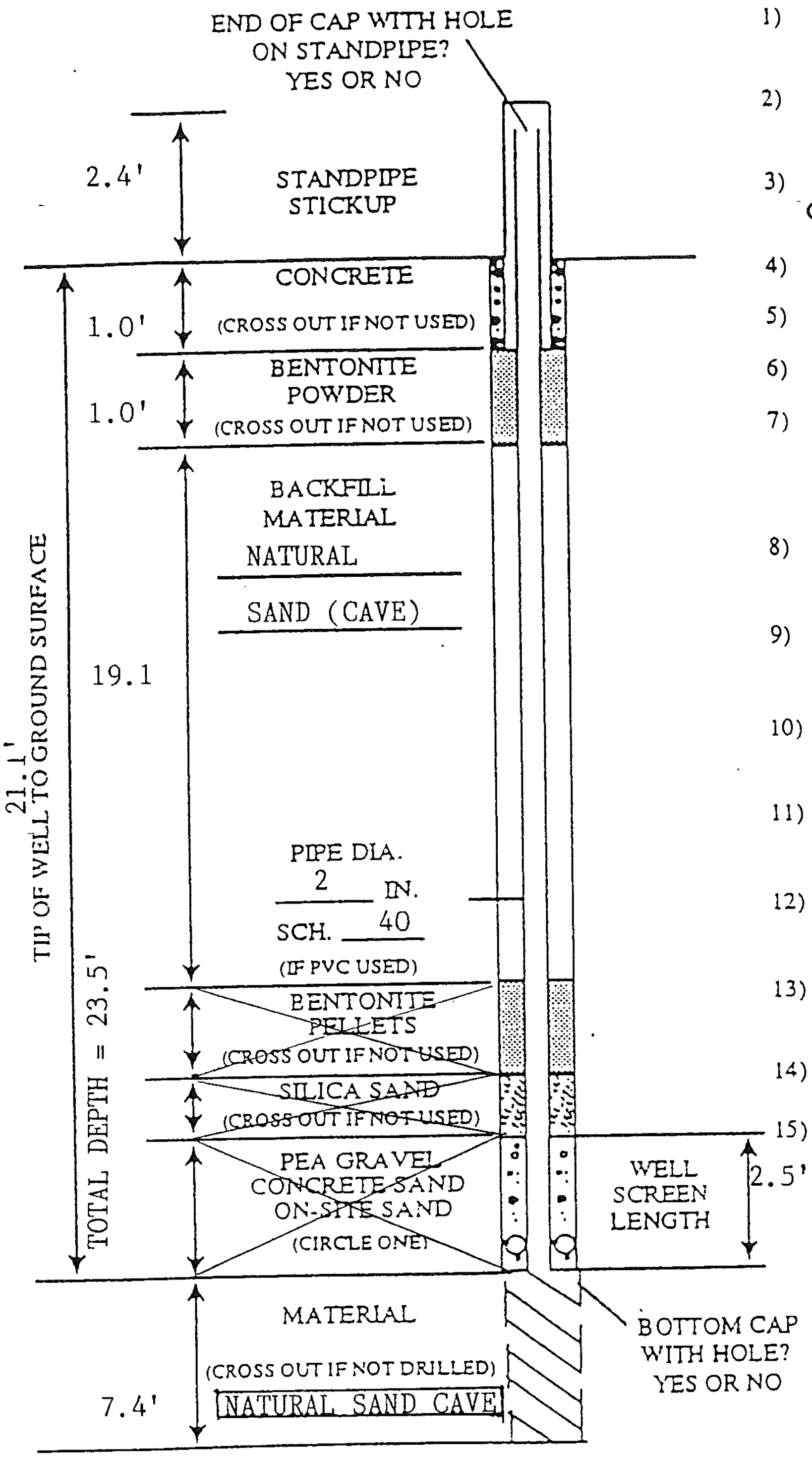
DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	SPT
			PA			Medium to coarse sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)	
			PA			Medium to coarse sand, trace gravel and silt - brown - medium dense - moist. (SP) NOTE: Beach Sand	
10.0			PA			Medium to coase sand, trace gravel and silt - brown - medium dense - wet. (SP)	
20.0							
30.0							
40.0							
50.0			PA			Silt and clay - gray - stiff. (CL-ML)	
58.0		1	SS				54
						END OF BORING See Well Installation Diagram for more details.	

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 10 ft — WS OR WD: WD	BORING STARTED 06/06/94	STS OFFICE Lansing-07	
WL BCR — ACR	BORING COMPLETED 06/06/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 50 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
6.5 FT OR DRY
2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW 10B DATE INSTALLED 6/1/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW GREGORY H. FOX/JANEEN D. GROVE

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150B

(VERSION 1: 05/90 - MIIDRAW "FIELDWELL")

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	MW-108
PROJECT NAME	ARCHITECT-ENGINEER
JH CAMPBELL	

SITE LOCATION
WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 601

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	Standard Penetration Blows/Ft.
			PA			Medium sand, trace gravel and silt - brown - loose - moist. (SP-FILL)	
			PA			Silty sand, trace gravel and roots - black - loose - moist. (SM-TOPSOIL)	
5.0						Medium sand, trace gravel and silt - brown - medium dense - wet. (SP) NOTE: Beach Sand	
10.0							
15.0			PA				
20.0							
25.0			PA			Silt and clay, trace sand - gray - very stiff. (CL-ML)	
		1	SS				39
28.5						END OF BORING See Well Installation Diagram for details.	

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 4 ft	WS OR WD WD	BORING STARTED 06/01/94	STS OFFICE Lansing-07	
WL BCR	ACR	BORING COMPLETED 06/01/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL		RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

Natural Resource Technology, Inc.
Standard Soil Boring Log

SOIL BORING LOG INFORMATION
Form - Non-WI#2 Rev. 8-2000

Facility/Project Name	**License/Permit/Monitoring Number**	**Boring Number**
Consumers Energy / J.H. Campbell Plant		*MW-11A*

Boring Drilled By (Firm name and name of crew chief)	**Date Drilling Started**	**Date Drilling Completed**	**Drilling Method**
Environmental Drilling and Contracting, Inc. *Sean Smith / Bob Miller*	*03/13/01*	*03/13/01*	*4-1/4" (ID) HSA*

Facility Well No.	**Unique Well No.**	**Common Well Name**	**Final Static Water Level**	**Surface Elevation**	**Borehole Diameter**
		MW-11A	*Feet MSL*	*Feet MSL*	*8.3 inches*

Boring Location **State Plane**	**Feet N** **Feet E**	**Lat** **Long**	**Local Grid Location (If applicable)** ☐ *N* ☐ *E* ☐ *S* ☐ *W*

County		**Civil Town/City/ or Village**
Ottawa		*Port Sheldon Township*

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				0'-0.5' <u>SANDY ORGANIC TOPSOIL</u>	OL									
			2 4	0.5'-18.5 <u>SAND</u>, brownish yellow (10YR 6/6), poorly graded, fine, round, trace silt, loose, moist.										
MW-11A (1)	20	3/3 5/7	6 8	wet at approximately 6.5 feet below ground surface										
MW-11A (2)	21	1/- 2/-	10 12 14	brownish yellow to light yellowish brown (2.5Y 7-6/4)	SP									
MW-11A (3)	18	3/3 3/7	16 18	pale yellow to light yellowish brown (2.5Y 7-6/4)										
MW-11A (4)	16	12/12 17/23	20	18.5'-31.8' <u>LEAN CLAY</u>, dark gray (10YR 4/1), trace very fine sand, stiff, no dilatency, medium toughness and plasticity, slightly moist.	CL									
			22	*End of Boring at 20.5 feet below ground surface*										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	**Natural Resource Technology, Inc.**

Facility/Project Name: JH CAMPBELL PLANT / CONSUMERS ENERGY	Local Grid Location of Well: ______ ft. ☐N. ☐S. ______ ft. ☐E. ☐W.	Well Name: MW-11A
Facility License, Permit or Monitoring Number	Grid Origin Location: Lat. ______ Long. ______ or	
Type of Well: Water Table Observation Well ☒ Piezometer ☐	St. Plane ______ ft. N, ______ ft. E.	Date Well Installed: 03/13/2001 (mm dd yy)
Distance Well Is From Waste/Source Boundary ______ ft.	Section Location of Waste/Source: ___1/4 of ___1/4 of Sec. ___, T. ___ N, R. ___ ☐E. ☐W.	Well Installed By: (Person's Name and Firm) SEAN SMITH, ENVIRONMENTAL DRILLING & Co
	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation ______ ft. MSL

B. Well casing, top elevation ______ ft. MSL

C. Land surface elevation ______ ft. MSL

D. Surface seal, bottom ______ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☒ Air ☐ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis):

E. Bentonite seal, top ______ ft. MSL or 1.0 ft.

F. Fine sand, top ______ ft. MSL or ______ ft.

G. Filter pack, top ______ ft. MSL or 3.0 ft.

H. Screen joint, top ______ ft. MSL or 4.0 ft.

I. Well bottom ______ ft. MSL or 14.0 ft.

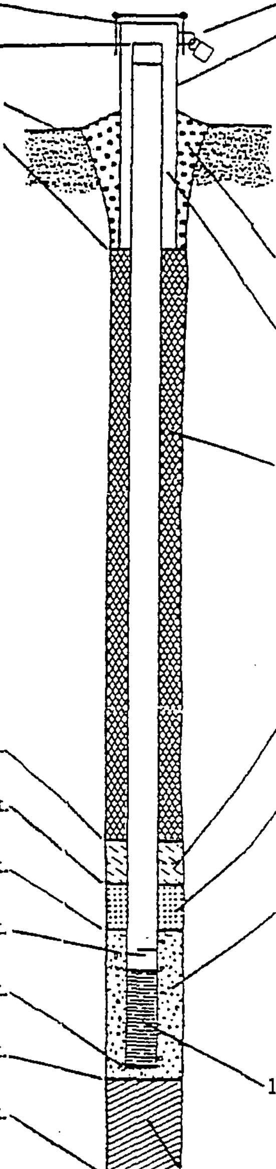
J. Filter pack, bottom ______ ft. MSL or 20.5 ft.

K. Borehole, bottom ______ ft. MSL or 20.5 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 2.25 in.

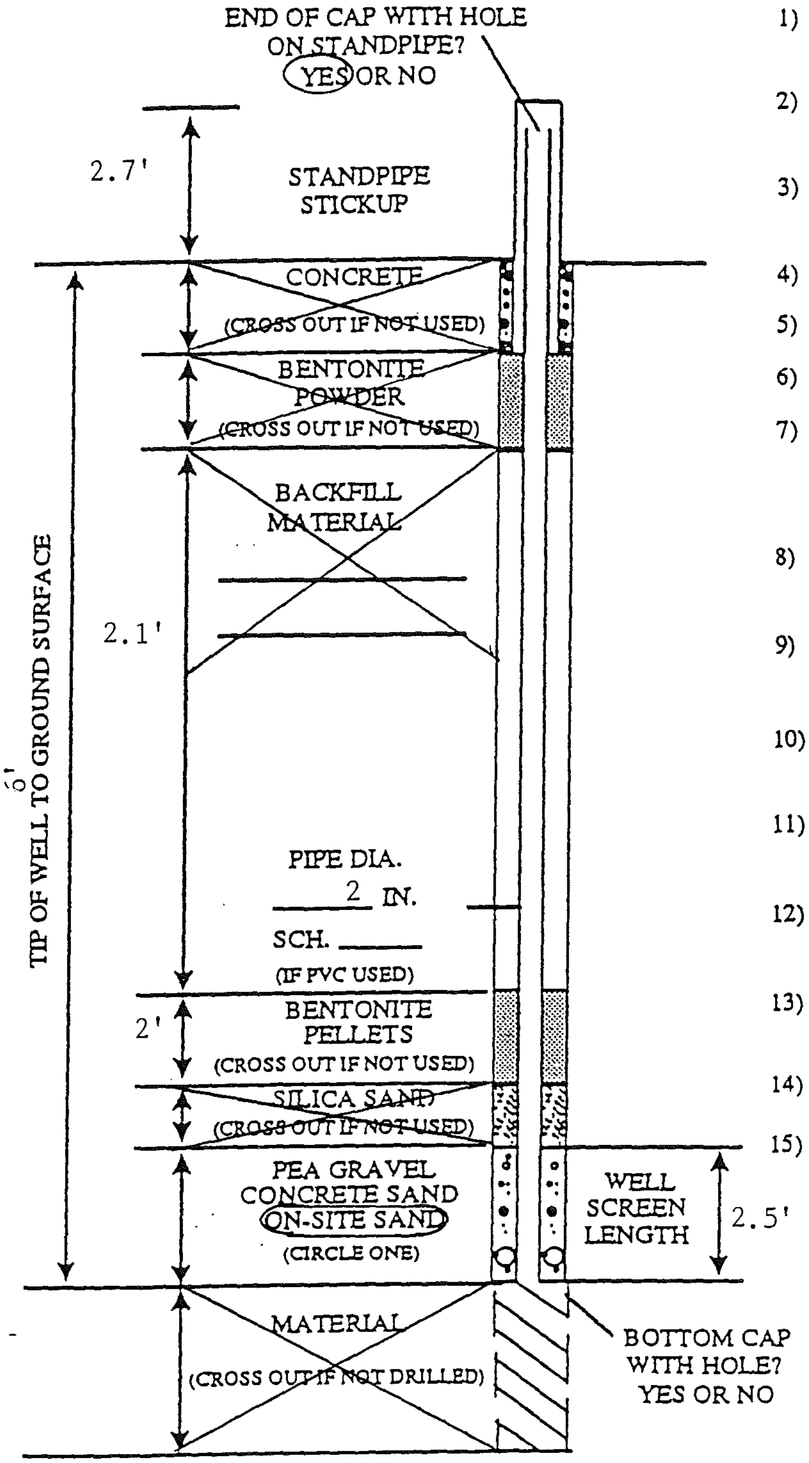


1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
   a. Inside diameter: ___ in
   b. Length: ___ ft
   c. Material: Steel ☒ Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ______
3. Surface seal: Bentonite ☒ Concrete ☐ Other ☐
4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ SAND Other ☒
5. Annular space seal: a. Granular Bentonite ☐
   b. ______Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ______Lbs/gal mud weight . . . . . Bentonite slurry ☐
   d. ______% Bentonite . . . . . . Bentonite-cement grout ☐
   e. ______Ft^3 volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒
6. Bentonite seal: a. Bentonite granules ☐
   b. ☐1/4 in. ☒3/8 in. ☐1/2 in. Bentonite ~~pellets~~ CHIPS ☒
   c. ______ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
   a. ______
   b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name and mesh siz
   a. FLAT ROCK, FILTER SAND, #30
   b. Volume added ______ ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐
10. Screen material: PVC
   a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
   b. Manufacturer BIG FOOT
   c. Slot size: 0.010 in
   d. Slotted length: 10.0 ft
11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	NATURAL RESOURCE TECHNOLOGY, INC.

STS Field Well Installation Diagram



1) TYPE OF PIPE
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 5'

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED?
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN., 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER ______

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
______ FT OR DRY
2) OTHER MEASUREMENTS:
DATE ______, ______ FT FROM T. ST. PIPE
DATE ______, ______ FT FROM T. ST. PIPE
DATE ______, ______ FT FROM T. ST. PIPE
DATE ______, ______ FT FROM T. ST. PIPE

AKA MW-12

WELL NO. MW 12-96 DATE INSTALLED 1/10/96 DRILL RIG HURRICANE

DRILLER TOM KALINOWSKI DRILL CREW CHRIS POWEL & GREG FOX

JOB/CLIENT CONSUMERS POWER CO STS PROJECT NO. 72583

(VERSION 1: 05/90 - MIIDRAW)

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER	MW-12-96 AKA MW-12
PROJECT NAME	ARCHITECT-ENGINEER
J.H. CAMPBELL	

SITE LOCATION
WEST OLIVE, MI

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

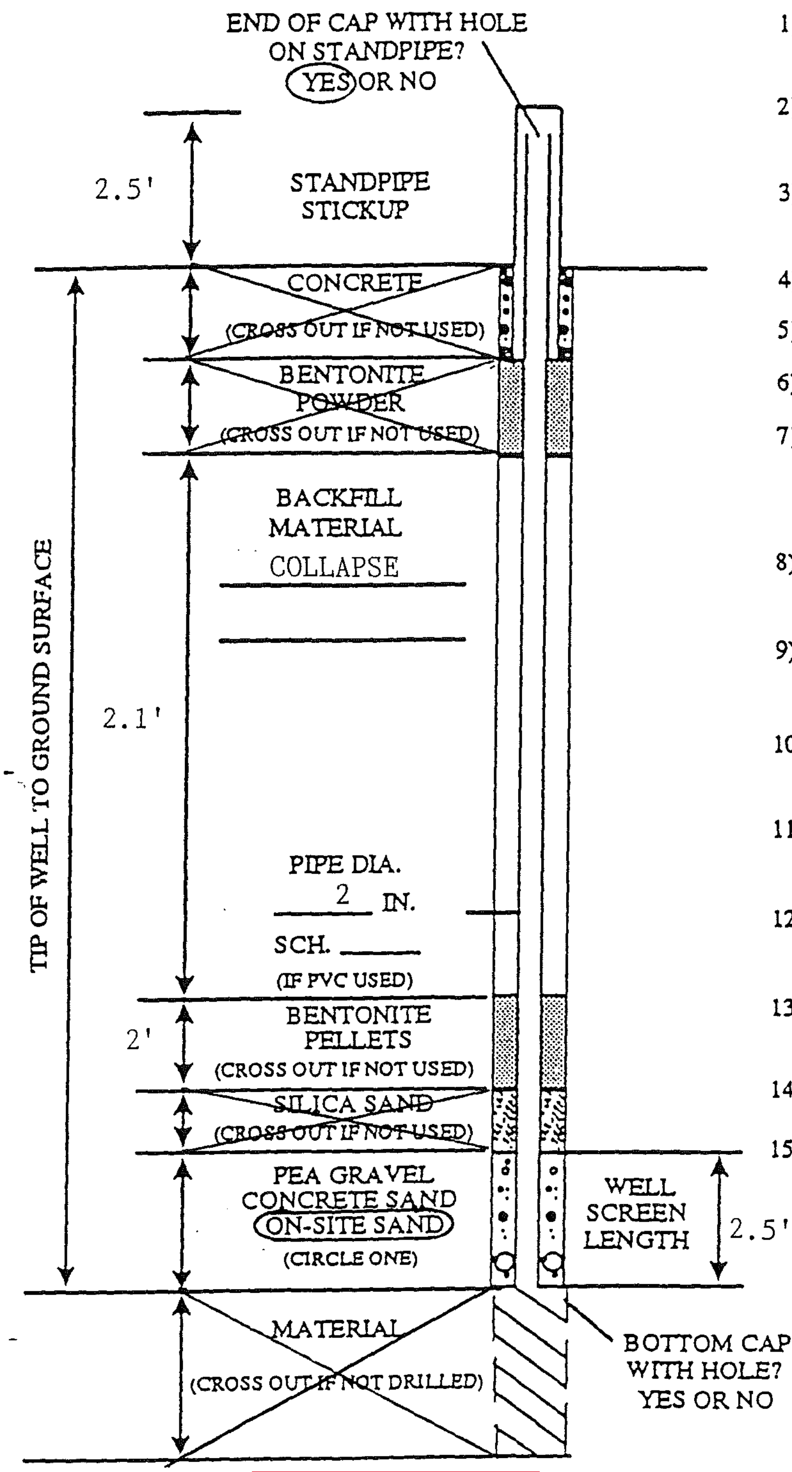
STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
						SURFACE ELEVATION
		1	CS			Organic topsoil, little fine to medium sand - brown - loose - moist. (Pt)
2.5		1A	CS			Fine to medium sand - brown - medium dense - moist to wet. (SP)
5.0		2	CS			
7.5						
8.0						END OF BORING Boring advanced with hydraulic push techniques. Monitoring Well installed. Screen set from 4.1' to 6.6'. CS = Continuous Sampler

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 5.1 ft WS OR WD WS	BORING STARTED 01/10/96	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 01/10/96	ENTERED BY DAP	SHEET NO. 1 OF 1
WL 5.1 ft @ 1 hr AB	RIG/FOREMAN GEOPROBE/GHF	APP'D BY JSM	STS JOB NO. 72583

STS Field Well Installation Diagram



1) TYPE OF PIPE
PVC, GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, THREADED, OTHER ________

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE 5'

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED?
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN., 30 MIN, OTHER ________

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER ________

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
________ FT OR DRY
2) OTHER MEASUREMENTS:
DATE ________, ________ FT FROM T. ST. PIPE
DATE ________, ________ FT FROM T. ST. PIPE
DATE ________, ________ FT FROM T. ST. PIPE
DATE ________, ________ FT FROM T. ST. PIPE

AKA MW-13

WELL NO. MW 13-96 DATE INSTALLED 1/9/96 DRILL RIG HURRICAN

DRILLER TOM KALINOWSKI DRILL CREW CHRIS POWELL & GREG FOX

JOB/CLIENT CONSUMERS POWER STS PROJECT NO. 72583

(VERSION 1: 05/90 - MIIDRAW)

STS Consultants Ltd.

CLIENT	CONSUMERS POWER
PROJECT NAME	J.H. CAMPBELL
LOG OF BORING NUMBER	MW-13-96 AKA MW-13
ARCHITECT-ENGINEER	
SITE LOCATION	WEST OLIVE, MI

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

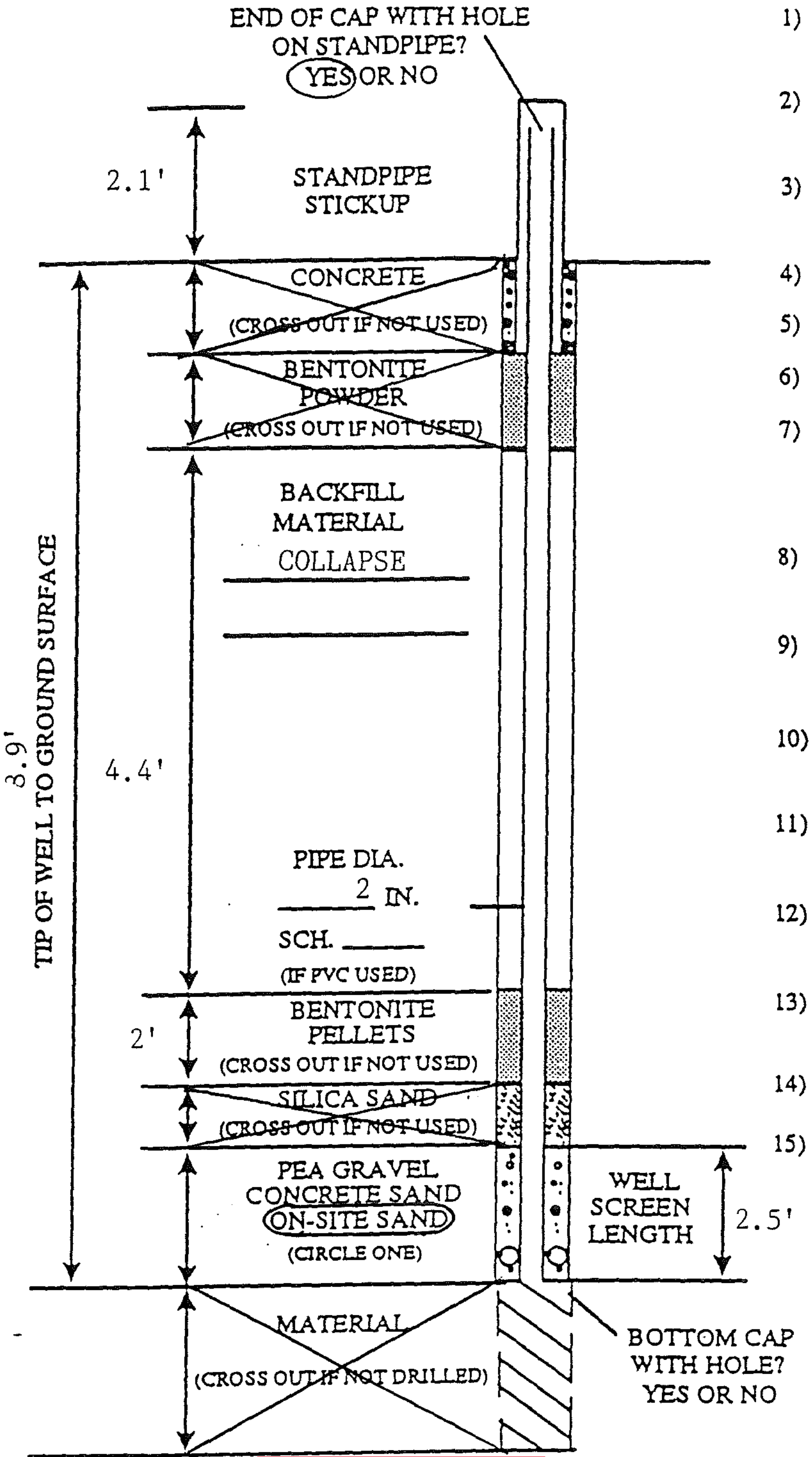
STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
						SURFACE ELEVATION
		1	CS			Organic topsoil, little fine to medium sand - brown - moist. (Pt)
2.5		1A	CS			Clayey silt, little fine to medium sand - brown - soft - moist to wet. (ML)
5.0		2	CS			
7.5		2A	CS			Clayey silt, trace fine sand - gray - very stiff - moist. (ML)
10.0		3	CS			
12.0						END OF BORING Boring advanced with hydraulic push techniques. Monitoring Well installed. Screen set from 5.5' to 8.0'. CS = Continuous Sampler

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 6.5 ft	WS OR WD WS	BORING STARTED 01/09/96	STS OFFICE Lansing-07
WL BCR	ACR	BORING COMPLETED 01/09/96	ENTERED BY DAP; SHEET NO. 1 OF 1
WL 6.5 ft @ 1 hr AB		RIG/FOREMAN GEOPROBE/GHF	APP'D BY JSM; STS JOB NO. 72583

STS Field Well Installation Diagram



1) TYPE OF PIPE
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 5'

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED?
SOLID AUGER, HOLLOW STEM AUGER, WATER
REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER ______

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
______ FT OR DRY
2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

AKA MW-14

WELL NO. MW 14-96 DATE INSTALLED 1-9-96 DRILL RIG HURRICANE

DRILLER TOM KALINOWSKI DRILL CREW CHRIS POWELL & GREG FOX

JOB/CLIENT CONSUMERS POWER CO. STS PROJECT NO. 72583

(VERSION 1: 05/90 - M11DRAW)

STS Consultants Ltd.	CLIENT CONSUMERS POWER	LOG OF BORING NUMBER	MW-14-96 AKA MW-14
	PROJECT NAME J.H. CAMPBELL	ARCHITECT-ENGINEER	

SITE LOCATION
WEST OLIVE, MI

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %
10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
						SURFACE ELEVATION
		1	CS			Organic topsoil, little fine to medium sand - brown - loose - moist. (Pt)
2.5		1A	CS			Fine to medium sand - brown - medium dense - moist. (SP)
5.0		2	CS			
7.5		3	CS			
10.0						END OF BORING Boring advanced using hydraulic push techniques. Monitoring Well installed. Screen set from 6.4' to 8.9'. CS = Continuous Sampler

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 7.2 ft — WS OR WD: WS	BORING STARTED 01/09/96	STS OFFICE	Lansing-07
WL — BCR — ACR	BORING COMPLETED 01/09/96	ENTERED BY DAP	SHEET NO. 1 OF 1
WL 7.2 ft @ 1 hr AB	RIG/FOREMAN GEOPROBE/GHF	APP'D BY JSM	STS JOB NO. 72583

Natural Resource Technology, Inc.
Standard Soil Boring Log

SOIL BORING LOG INFORMATION
Form - Non-WI#2 Rev. 8-2000

Facility/Project Name *Consumers Energy / J.H. Campbell Plant*			**License/Permit/Monitoring Number**		**Boring Number** *MW-15*	
Boring Drilled By (Firm name and name of crew chief) *Environmental Drilling and Contracting, Inc.* *Sean Smith / Bob Miller*			**Date Drilling Started** *03/06/01*	**Date Drilling Completed** *03/06/01*	**Drilling Method** *4-1/4" (ID) HSA*	
Facility Well No.	**Unique Well No.**	**Common Well Name** *MW-15*	**Final Static Water Level** *Feet MSL*	**Surface Elevation** *Feet MSL*	**Borehole Diameter** *8.3 inches*	
Boring Location **State Plane**		**Feet N** **Feet E**	**Lat** **Long**	**Local Grid Location (if applicable)** ☐ N ☐ S ☐ E ☐ W		
County *Ottawa*				**Civil Town/City/ or Village** *Port Sheldon Township*		

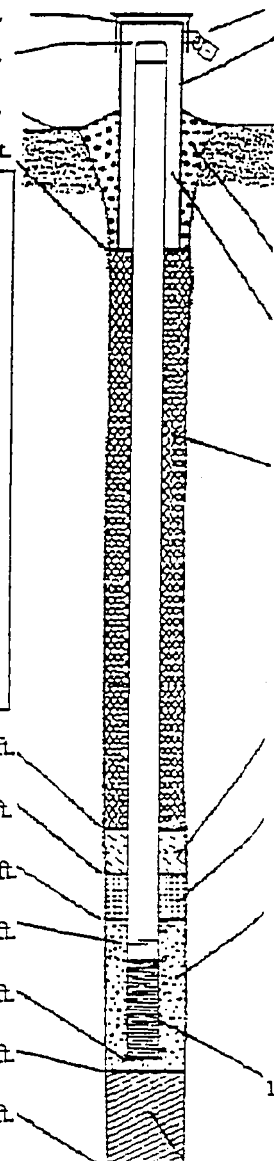
Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0	0'-0.5' SANDY ORGANIC TOPSOIL	OL									
			2	0.5'-17' SAND, reddish yellow to strong brown (7.5YR 5-6/6), poorly graded, fine to medium, predominantly medium, round, loose, moist.										
			4											
MW-15 (1)	17	3/4 4/6	6	wet at approximately 6.5 feet below ground surface										
			8		SP									
MW-15 (2)	18	1/2 1/2	10	trace broken shells										
			12											
			14											
MW-15 (3)	16	1/1 1/1	16	yellowish brown (10YR 5/6), trace silt, no shells										
			18	*End of Boring at 17 feet below ground surface*										
			20											
			22											

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature *[signature]*	Firm **Natural Resource Technology, Inc.**

MONITORING WELL CONSTRUCTION

Facility/Project Name: CONSUMERS ENERGY / JH CAMPBELL PLANT	Local Grid Location of Well ______ ft. ☐ N. ☐ S. ______ ft. ☐ E. ☐ W.		Well Name: MW-15
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___° ___' ___" Long. ___° ___' ___" or		
	St. Plane ______ ft. N, ______ ft. E. S/C/N		Date Well Installed 03/06/2001 (m m d d y y y y)
	Section Location of Waste/Source ___ 1/4 of ___ 1/4 of Sec. ___, T. ___ N, R. ___ ☐ E ☐ W		Well Installed By: Name (first, last) and Firm: SEAN SMITH, ENVIRONMENTAL DRILLING + CONST
	Location of Well Relative to Waste/Source: u ☐ Upgradient, s ☐ Sidegradient, d ☐ Downgradient, n ☐ Not Known	Gov. Lot Number	



A. Protective pipe, top elevation _ _ _ _ _ _ _ ft. MSL
B. Well casing, top elevation _ _ _ _ _ _ _ ft. MSL
C. Land surface elevation _ _ _ _ _ _ _ ft. MSL
D. Surface seal, bottom _ _ _ _ _ _ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☒ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top _ _ _ _ _ _ ft. MSL or 2.0 ft.
F. Fine sand, top _ _ _ _ _ _ ft. MSL or _ _ _ _ ft.
G. Filter pack, top _ _ _ _ _ _ ft. MSL or 3.0 ft.
H. Screen joint, top _ _ _ _ _ _ ft. MSL or 4.0 ft.
I. Well bottom _ _ _ _ _ _ ft. MSL or 14.0 ft.
J. Filter pack, bottom _ _ _ _ _ _ ft. MSL or 17.0 ft.
K. Borehole, bottom _ _ _ _ _ _ ft. MSL or 17.0 ft.
L. Borehole, diameter 8.3 in.
M. O.D. well casing 2.38 in.
N. I.D. well casing 2.25 in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: _ _ . _ in.
b. Length: _ _ . _ ft.
c. Material: Steel ☒ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:
3. Surface seal: Bentonite ☒ Concrete ☐ Other ☐
4. Material between well casing and protective pipe: Bentonite ☐ SAND Other ☒
5. Annular space seal: a. Granular/Chipped Bentonite ☒
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. ______ % Bentonite . . . . . . Bentonite-cement grout ☐
e. ______ Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒
6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
c. ______ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. ______
b. Volume added ______ ft^3
8. Filter pack material: Manufacturer, product name & mesh size
a. FLAT ROCK, FILTER SAND, #30
b. Volume added ______ ft^3
9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐
10. Screen material: PVC
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer BIG FOOT
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Rebecca J. Cople	NATURAL RESOURCE TECHNOLOGY, INC.

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	MW-A1 Replacement
PROJECT NAME	ARCHITECT-ENGINEER
ASH STORAGE FACILITY	

SITE LOCATION
WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}
						SURFACE ELEVATION 611.2	
						Fine to medium sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)	
						Fine to medium sand, trace gravel and silt - brown - medium dense - moist to wet. (SP)	
5.0							
			CS				
10.0							
15.0							
15.6						END OF BORING	

Boring advanced using hydraulic push techniques.

See Well Installation Diagram for more details.

CS = Continuous Sampler

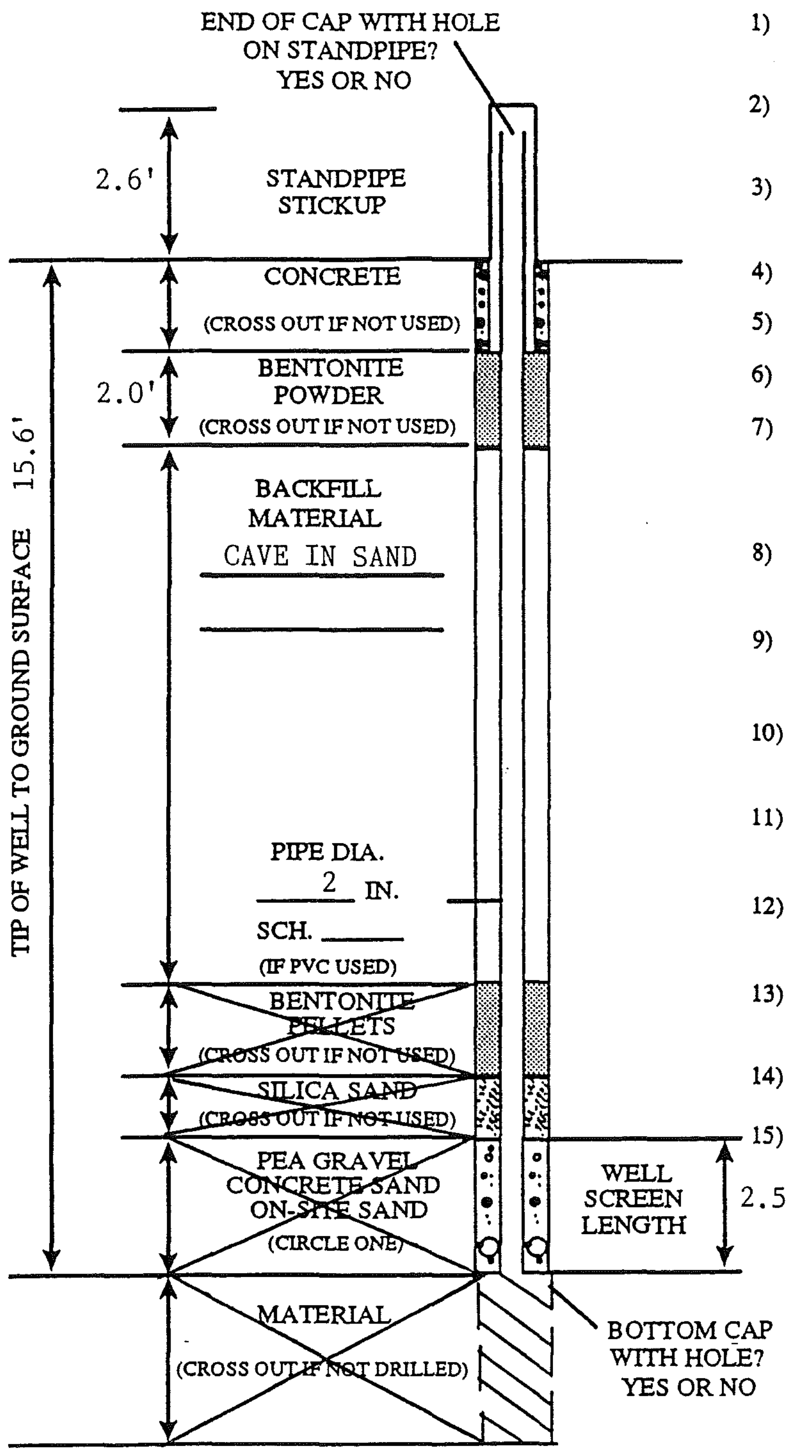
Top of Casing Elevation = 613.57

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 7.5 WD	BORING STARTED 8/28/96	STS OFFICE Lansing Area-07	
WL	BORING COMPLETED 8/28/96	ENTERED BY DAP	SHEET NO. 1 OF 1
WL	RIG/FOREMAN Geoprobe / TPK	APP'D BY JSM	STS JOB NO. 72150AB

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE
   PVC, GALVANIZED, STAINLESS, OTHER ________
2) TYPE OF PIPE JOINTS
   BELLED, COUPLINGS, THREADED, OTHER ________
3) TYPE OF WELL SCREEN
   PVC, GALVANIZED, STAINLESS, OTHER 2.5
4) SCREEN SIZE 10 SLOT
5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO
6) WAS SOLVENT USED? YES OR NO
7) WAS DRILLING MUD USED? NO
   SOLID AUGER, HOLLOW STEM AUGER, WATER
   REVERT, BENTONITE
8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
   YES OR NO
9) HOW WAS WELL DEVELOPED?
   BAILING, PUMPING, SURGING, COMPRESSED AIR
10) TIME SPENT FOR WELL DEVELOPMENT
    5 MIN., 15 MIN, 30 MIN, OTHER ________
11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
    5 GAL, 10 GAL, 15 GAL, OTHER 30 GAL
12) WATER CLARITY BEFORE DEVELOPMENT
    CLEAR, TURBID, OPAGUE
13) WATER CLARITY AFTER DEVELOPMENT
    CLEAR, TURBID, OPAGUE
14) DID THE WATER SMELL? YES OR NO
15) WATER LEVEL SUMMARY
    1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
    ________ FT OR DRY
    2) OTHER MEASUREMENTS:
    DATE ________ , ________ FT FROM T, ST. PIPE
    DATE ________ , ________ FT FROM T, ST. PIPE
    DATE ________ , ________ FT FROM T, ST. PIPE
    DATE ________ , ________ FT FROM T, ST. PIPE

WELL NO. MW-A1 REPLACEMENT DATE INSTALLED 8-28-96 DRILL RIG PROBE

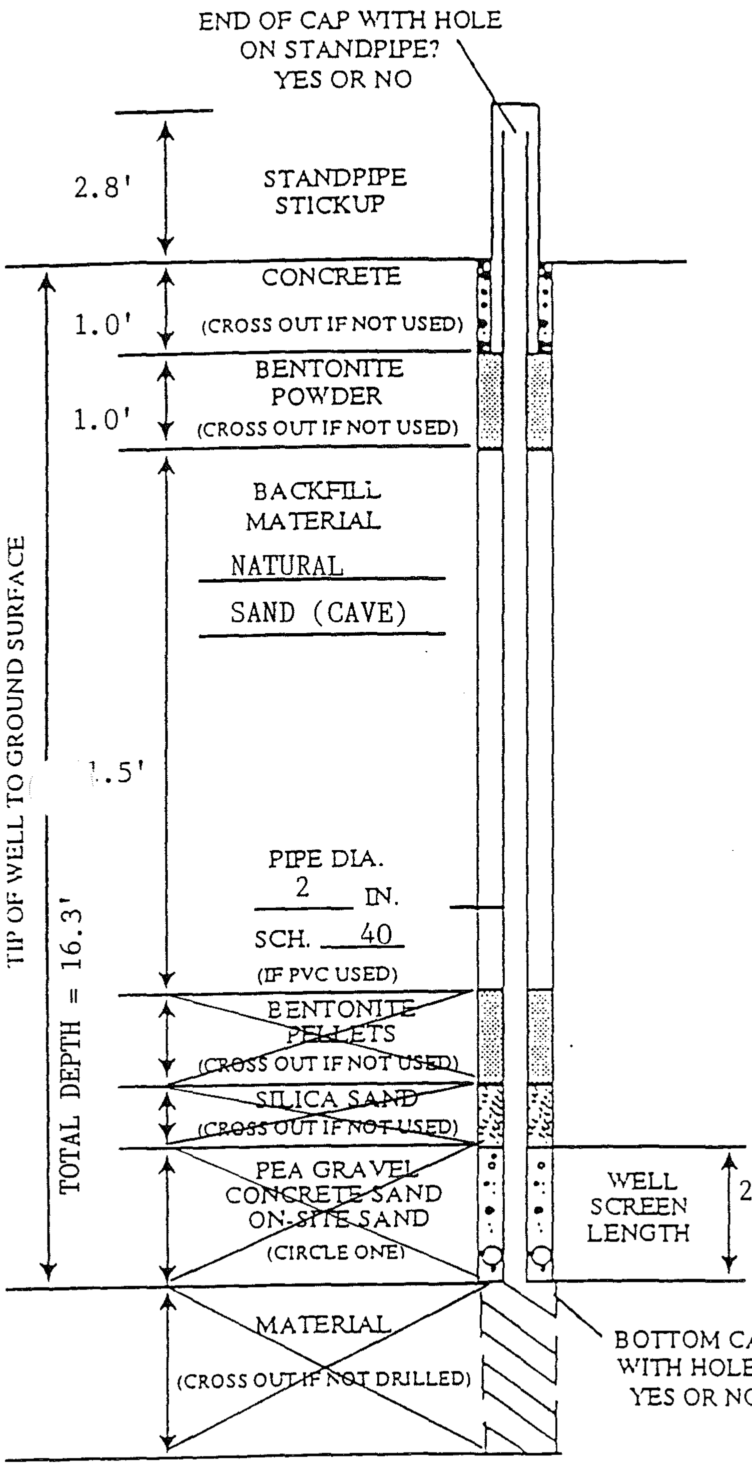
DRILLER TOM KALINOWSKI DRILL CREW PAT BOWYER

JOB/CLIENT CONSUMERS POWER COMPANY STS PROJECT NO. 72150AA

(VERSION 1: 05/90 - M11DRAW"FIELDWELL")

S[illegible] Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH ~~THREADED~~, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN., 60 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 25 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
6.5 FT OR DRY

2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW A2 DATE INSTALLED 6/1/94 DRILL RIG 550

D[illegible]LER C. DENNIS HICKEY DRILL CREW GREGORY H. FOX/JANEEN D. GROVE

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150B

(VERSION 1: 05/90 - MIIDRAW"FIELDWELL")

STS Consultants Ltd.	CLIENT CONSUMERS POWER COMPANY	LOG OF BORING NUMBER MW-A2
	PROJECT NAME JH CAMPBELL	ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

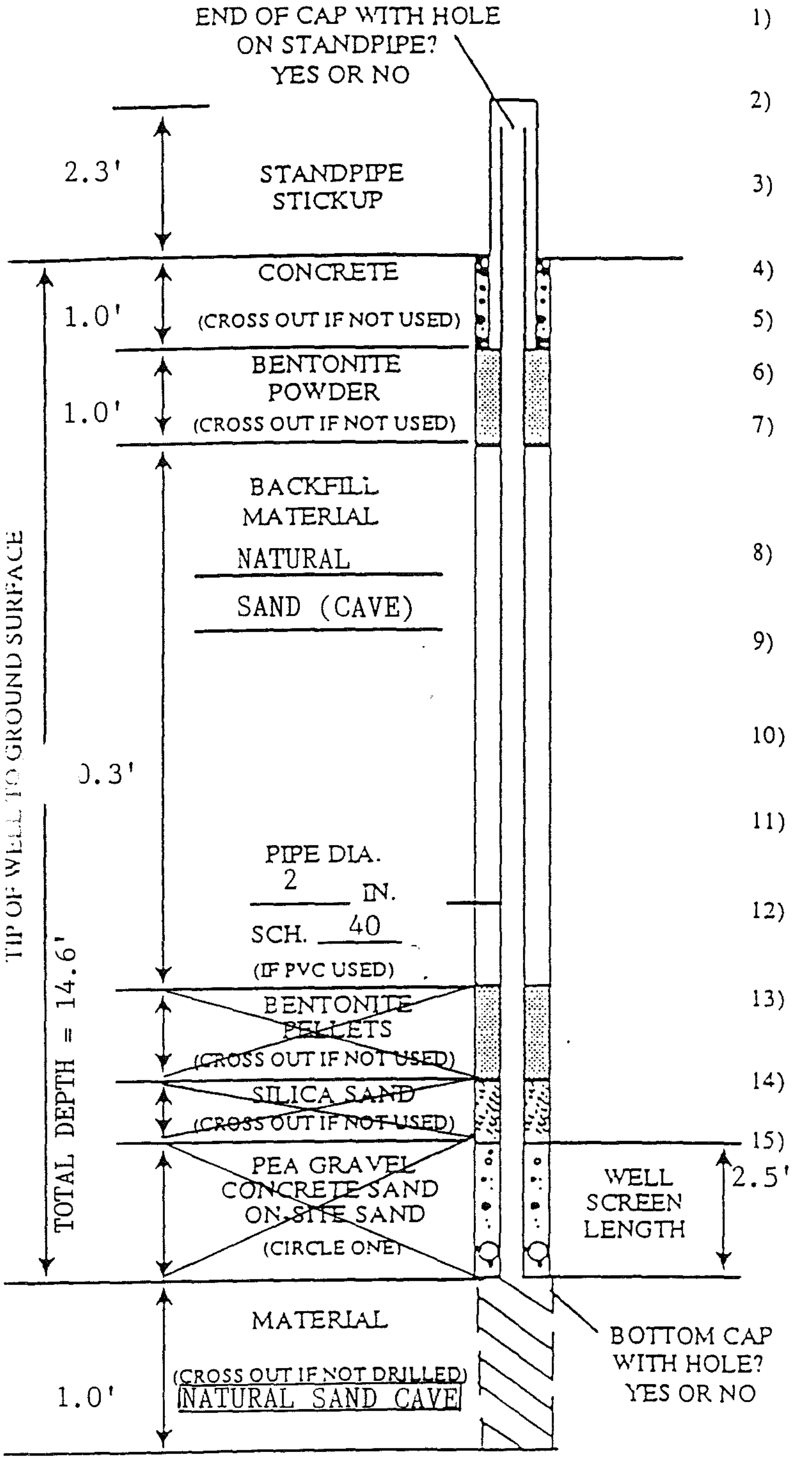
DEPTH (FT) / ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
					SURFACE ELEVATION
		PA			Fine to medium sand, trace gravel, silt and roots - loose - moist. (SP-TOPSOIL)
		PA			Fine to medium sand, trace gravel and silt - brown - medium dense - moist. (SP) NOTE: Beach Sand
5.0					Fine to medium sand, trace gravel and silt - brown - medium dense - wet. (SP)
		PA			
10.0					
13.5					END OF BORING See Well Installation Diagram for more details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 4 ft WS OR WD WD	BORING STARTED 06/01/94	STS OFFICE Lansing-07
WL BCR ACR	BORING COMPLETED 06/01/94	ENTERED BY DAP / SHEET NO. 1 OF 1
WL	RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM / STS JOB NO. 72150R

STS Consultants, Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF ~~PIPE~~
PVC, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS
BELLED, COUPLINGS, FLUSH THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 2.5' #10 SLOT

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER, WATER REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT
5 MIN., 15 MIN, 30 MIN, OTHER ______

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 GAL, 10 GAL, 15 GAL, OTHER 25 GAL

12) WATER CLARITY BEFORE DEVELOPMENT
CLEAR, TURBID, OPAGUE

13) WATER CLARITY AFTER DEVELOPMENT
CLEAR, TURBID, OPAGUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY
1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
6 FT OR DRY
2) OTHER MEASUREMENTS:
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE
DATE ______ , ______ FT FROM T. ST. PIPE

WELL NO. MW A3 DATE INSTALLED 6/2/94 DRILL RIG 550

DRILLER C. DENNIS HICKEY DRILL CREW GREGORY H. FOX/JANEEN D. GROVE

JOB/CLIENT J.H. CAMPBELL - CPCO STS PROJECT NO. 72150R

(VERSION 1: 05/90 - MIIDRAW "FIELDWELL")

STS Consultants Ltd.	CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER: MW-A3
	PROJECT NAME: JH CAMPBELL	ARCHITECT-ENGINEER

SITE LOCATION: WEST OLIVE TOWNSHIP

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2}: 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT %: 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT.: 10 20 30 40 50

DEPTH (FT)	ELEVATION (FT)	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL
						SURFACE ELEVATION
			PA			Medium sand, trace gravel, silt and roots - brown - loose - moist. (SP-TOPSOIL)
			PA			Medium sand, trace gravel and silt - brown - medium dense - moist. (SP) NOTE: Beach Sand
5.0						Medium sand, trace gravel and silt - brown - medium dense - wet. (SP)
			PA			
10.0						
13.5						END OF BORING See Well Installation Diagram for more details.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

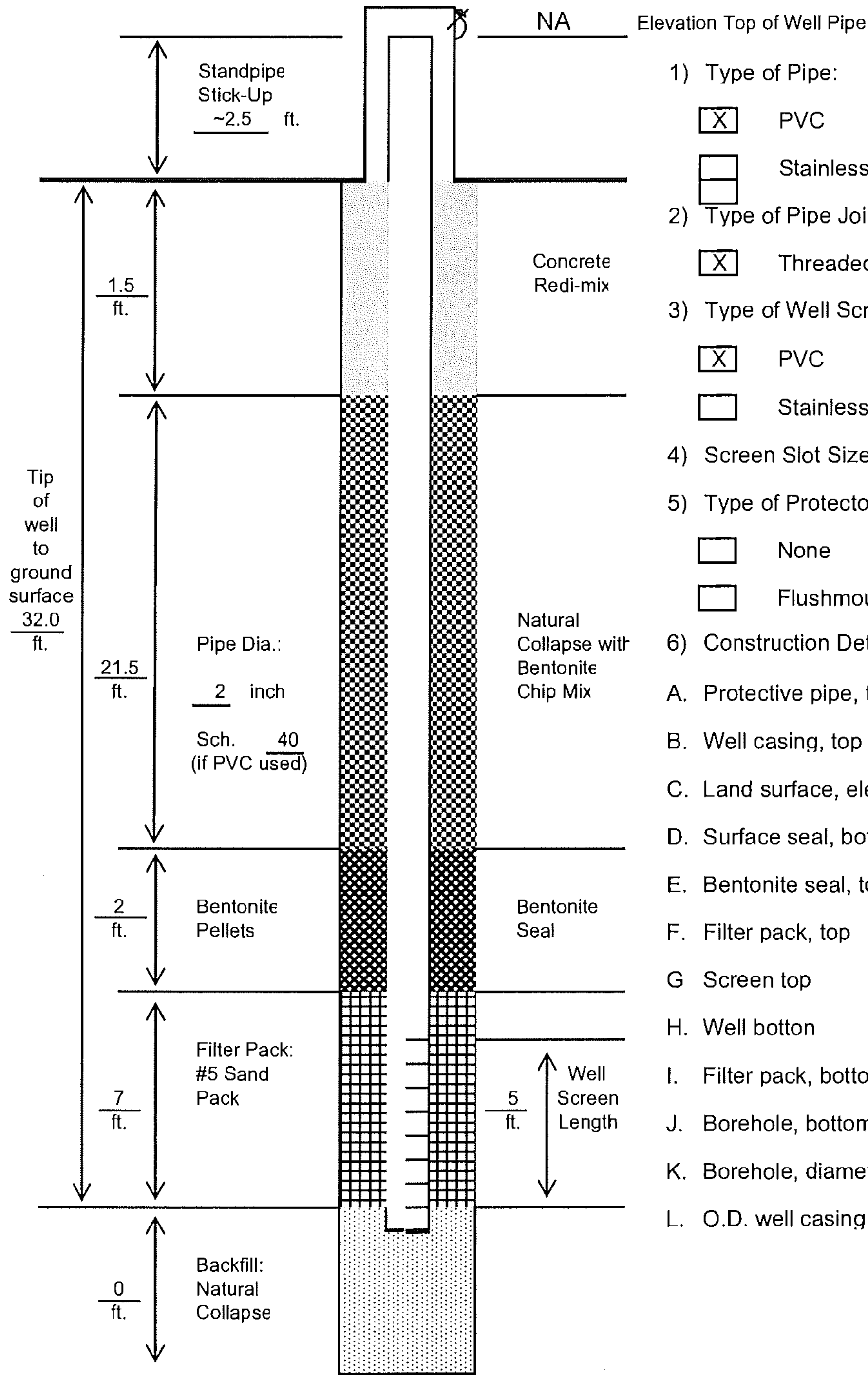
WL 3.5 ft	WS OR WD: WD	BORING STARTED 06/02/94	STS OFFICE Lansing-07	
WL BCR	ACR	BORING COMPLETED 06/02/94	ENTERED BY DAP	SHEET NO. 1 OF 1
WL		RIG/FOREMAN 550/CDH	APP'D BY JDG/JSM	STS JOB NO. 72150R

WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation STS PROJECT NO. 200706041

WELL NO.: **MW-B1** DATE INSTALLED: 12/13/07 DRILLERS: Shepler DRILL RIG: Hollow Stem Auger

NORTHING: 804.80 EASTING: 3996.22



1) Type of Pipe:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

2) Type of Pipe Joint:

- [X] Threaded
- [ ] Other

3) Type of Well Screen:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

- [ ] None
- [X] Steel Pipe with Lock
- [ ] Flushmount

6) Construction Details

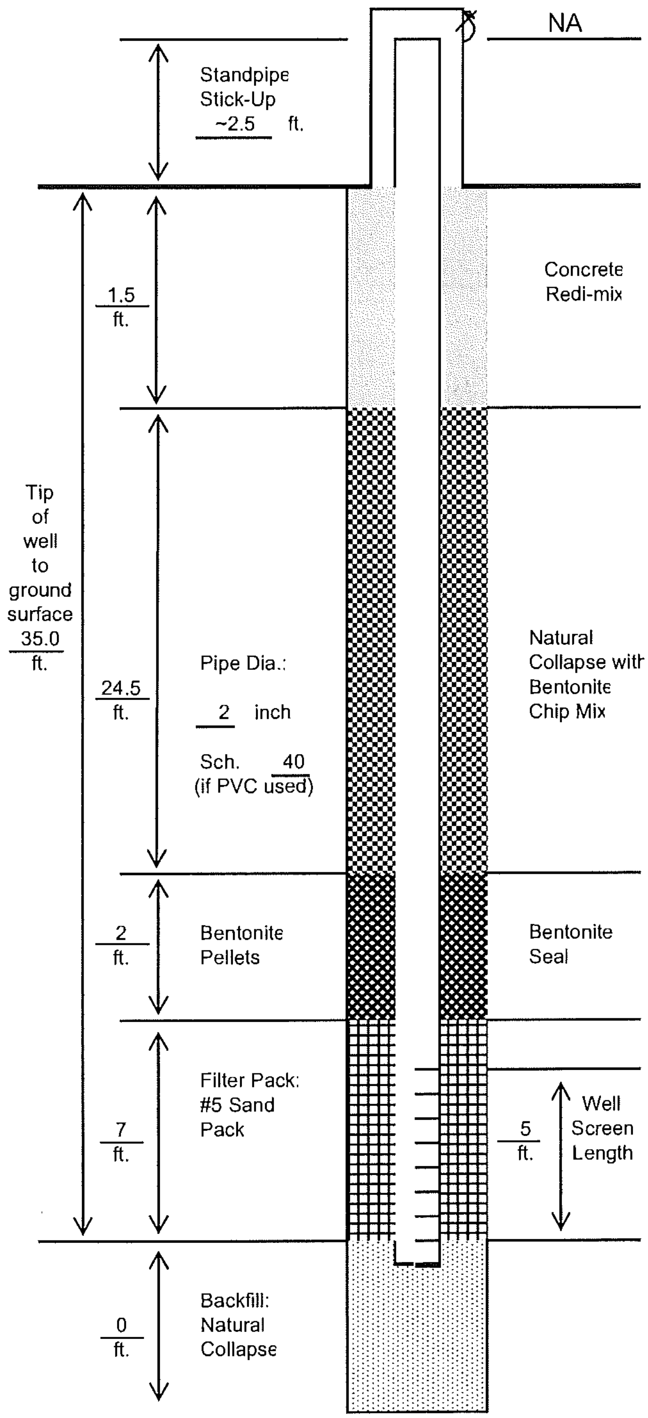
A. Protective pipe, top elevation			NA	ft. MSL
B. Well casing, top elevation			NA	ft. MSL
C. Land surface, elevation			NA	ft. MSL
D. Surface seal, bottom		ft. MSL or	1.50	ft. BGS
E. Bentonite seal, top		ft. MSL or	23.00	ft. BGS
F. Filter pack, top		ft. MSL or	25.00	ft. BGS
G Screen top		ft. MSL or	27.00	ft. BGS
H. Well botton		ft. MSL or	32.00	ft. BGS
I. Filter pack, bottom		ft. MSL or	32.00	ft. BGS
J. Borehole, bottom		ft. MSL or	32.00	ft. BGS
K. Borehole, diameter	8.0	inches		
L. O.D. well casing	2.00	inches		

WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation STS PROJECT NO. 200706041

WELL NO.: **MW-B2** DATE INSTALLED: 12/13/07 DRILLERS: Shepler DRILL RIG: Hollow Stem Auger

NORTHING: 802.20 EASTING: 4500.00



NA Elevation Top of Well Pipe

1) Type of Pipe:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

2) Type of Pipe Joint:

- [X] Threaded
- [ ] Other

3) Type of Well Screen:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

- [ ] None
- [X] Steel Pipe with Lock
- [ ] Flushmount

6) Construction Details

A.	Protective pipe, top elevation	NA ft. MSL		
B.	Well casing, top elevation	NA ft. MSL		
C.	Land surface, elevation	NA ft. MSL		
D.	Surface seal, bottom	ft. MSL or	1.50 ft. BGS	
E.	Bentonite seal, top	ft. MSL or	26.00 ft. BGS	
F.	Filter pack, top	ft. MSL or	28.00 ft. BGS	
G	Screen top	ft. MSL or	30.00 ft. BGS	
H.	Well botton	ft. MSL or	35.00 ft. BGS	
I.	Filter pack, bottom	ft. MSL or	35.00 ft. BGS	
J.	Borehole, bottom	ft. MSL or	35.00 ft. BGS	
K.	Borehole, diameter	8.0 inches		
L.	O.D. well casing	2.00 inches		

STS

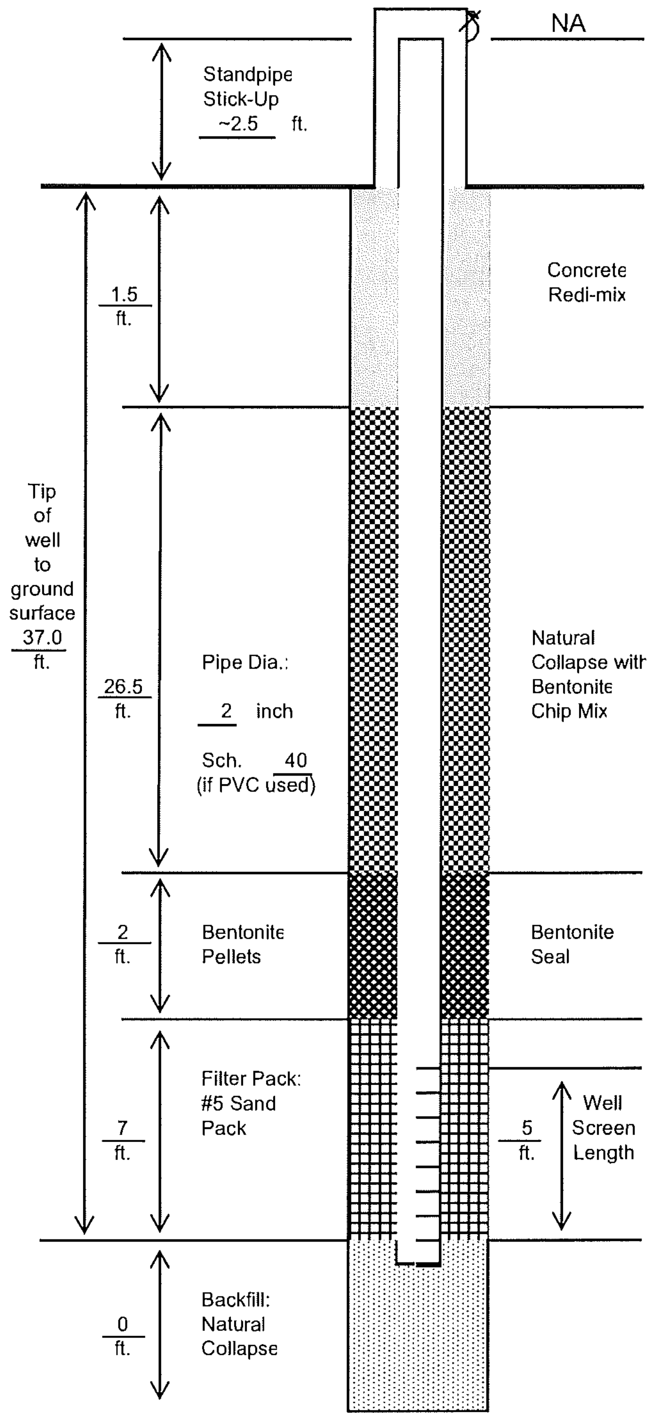
WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation   STS PROJECT NO. 200706041

WELL NO.: **MW-B3**   DATE INSTALLED: 12/13/07   DRILLERS: Shepler   DRILL RIG: Hollow Stem Auger

NORTHING: 802.55   EASTING: 4997, 50

NA Elevation Top of Well Pipe



1) Type of Pipe:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

2) Type of Pipe Joint:

- [X] Threaded
- [ ] Other

3) Type of Well Screen:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

- [ ] None
- [X] Steel Pipe with Lock
- [ ] Flushmount

6) Construction Details

A.	Protective pipe, top elevation	NA ft. MSL		
B.	Well casing, top elevation	NA ft. MSL		
C.	Land surface, elevation	NA ft. MSL		
D.	Surface seal, bottom	ft. MSL or	1.50	ft. BGS
E.	Bentonite seal, top	ft. MSL or	28.00	ft. BGS
F.	Filter pack, top	ft. MSL or	30.00	ft. BGS
G	Screen top	ft. MSL or	32.00	ft. BGS
H.	Well botton	ft. MSL or	37.00	ft. BGS
I.	Filter pack, bottom	ft. MSL or	37.00	ft. BGS
J.	Borehole, bottom	ft. MSL or	37.00	ft. BGS
K.	Borehole, diameter	8.0 inches		
L.	O.D. well casing	2.00 inches		

WATER WELL DRILLING AND PUMP INSTALLATION WELLOGIC FIELD WORK SHEET

Well B-4

Well owner: ____
Permit number: ____
Drill rig operator: Randy Shepler
Job number: 1100454
Date: 03/26/2007

Well depth: 45 ft.

Well type: ✓ new
___ dry hole
___ replacement

Well use: ___ household
___ public (well label & WSSN needed)
___ other Monitoring Well

Drilling method: ___ mud rotary
___ cable tool
___ other 4¼ Auger

Date completed: 03/26/07

CASING type: ✓ pvc
___ steel galvanized
___ steel black
___ other ____

Diameter: 2 in. to 45 ft. depth
___ in. to ___ ft. depth

Casing joint: ___ solvent welded
___ welded
___ threaded and coupled
___ other Flush Joint

Height: 3 ft. above grade

Casing fittings: ___ centralizer
___ drive shoe
___ shale packer
___ other ____

BOREHOLE diameter: 8 in. to 45 ft. depth
___ in. to ___ ft. depth

STATIC WATER LEVEL: N/A ft. below / above grade

WELLHEAD COMPLETION:
___ 12" above grade
___ pitless adapter
___ well house
___ other Exp. CAP.

NEAREST SOURCE OF CONTAMINATION:
Type ____ ft. ___ direction ____
Type ____ ft. ___ direction ____

SCREEN: installed ✓ yes ___ no

Well intake: ___ bedrock well
___ unscreened drift well

Filter pack: ✓ yes ___ no

Filter pack from: 38 ft. to 45 ft.

Filter type (brand): KtE #1

Screen material: ✓ pvc slotted
___ s.s. wirewrapped
___ other ____

Screen diameter: 2 in. ___ telescoped ✓ pipe size

Screen length: 5 ft. Slot: 10

Set between: 40 ft. and 45 ft.

Blank: ___ ft. above / below / other

Screen fittings: ___ k packer
___ bremer check
___ other Attached

GROUTING method: ___ pipe outside casing
___ driven dry granular
✓ other Chips

Number of bags: 1

Additives: None.

Grout material: ___ high solids bentonite
___ neat cement & bentonite
___ neat cement
___ other bentonite chips

Grouting depth: 4 ft. to 8 ft.

DEPTH TO WATER WHILE PUMPING:

___ ft. after ___ hrs. at ___ gpm

Yield test method: ___ air ___ bailer ___ test pump
___ other ____

PUMP installed: ___ yes ___ no

Pump installation only ___ yes ___ no

Manufacturer ________

Model no ________ hp. ____

Drop pipe diameter: ____ in Length ____ ft

Pump capacity: ____ gpm

Drawdown seal ___ yes ___ no

Pump type ___ submersible
___ other ________

PRESSURE TANK installed: ___ yes ___ no

Tank buried: ___ yes ___ no

Tank type: ___ bladder/diaphragm
___ other ________

Manufacturer ________

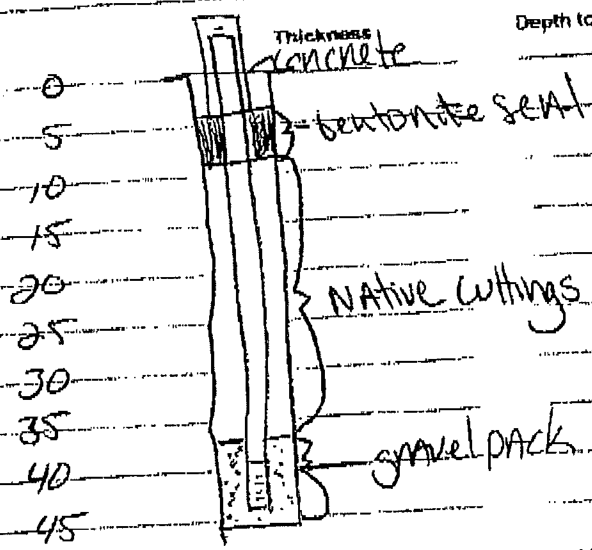
Model no. ________

Total tank capacity: ____ gallons

GEOLOGY
Formation Description

Thickness

Depth to Bottom:



General remarks:

N 803.015

E 5500.253

Ground 631.895

Top of Casing 634.48

Engineering &
Environmental
Solutions, LLC

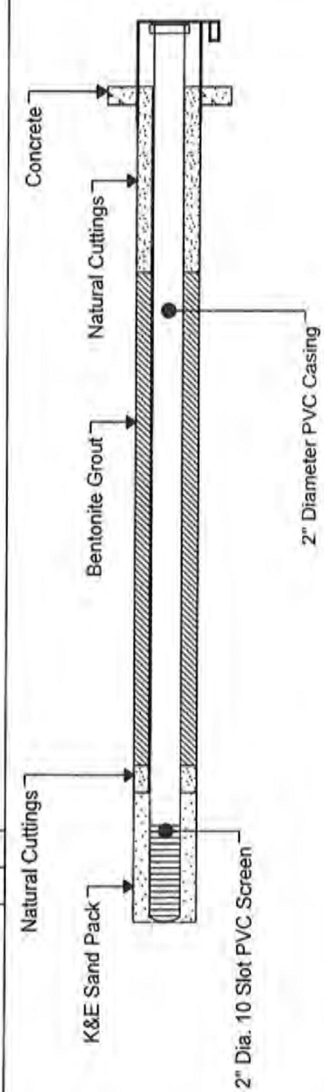
200 North Franklin Street
Suite 202
Zeeland, Michigan 49464

Project Name: Consumers Energy Company

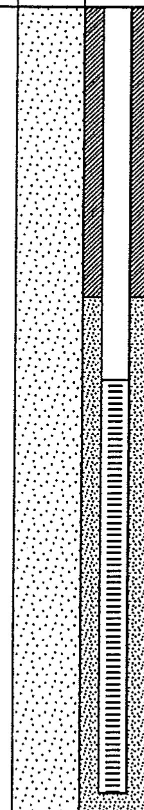
Log of Borehole: MW-B4R

Project Number: 005-11-001
Start Date: 5-23-2011
Site Location: J.H. Campbell
End Date: 5-23-2011
Drilling Method: 4.25" OD HSA
Driller: EDAC
Sampling Method: 2' Split Spoon
Crew Chief: Rick
Ground Elevation (feet): 633.80
Depth to Water (ft BGS during drilling): 36
Top of Casing Elevation (feet): 636.16
Easting: 5514
Logged By: Kurt Van Appledorn
Northing: 802
Comments: Original MW-B4 was abandoned in place by backfilling with bentonite grout

SUBSURFACE PROFILE				SAMPLE				Well Completion Details
Depth (feet BGS)	Symbol	Description	Depth/Elev.	Sample Length (feet)	Recovery (feet)	Blow Counts	PID (ppb)	
-5								
0		Ground Surface	633.8 / 0.0					
40		Brown (7.5YR/5/3) fine SAND, trace medium sand, wet.		2	1.3	2 2 4 6		
				2	1.0	7 14 18 23		
45		End of Boring	588.8 / 45.0					



Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
MW-B5 (5)	21	5/6 8/6	26											
			28											
MW-B5 (6)	15	2/3 6/6	30	yellow (10YR 7/6)										
			32											
			34		SP									
MW-B5 (7)	22	2/4 6/7	36	very pale brown (10YR 7/4) wet at approximately 36 feet below ground surface										
			38											
			40											
			42											
			44	*End of Boring at 43.5 feet below ground surface*										
			46											
			48											
			50											
			52											
			54											
			56											
			58											
			60											
			62											



MONITORING WELL CONSTRUCT

Facility/Project Name JH CAMPBELL PLANT CONSUMERS ENERGY

Local Grid Location of Well ____ ft. □ N. □ S. ____ ft. □ E. □ W.

Well Name MW - B5

Facility License, Permit or Monitoring Number

Grid Origin Location Lat. ____ Long. ____ or St. Plane ____ ft. N, ____ ft. E.

Type of Well Water Table Observation Well ■ Piezometer □

Date Well Installed 03 / 14 / 200 (m m / d d / y y)

Section Location of Waste/Source ___1/4 of ___ 1/4 of Sec. ___, T. ___ N, R. ___ □ E. □ W.

Distance Well Is From Waste/Source Boundary ____ ft.

Well Installed By: (Person's Name and Firm) SEAN SMITH ENVIRONMENTAL DRILLING + C

Location of Well Relative to Waste/Source
u □ Upgradient s □ Sidegradient
d □ Downgradient n □ Not Known

A. Protective pipe, top elevation ____ ft. MSL

B. Well casing, top elevation 634.89 ft. MSL

C. Land surface elevation ____ ft. MSL

D. Surface seal, bottom ____ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP □ GM □ GC □ GW □ SW □ SP ■
SM □ SC □ ML □ MH □ CL □ CH □
Bedrock □

13. Sieve analysis attached? □ Yes ■ No

14. Drilling method used: Rotary □ Hollow Stem Auger ■ Other □

15. Drilling fluid used: Water ■ Air □ Drilling Mud □ None □

16. Drilling additives used? □ Yes ■ No

Describe N/A

17. Source of water (attach analysis):

E. Bentonite seal, top ____ ft. MSL or 1 0 ft.

F. Fine sand, top ____ ft. MSL or ____ ft.

G. Filter pack, top ____ ft. MSL or 31 0 ft.

H. Screen joint, top ____ ft. MSL or 330 ft.

I. Well bottom ____ ft. MSL or 430 ft.

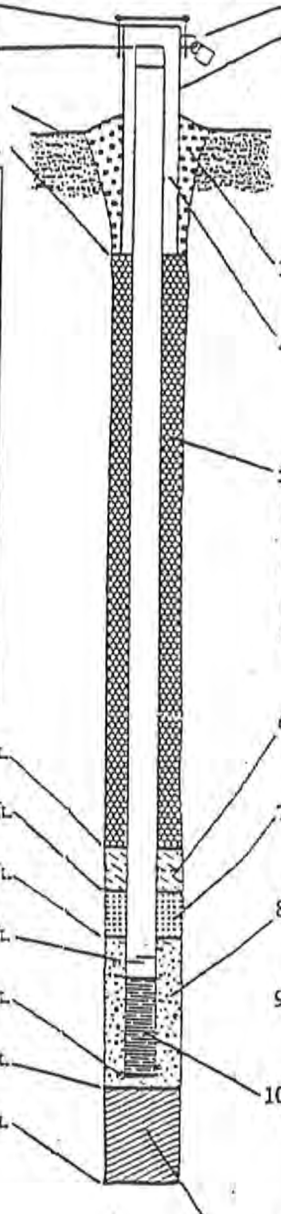
J. Filter pack, bottom ____ ft. MSL or 435 ft.

K. Borehole, bottom ____ ft. MSL or 435 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 2.25 in.



1. Cap and lock? ■ Yes □ N

2. Protective cover pipe:
a. Inside diameter: --.--
b. Length: --.--
c. Material: Steel ■ Other □
d. Additional protection? □ Yes ■ N
If yes, describe:

3. Surface seal: Bentonite ■ Concrete □ Other □

4. Material between well casing and protective pipe: Bentonite □ Annular space seal □ SAND Other ■

5. Annular space seal: a. Granular Bentonite □
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry □
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry □
d. ____ % Bentonite . . . . . Bentonite-cement grout □
e. ____ Ft^3 volume added for any of the above
f. How installed: Tremie □ Tremie pumped □ Gravity ■

6. Bentonite seal: a. Bentonite granules □
b. □ 1/4 in. ■ 3/8 in. □ 1/2 in. Bentonite ~~pellets~~ CHIPS ■
c. ____ Other □

7. Fine sand material: Manufacturer, product name & mesh si
a.
b. Volume added ____ ft^3

8. Filter pack material: Manufacturer, product name and mesh
a. FLAT ROCK, FILTER SAND #30
b. Volume added ____ ft^3

9. Well casing: Flush threaded PVC schedule 40 ■ Flush threaded PVC schedule 80 □ Other □

10. Screen material: PVC
a. Screen type: Factory cut ■ Continuous slot □ Other □
b. Manufacturer BIG FOOT
c. Slot size: 0.010
d. Slotted length: 10.0

11. Backfill material (below filter pack): None ■ Other □

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	MW - B5
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well 45 min.

4. Depth of well (from top of well casing) __ . __ ft.

5. Inside diameter of well 2.25 in.

6. Volume of water in filter pack and well casing __ . __ gal.

7. Volume of water removed from well 120.0 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. __ . __ ft.	__ . __ ft.
Date	b. 03/15/2001 (mm dd yyyy)	03/15/200[illegible] (mm dd yyyy)
Time	c. __ : __ ☐ a.m. ☐ p.m.	__ : __ ☐ a.m. ☐ p.m.
12. Sediment in well bottom	__ . __ inches	__ . __ inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe)	Clear ☒ Turbid ☐ (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	__ . __ mg/l	__ . __ mg/l
15. COD	__ . __ mg/l	__ . __ mg/l

16. Well developed by: Name (first, last) and Firm
First Name: JAMIE Last Name:
Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

ALTERNATED SURGE AND PURGE ~ EVERY 10-15 MINUTES

Name and Address of Facility Contact/Owner/Responsible Party
First Name: ______ Last Name: ______
Facility/Firm: CONSUMERS ENERGY
Street: 212 WEST MICHIGAN AVENUE
City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.
Signature: [signature]
Print Name: REBECCA J. KOEPKE
Firm: NATURAL RESOURCE TECHNOLOGY, INC.

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Consumers Energy / J.H. Campbell Plant		MW-B6

Boring Drilled By (Firm name and name of crew chief)	Date Drilling Started	Date Drilling Completed	Drilling Method
Environmental Drilling and Contracting, Inc. Sean Smith / Bob Miller	03/13/01	03/13/01	4-1/4" (ID) HSA

Facility Well No.	Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
			Feet MSL	Feet MSL	8.3 inches

Boring Location		Lat / Long	Local Grid Location (if applicable)
State Plane	Feet N Feet E	Lat Long	☐ N ☐ S ☐ E ☐ W

County		Civil Town/City/ or Village
Ottawa		Port Sheldon Township

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–2	0'-0.5' SANDY ORGANIC SOIL, very dark brown, very fine to fine, loose, moist.	OL									
			2–4	0.5'-30.5' SAND, very pale brown (10YR 7/4), poorly graded, fine, trace silt, round, loose, slightly moist.	SP									
MW-B6 (1)	12	2/5 4/5	6											
MW-B6 (2)	16	3/2 3/5	10	very fine.	SP									
MW-B6 (3)	16	4/11 14/20	16	very pale brown (10YR 8/3), fine.										
MW-B6 (4)	15	4/10 15/11	20	fine to medium, moist.	SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
	Natural Resource Technology, Inc.

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
MW-B6 (5)	18	4/9 11/15	26											
			28		SP									
			30											
				End of Boring at 30.5 feet below ground surface										
			32											
			34											
			36											
			38											
			40											
			42											
			44											
			46											
			48											
			50											
			52											
			54											
			56											
			58											
			60											
			62											

MONITORING WELL CONSTRUCT

Facility/Project Name JH CAMPBELL PLANT CONSUMERS ENERGY	Local Grid Location of Well ____ ft. □N □S ____ ft. □E □W	Well Name MW-B6
Facility License, Permit or Monitoring Number	Grid Origin Location Lat. ____ Long. ____ or	
Type of Well: Water Table Observation Well ■ Piezometer □	St. Plane ____ ft. N. ____ ft. E.	Date Well Installed 03 / 13 / 20c (m m / d d / y y)
Distance Well Is From Waste/Source Boundary ____ ft.	Section Location of Waste/Source ___1/4 of ___1/4 of Sec. ___, T. ___ N, R. ___ □E □W	Well Installed By: (Person's Name and Firm) SEAN SMITH ENVIRONMENTAL DRILLING + C
	Location of Well Relative to Waste/Source: u □ Upgradient s □ Sidegradient d □ Downgradient n □ Not Known	

A. Protective pipe, top elevation ____ ft. MSL

B. Well casing, top elevation 615.90 ft. MSL

C. Land surface elevation ____ ft. MSL

D. Surface seal, bottom ____ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP □ GM □ GC □ GW □ SW □ SP ■
SM □ SC □ ML □ MH □ CL □ CH □
Bedrock □

13. Sieve analysis attached? □ Yes ■ No

14. Drilling method used: Rotary □ Hollow Stem Auger ■ Other □

15. Drilling fluid used: Water ■ Air □ Drilling Mud □ None □

16. Drilling additives used? □ Yes ■ No

Describe N/A

17. Source of water (attach analysis):

E. Bentonite seal, top ____ ft. MSL or 1.0 ft.

F. Fine sand, top ____ ft. MSL or ____ ft.

G. Filter pack, top ____ ft. MSL or 18.0 ft.

H. Screen joint, top ____ ft. MSL or 20.0 ft.

I. Well bottom ____ ft. MSL or 30.0 ft.

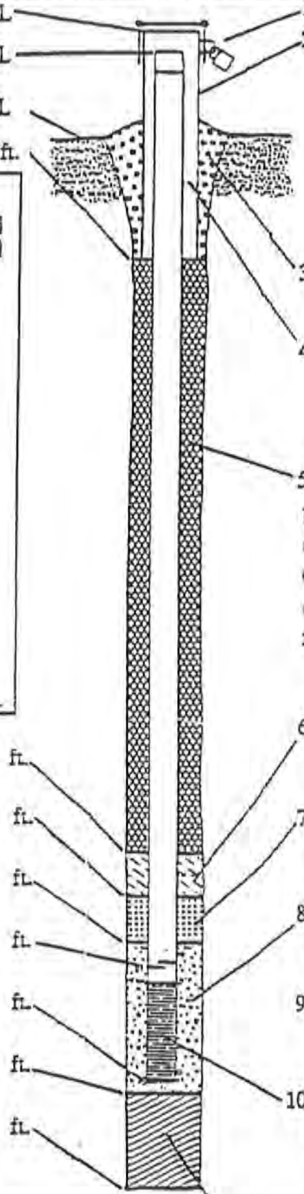
J. Filter pack, bottom ____ ft. MSL or 30.5 ft.

K. Borehole, bottom ____ ft. MSL or 30.5 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 2.25 in.



1. Cap and lock? ■ Yes □

2. Protective cover pipe:
a. Inside diameter:
b. Length:
c. Material: Steel ■ Other □
d. Additional protection? □ Yes ■
If yes, describe:

3. Surface seal: Bentonite ■ Concrete □ Other □

4. Material between well casing and protective pipe: Bentonite □ Annular space seal □ SAND Other ■

5. Annular space seal: a. Granular Bentonite □
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry □
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry □
d. ____ % Bentonite . . . . . . Bentonite-cement grout □
e. ____ Ft^3 volume added for any of the above
f. How installed: Tremie □ Tremie pumped □ Gravity ■

6. Bentonite seal: a. Bentonite granules □
b. □1/4 in. ■3/8 in. □1/2 in. Bentonite ~~pellets~~ CHIPS ■
c. ____ Other □

7. Fine sand material: Manufacturer, product name & mesh si
a. ____
b. Volume added ____ ft^3

8. Filter pack material: Manufacturer, product name and mesh
a. FLAT ROCK, FILTER SAND, #30
b. Volume added ____ ft^3

9. Well casing: Flush threaded PVC schedule 40 ■ Flush threaded PVC schedule 80 □ Other □

10. Screen material: PVC
a. Screen type: Factory cut ■ Continuous slot □ Other □
b. Manufacturer BIG FOOT
c. Slot size: 0.010
d. Slotted length: 10.0

11. Backfill material (below filter pack): None ■ Other □

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	MW - B6
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well 45 min.

4. Depth of well (from top of well casisng) ___.__ ft.

5. Inside diameter of well 2.25 in.

6. Volume of water in filter pack and well casing ___.__ gal.

7. Volume of water removed from well 1200 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No (If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. ___.__ ft.	___.__ ft.
Date	b. 03/15/2001 (mm dd yyyy)	03/15/200[illegible] (mm dd yyyy)
Time	c. __:__ ☐ a.m. ☐ p.m.	__:__ ☐ a.m. ☐ p.m.
12. Sediment in well bottom	__.__ inches	__.__ inches
13. Water clarity	Clear ☐ Turbid ☒ (Describe)	Clear ☒ Turbid ☐ (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Well developed by: Name (first, last) and Firm

First Name: JAMIE Last Name:

Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

ALTERNATED SURGE AND PURGE ~ EVERY 10-15 MINUTES

Name and Address of Facility Contact/Owner/Responsible Party

First Name: ________ Last Name: ________

Facility/Firm: CONSUMERS ENERGY

Street: 212 WEST MICHIGAN AVENUE

City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Name: REBECCA J. KOEPKE

Firm: NATURAL RESOURCE TECHNOLOGY, INC.

ERM
Environmental Resources Management
3352 128th Avenue
Holland, Michigan 49424
(616) 399-3500
(616) 399-3777 (fax)

WELL CONSTRUCTION SUMMARY

WELL No. MW-B7

PROJECT: Consumers Energy-J.H.Cambell

PROJECT No. W0406.00.01

CONSTRUCTION TIME LOG

TASK	START DATE	START TIME	FINISH DATE	FINISH TIME
DRILLING: (METHOD) HSA-4.25" I.D.	8/29/01	1:15 PM	8/29/01	4:15 PM
WELL PLACEMENT:	8/29/01	2:30 PM	8/29/01	2:35 PM
FILTER PLACEMENT:	8/29/01	2:40 PM	8/29/01	2:50 PM
GROUTING:	8/29/01	3:55 PM	8/29/01	4:15 PM
DEVELOPMENT:	8/29/01	3:00 PM	8/29/01	3:40 PM
OTHER:				

WATER LEVEL MEASUREMENTS

DATE	TIME	WATER LEVEL	ELEVATION
8/30/01	8:50 AM	24.9 ft TOC	588.51 ft

WELL DEVELOPMENT

Use Grundfos pump - start turbid brown (5 gallons), steady rate ~ 45 gallons, slight yellow/brown color at end

STABILIZATION TEST DATA

DATE	pH	SPECIFIC COND.	TEMP (°C)

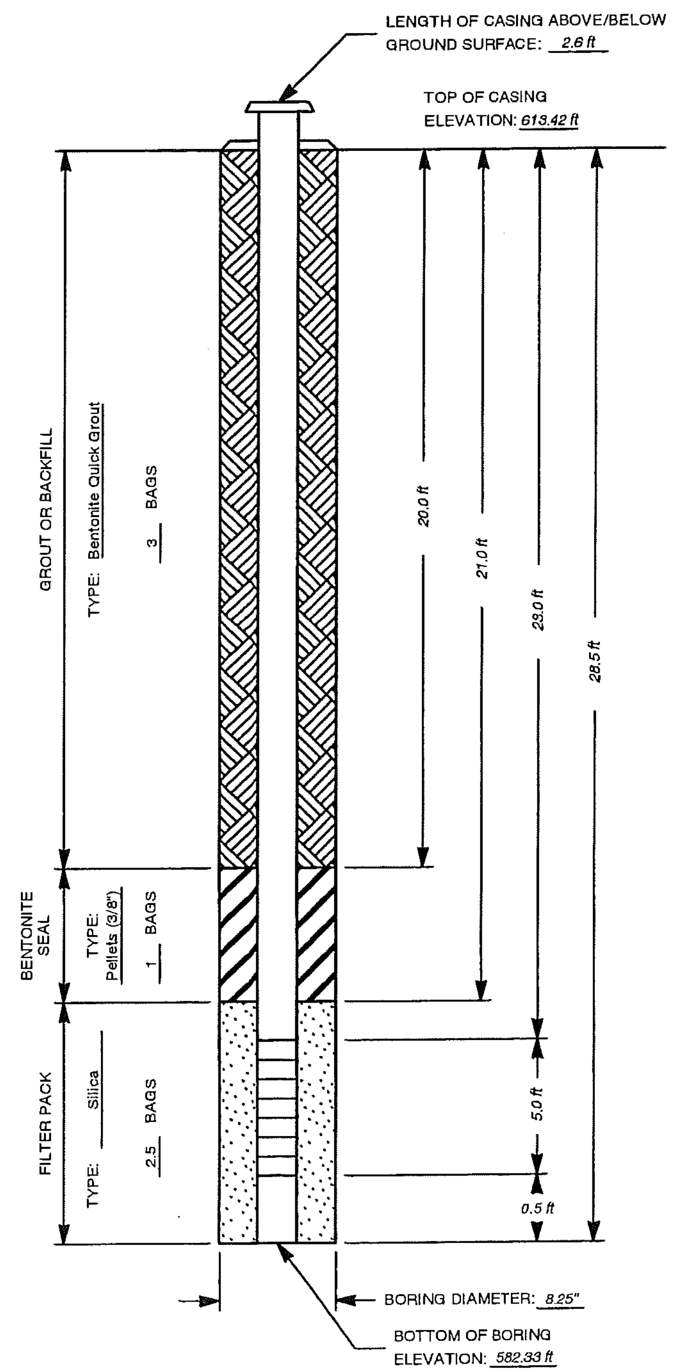
CONSTRUCTION SUMMARY

DRILLER EDAC - Sean Smith, Holland, Michigan

WELL CASING
MATERIAL: PVC DIA: 2.0"
TOTAL LENGTH: 25.6 ft
CAP TYPE: J-Plug

WELL SCREEN
MATERIAL: PVC DIA: 2.0"
TOTAL LENGTH: 5.0 ft WELL PT: 0.5 ft
SLOT / TYPE: 0.01

PROTECTIVE WELL CASING
MATERIAL: Steel DIA: 4.0"
HEIGHT ABOVE GROUND: 2.6 ft
LOCK TYPE: None



CONSTRUCTION NOTES

~600' East of MW-B6 - Elevations based on MW-B6 elevation provided by Consumers Energy

Soil and water placed on ground near well per CEC

Replacement of old MW-B7

Environmental Resources Management
3352 128th Avenue
Holland, Michigan 49424
(616) 399-3500
(616) 399-3777 (fax)
ERM

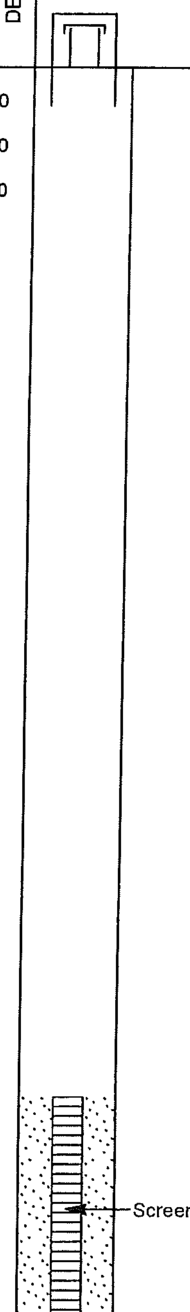
BORING/WELL CONSTRUCTION LOG

PROJECT NUMBER	W0406.00.01	**BORING/WELL NUMBER**	MW-B7
PROJECT NAME	Consumers Energy-J.H.Cambell	**START DATE**	8/29/2001
LOCATION	East of Cell 7	**FINISH DATE**	8/29/2001
DRILLING METHOD	HSA - 4.25" I.D.	**CONTRACTOR**	EDAC - Holland, MI
SAMPLING METHOD	2' Split Spoon	**CREW CHIEF**	Sean Smith
GROUND ELEVATION (ft)	610.83	**WEATHER**	Sunny, 75°F, Light breeze from South
TOP OF CASING ELEVATION (ft)	613.42	**BACKFILL MATERIAL**	Bentonite Slurry
LOGGED BY	PMS	**DEPTH TO WATER DURING DRILLING (ft)**	22.0

REMARKS Completed with above ground riser and protective casing(~3');blow count-hammer height is controlled manually.

PID (ppm)	BLOW COUNTS	RECOVERY (feet)	SAMPLE ID.	EXTENT	DEPTH (ft. BGL)	U.S.C.S.	LITHOLOGIC DESCRIPTION	CONTACT DEPTH
	2, 2, 2, 5	1.5	SS		0-2		0'-1' Semi compact dark, organic, clayey, fine SAND, moist 1'-2' Loose, tan, fine SAND, trace silt, moist	1.00 2.00
	8, 7, 6, 6	1.6	SS		2-4		2'-3' Medium compact, light brown, fine SAND, trace clay, moist 3'-28.5' Loose, tan, fine SAND, trace silt, moist	3.00
	8, 8, 7, 7	1.5	SS		4-6		Wet at 22' Grades to light brown	
	7, 6, 4, 5	1.4	SS		6-8			
	6, 5, 5, 6	1.0	SS		8-10			
	3, 4, 5, 5	1.2	SS		10-12			
	6, 7, 7, 7	1.5	SS		12-14			
	4, 4, 4, 7	1.2	SS		14-16			
	4, 4, 4, 6		SS		16-18			
	1, 3, 5, 4	1.0	SS		18-20			
	2, 2, 2, 2	1.6	SS		20-22		∇	
	2, 2, 2, 2	1.5	SS		22-24			
	1, 2, 2, 3	1.5	SS		24-26			
	4, 6, 12, 19	1.8	SS		26-28.5			
					28.5		28.5 End of Boring	28.50

WELL DIAGRAM



BORING WELL CONSTRUCTION CONJHCAM.GPJ ERM_MI.GDT 10/8/01

Natural Resource Technology, Inc.
Standard Soil Boring Log

Old well

SOIL BORING LOG INFORMATION
Form - Non-WI#2 Rev. 8-2000

Facility/Project Name Consumers Energy / J.H. Campbell Plant			**License/Permit/Monitoring Number**		**Boring Number** MW-B7
Boring Drilled By (Firm name and name of crew chief) Environmental Drilling and Contracting, Inc. Sean Smith / Bob Miller			**Date Drilling Started** 03/15/01	**Date Drilling Completed** 03/15/01	**Drilling Method** 4-1/4" (ID) HSA
Facility Well No.	**Unique Well No.**	**Common Well Name** MW-B7	**Final Static Water Level** Feet MSL	**Surface Elevation** Feet MSL	**Borehole Diameter** 8.3 inches
Boring Location State Plane		Feet N Feet E	Lat Long	**Local Grid Location (If applicable)** ☐ N ☐ S ☐ E ☐ W	
County Ottawa			**Civil Town/City/ or Village** Port Sheldon Township		

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–0.5	0'-0.5' SANDY ORGANIC SOIL, very dark brown, very fine to fine, loose, moist.	OL									
			0.5–5	0.5'-36.5' SAND, brownish yellow (10YR 6/8), poorly graded, fine, trace silt, round, loose, slightly moist.	FILL (SP)									
MW-B7 (1)	21	10/11 16/19	5–7											
MW-B7 (2)	20	14/18 20/20	10–12											
MW-B7 (3)	22	14/12 18/20	15–17	trace of coal fragments										
MW-B7 (4)	20	3/5 5/5	20–22	brownish yellow (10YR 6/6), no coal fragments										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature]

Firm **Natural Resource Technology, Inc.**

Old well

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
MW-B7 (5)	20	2/7 8/8	26	mixed brownish yellow, brown, very dark brown, and strong brown										
MW-B7 (6)	20	3/8 10/12	30	very pale brown (10YR 7/4), wet	FILL (SP)									
			36.5	*End of Boring at 36.5 feet below ground surface*										

Depth scale: 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62

Old well

MONITORING WELL CONSTRUC

Facility/Project Name JH CAMPBELL CONSUMERS ENERGY PLANT	Local Grid Location of Well ____ ft. ☐N ☐S ____ ft. ☐E ☐W	Well Name MW-B7
Facility License, Permit or Monitoring Number	Grid Origin Location Lat. ____ Long. ____ or	
Type of Well Water Table Observation Well ☒ Piezometer ☐	St. Plane ____ ft. N, ____ ft. E.	Date Well Installed 03/15/20 (m m d d y y)
Distance Well Is From Waste/Source Boundary ____ ft.	Section Location of Waste/Source ____ 1/4 of ____ 1/4 of Sec. ____, T. ____ N, R. ____ ☐E ☐W	Well Installed By: (Person's Name and Fir SEAN SMITH ENVIRONMENTAL DRILLING &
	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation ____ ft. MSL

B. Well casing, top elevation 613.42 ft. MSL

C. Land surface elevation ____ ft. MSL

D. Surface seal, bottom ____ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☒ Air ☐ Drilling Mud ☐ None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis):

E. Bentonite seal, top ____ ft. MSL or 1.0 ft.

F. Fine sand, top ____ ft. MSL or ____ ft.

G. Filter pack, top ____ ft. MSL or 24.0 ft.

H. Screen joint, top ____ ft. MSL or 26.0 ft.

I. Well bottom ____ ft. MSL or 36.0 ft.

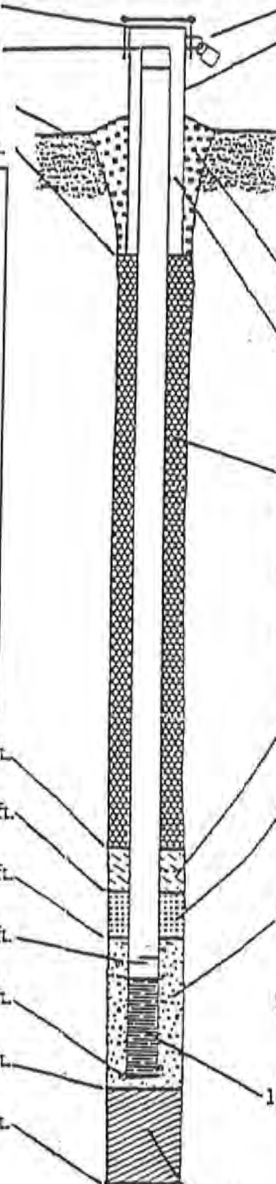
J. Filter pack, bottom ____ ft. MSL or 36.5 ft.

K. Borehole, bottom ____ ft. MSL or 36.5 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 2.25 in.



1. Cap and lock? ☒ Yes ☐

2. Protective cover pipe:
a. Inside diameter: ____
b. Length: ____
c. Material: Steel ☒ Other ☐
d. Additional protection? ☐ Yes ☒
If yes, describe: ____

3. Surface seal: Bentonite ☒ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ Annular space seal ☐ SAND Other ☒

5. Annular space seal: a. Granular Bentonite ☐
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. ____ % Bentonite . . . . . . Bentonite-cement grout ☐
e. ____ Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
b. ☐1/4 in. ☒3/8 in. ☐1/2 in. Bentonite ~~pellets~~ CHIPS ☒
c. ____ Other ☐

7. Fine sand material: Manufacturer, product name & mesh s
a. ____
b. Volume added ____ ft^3

8. Filter pack material: Manufacturer, product name and mesh
a. FLAT ROCK FILTER SAND, #30
b. Volume added ____ ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ Flush threaded PVC schedule 80 ☐ Other ☐

10. Screen material: PVC
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer BIG FOOT
c. Slot size: 0.01
d. Slotted length: 10.

11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Old well

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	MW-B7
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well 45 min.

4. Depth of well (from top of well casisng) __ . __ ft.

5. Inside diameter of well 2.25 in.

6. Volume of water in filter pack and well casing __ . __ gal.

7. Volume of water removed from well 120.0 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No (If yes, attach results)

		Before Development	After Development
11. Depth to Water (from top of well casing)	a.	__ . __ ft.	__ . __ ft.
Date (mm dd yyyy)	b.	03/15/2001	03/15/20[illegible]
Time	c.	__:__ ☐ a.m. ☐ p.m.	__:__ ☐ a.m. ☐ p.m.
12. Sediment in well bottom		__ . __ inches	__ . __ inches
13. Water clarity		Clear ☐ Turbid ☒ (Describe)	Clear ☒ Turbid ☐ (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

	Before Development	After Development
14. Total suspended solids	__ . __ mg/l	__ . __ mg/l
15. COD	__ . __ mg/l	__ . __ mg/l

16. Well developed by: Name (first, last) and Firm
First Name: JAMIE Last Name:
Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

ALTERNATED SURGE AND PURGE ~ EVERY 10-15 MINUTES

Name and Address of Facility Contact/Owner/Responsible Party
First Name: ______ Last Name: ______
Facility/Firm: CONSUMERS ENERGY
Street: 212 WEST MICHIGAN AVENUE
City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.
Signature: [signature]
Print Name: REBECCA J. KOEPKE
Firm: NATURAL RESOURCE TECHNOLOGY, INC.

DRILLING AND SAMPLING LOG

HOLE NO. Pz-22

ELEV. 601.0

PROJECT J. H. Campbell Plant, Consumers Power Co. DEPTH 23.8 ft.

FEATURE Groundwater Study DEPTH TO WATER 8.3 ft. 8/6/76

JOB NO. 64-0047-954 DRILLER Balzer Cook LOGGED BY P. D. Lidel

LOCATION

DRILLING CO. Great Lakes Soiltest Services DRILL RIG Mobil B-40

Completion Date 8/6/76

Drilling Method: Eight-inch hollow stem auger, Standard Penetration Resistance Test and split spoon samples taken every five feet.

DEPTH (ELEV.)	CLASS	FIELD DESCRIPTION	SAMPLE NUMBER	RECOVERY	SPT	REMARKS
0 (601.0)	SP	0.0 - 20.0 Sand, brown, very fine grained, loose, damp above water table (SP). 0.0 - 0.5 Sand is dark brown due to presence of organic matter and roots	1	100	X	1/1/1
5			2	100	X	1/3/3 Bag sample #4 taken between 5.0 and 6.0 ft.
10			3	100	X	2/2/2 Bag sample #5 taken at 13 ft.
15			4	40	X	1/1/1
20			5	100	X	3/3/7
(581.0)		Bottom of Boring - 20.0 ft. Drove 2 in. dia. well screen to 23.8 with 1.0 ft. of casing above ground. Hole sealed with 1/2 bag of bentonite.				
25						
30						

Commonwealth Associates Inc. Engineers/Consultants/Architects 209 E Washington Avenue Jackson, Michigan 49201

SHEET 1 OF 1

DRILLING AND SAMPLING LOG

HOLE NO. Pz-23

ELEV. 602.9

PROJECT J. H. Campbell Plant, Consumers Power Co. DEPTH 18.6 ft.

FEATURE Groundwater Study DEPTH TO WATER 9.7 ft. 8/5/76

JOB NO. 64-0047-954 DRILLER Balzer Cook LOGGED BY P. D. Lidel

LOCATION

DRILLING CO. Great Lakes Soiltest Services DRILL RIG Mobil B-40

Completion Date 8/5/76

Drilling Method: Eight-inch hollow stem auger, Standard Penetration Resistance Test and split spoon samples taken every five feet.

DEPTH (ELEV.)	CLASS	FIELD DESCRIPTION	SAMPLE NUMBER	RECOVERY	SPT	REMARKS
0 (602.9)	SP	0.0 - 16.0 Sand, brown, very fine grained, loose and dry at surface becoming more damp toward water table (SP) 0.0 - 0.5 Sand is dark brown due to the presence of organic matter.	1	66	X	1/0/0
5			2	100	X	2/2/4 Bag sample #1 taken between 7.0 and 9.0 ft.
10			3	100	X	2/3/3
15			4	33	X	1/1/1
(584.3)		Bottom of Boring - 16.0 ft. Drove 2 in. dia. well screen to 18.6 ft. with 1.0 ft. of casing above ground. Hole sealed with 1/2 bag of bentonite.				
20						
25						
30						

Commonwealth Associates Inc. Engineers/Consultants/Architects 209 E Washington Avenue Jackson, Michigan 49201

SHEET 1 OF 1

DRILLING AND SAMPLING LOG

HOLE NO. Pz-24

ELEV. 596.7

PROJECT J. H. Campbell Plant, Consumers Power Co. DEPTH 17.0 ft.

FEATURE Groundwater Study DEPTH TO WATER 4.0 ft. 8/6/76

JOB NO. 64-0047-954 DRILLER Balzer Cook LOGGED BY P. D. Lidel

LOCATION

DRILLING CO. Great Lakes Soiltest Services DRILL RIG. Mobil B-40

Completion Date 8/6/76

Drilling Method: Eight-inch hollow stem auger, Standard Penetration Resistance Test and split spoon samples taken every five feet.

DEPTH (ELEV.)	CLASS	FIELD DESCRIPTION	SAMPLE NUMBER	RECOVERY	SPT	REMARKS
0 (596.7)	SP	0.0 - 13.0 Sand, brown, very fine grained, loose, damp above water table at 4.0 ft., contains organic matter in upper 0.5 ft. (SP)	1	100	X	1/1/2
5			2	100	X	1/2/2
10			3	75	X	1/1/1
	ML	13.0 - 17.0 Sandy silt, gray, dense, about 80% silt and 20% fine sand present (ML)				
15			4	100	X	21/25/26
(579.7)		Bottom of Boring - 17.0 ft.				
20		Piezometer installation was offset from sampled hole. Augered to 10.0 ft. and drove 2 in. dia. well screen to 13.3 ft. with a 1.0 ft. of casing above ground. Hole sealed with 1/2 bag of bentonite.				
25						
30						

Commonwealth Associates Inc. Engineers/Consultants/Architects 209 E Washington Avenue Jackson, Michigan 49201

SHEET 1 OF 1

DRILLING AND SAMPLING LOG

HOLE NO. Pz-25

ELEV. 587.0

PROJECT J. H. Campbell Plant, Consumers Power Co. DEPTH 13.2 ft.

FEATURE Groundwater Study DEPTH TO WATER 4.0 ft. 8/6/76

JOB NO. 64-0047-954 DRILLER Balzer Cook LOGGED BY P. D. Lidel

LOCATION

DRILLING CO. Great Lakes Soiltest Services DRILL RIG. Mobil B-40

Completion Date 8/6/76

Drilling Method: Eight-inch hollow stem auger, Standard Penetration Resistance Test and split spoon samples taken every five feet.

DEPTH (ELEV.)	CLASS	FIELD DESCRIPTION	SAMPLE NUMBER	RECOVERY	SPT	REMARKS
0 (587.0)	SP	0.0 - 10.0 Sand, brown, very fine grained, loose, damp above water table, contains some organic matter in upper 0.5 ft. (SP)	1	100	X	1/1/1
5			2	100	X	1/2/2
10			3	33	X	1/1/1
(577.0)		Bottom of Boring - 10.0 ft.				
		Drove 2 in. dia. well screen to 13.2 ft. with 1.0 ft. of casing above ground. Hole sealed with 1/2 bag of bentonite.				
15						
20						
25						
30						

Commonwealth Associates Inc. Engineers/Consultants/Architects 209 E Washington Avenue Jackson, Michigan 49201

SHEET 1 OF 1

Consumers Power Company
J. H. Campbell Plant, Unit 3
Groundwater Study
W. O. 64-0047-954

BORING PZ-16R

SURFACE ELEVATION 601.8
COORDINATE

ELEV. IN FEET	OTHER TESTS	STRENGTH TEST (PSF)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FIELD MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT RECOVERY (%)	RQD	DEEP IN FEET
600									
									5
590									10
									15
580									20
									25
570									30
									35

BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
2	SPT	SP	LIGHT BROWN SAND: fine to medium-grained, trace of fine gravel, very loose to loose grading to medium dense, 0'-35'.
6	SPT		
2	SPT		
3	O		
15	O		
20	O		
22	O		

Completed boring at 35' on 9/6/79.
Installed PVC standpipe piezometer with bottom of screen at elev. 570.5.

BORING PZ-37

SURFACE ELEVATION 600.3
COORDINATE

ELEV. IN FEET	OTHER TESTS	STRENGTH TEST (PSF)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FIELD MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT RECOVERY (%)	RQD	DEEP IN FEET
600									
									5
590									10
									15
									20

BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
11	SPT	SP	LIGHT BROWN SAND: very fine to fine-grained, trace of coarse sand and fine gravel, very loose ranging to medium dense. 0'-20'
4	SPT		
4	SPT		
18	O		

Completed boring at 20' on 9/6/79
Installed PVC standpipe piezometer with bottom of screen at elev. 581.6.

EXPLANATION

■ Standard Penetration Test (SPT)

O SPT (no recovery)

LOG OF BORING

Gilbert/Commonwealth

PLATE

Consumers Power Company
J. H. Campbell Plant
Groundwater Study
W. O. 64-0047-954

BORING PZ-40

SURFACE ELEVATION 590.1
COORDINATE

ELEV. IN FEET	OTHER TESTS	STRENGTH TEST (PSF)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FIELD MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT RECOVERY (%)	RQD	DEEP IN FEET	BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
590													
									5	4		SP	LIGHT BROWN SAND: fine to medium-grained, trace of coarse sand and fine gravel, very loose to medium dense, 0'-25'.
580									10	6			
									15	5			
570									20	14			
									25	8	O		

Completed boring at 25'on 9/7/79. Installed PVC standpipe piezometer with bottom of screen at elev. 568.3.

BORING PZ-41

SURFACE ELEVATION 616.0
COORDINATE

ELEV. IN FEET	OTHER TESTS	STRENGTH TEST (PSF)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FIELD MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT RECOVERY (%)	RQD	DEEP IN FEET	BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
615													
									5	3		SP	LIGHT BROWN SAND: very fine to fine-grained, trace of coarse sand and fine gravel, loose grading to medium dense, 0'-35'.
605									10	7			
									15	12			
595									20	10			
									25	12			
585									30	22			
									35	23	O		

Completed boring at 35'on 9/6/79. Installed PVC standpipe piezometer with bottom of screen at elev. 584.0.

LOG OF BORING

Gilbert/Commonwealth

PLATE

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Consumers Energy / J.H. Campbell Plant		RW-1

Boring Drilled By (Firm name and name of crew chief)	Date Drilling Started	Date Drilling Completed	Drilling Method
Environmental Drilling and Contracting, Inc. Sean Smith / Bob Miller / Jamie Bruarseme	04/10/01	04/10/01	12-1/4" (ID) HSA

Facility Well No.	Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		RW-4	Feet MSL	Feet MSL	15.8 inches

Boring Location			Local Grid Location (if applicable)
State Plane	Feet N Feet E	Lat Long	☐ N ☐ E ☐ S ☐ W

County		Civil Town/City/ or Village
Ottawa		Port Sheldon Township

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–0.5	Drilled without sampling - reference soil boring log for SB-1 for lithology	OL									
			0.5–10		SP									
			10–20		SP									
			20–24		SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
	Natural Resource Technology, Inc.

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			26–30		SP									
			30–50	Bottom 2" of augers contained gray LEAN CLAY, reference SB-1 for description	SP									
			50	*End of Boring at 50 feet below ground surface*	CL									

MONITORING WELL CONSTRUCTIO

Facility/Project Name: CONSUMERS ENERGY / JH CAMPBELL

Local Grid Location of Well: ______ ft. ☐ N. ☐ S. ______ ft. ☐ E. ☐ W.

Well Name: RW-1

Facility License, Permit or Monitoring No.

Local Grid Origin ☐ (estimated: ☐) or Well Location ☐

Lat. ___ ° ___ ' ___ " Long. ___ ° ___ ' ___ " or

Facility ID

St. Plane ______ ft. N, ______ ft. E. S/C/N

Date Well Installed: 04/10/2001 (m m d d y y y y)

Section Location of Waste/Source

___ 1/4 of ___ 1/4 of Sec. ___, T. ___ N, R. ___ ☐ E ☐ W

Well Installed By: Name (first, last) and Fir: SEAN SMITH

ENVIRONMENTAL DRILLING + CONST

Location of Well Relative to Waste/Source:
u ☐ Upgradient s ☐ Sidegradient
d ☐ Downgradient n ☐ Not Known

Gov. Lot Number

A. Protective pipe, top elevation ______ ft. MSL

B. Well casing, top elevation ______ ft. MSL

C. Land surface elevation ______ ft. MSL

D. Surface seal, bottom ______ ft. MSL or 6.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☒ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐
Hollow Stem Auger ☒
Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐
Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top ______ ft. MSL or 15.0 ft.

F. Fine sand, top ______ ft. MSL or 16.0 ft.

G. Filter pack, top ______ ft. MSL or 18.0 ft.

H. Screen joint, top ______ ft. MSL or 20.0 ft.

I. Well bottom ______ ft. MSL or 50.0 ft.

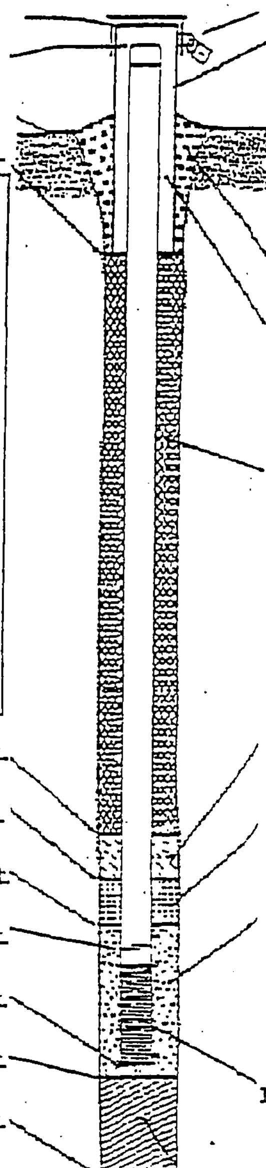
J. Filter pack, bottom ______ ft. MSL or 50.0 ft.

K. Borehole, bottom ______ ft. MSL or 50.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.65 in.

N. I.D. well casing 8.63 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
a. Inside diameter: ___ in.
b. Length: ___ ft.
c. Material: Steel ☐ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:

3. Surface seal: Bentonite ☐ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: N/A
Bentonite ☐ Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☐
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. 40 % Bentonite . . . . . . Bentonite-~~cement~~ grout ☒
e. ______ Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☒ Gravity ☐

6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. Flat Rock 10-40
b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. FLAT ROCK FILTER SAND #30
b. Volume added ______ ft^3

9. Well casing: Flush threaded PVC schedule 40 ☐
Flush threaded PVC schedule 80 ☐
Black Carbon Steel Other ☒

10. Screen material: Stainless Steel
a. Screen type: Factory cut ☒
Continuous slot ☐
Other ☐
b. Manufacturer Johnson
c. Slot size: 0.020 in.
d. Slotted length: 30.0 ft.

11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature]

Firm: NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	RW-1
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well 260 min.

4. Depth of well (from top of well casisng) 47.9 ft.

5. Inside diameter of well 8.63 in.

6. Volume of water in filter pack and well casing ___.__ gal.

7. Volume of water removed from well 10,600.0 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 27.00 ft.	29.5 ft.
Date	b. 04/10/2001	04/11/200
Time	c. 3:30 ☐ a.m. ☒ p.m.	9:15 ☒ a.m. ☐ p.m.
12. Sediment in well bottom	__.__ inches	0.0 inches
13. Water clarity	Clear ☐ 10 Turbid ☒ 15 (Describe) H. Brown	Clear ☒ 20 Turbid ☐ 25 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Well developed by: Name (first, last) and Firm
First Name: Last Name:
Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

Name and Address of Facility Contact/Owner/Responsible Party
First Name: ________ Last Name: ________
Facility/Firm: CONSUMERS ENERGY
Street: 212 WEST MICHIGAN AVENUE
City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.
Signature: [signature]
Print Name: Adam H. Shingledecker
Firm: NATURAL RESOURCE TECHNOLOGY, INC.

SOIL BORING LOG INFORMATION
Form - Non-WI#2 Rev. 8-2000

acility/Project Name Consumers Energy / J.H. Campbell Plant	**License/Permit/Monitoring Number**	**Boring Number** RW-2

Boring Drilled By (Firm name and name of crew chief) Environmental Drilling and Contracting, Inc. 2ean Smith / Bob Miller / Jamie Bruarseme	**Date Drilling Started** 04/09/01	**Date Drilling Completed** 04/09/01	**Drilling Method** 12-1/4" (ID) HSA

Facility Well No.	**Unique Well No.**	**Common Well Name** RW-2	**Final Static Water Level** Feet MSL	**Surface Elevation** Feet MSL	**Borehole Diameter** 15.8 inches

Boring Location **State Plane**	**Feet N** **Feet E**	**Lat** **Long**	**Local Grid Location (if applicable)** ☐ N ☐ E ☐ S ☐ W

County Ottawa	**Civil Town/City/ or Village** Port Sheldon Township

Sample Number and Type	Sample Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
				Drilled without sampling - reference soil boring log for SB-1 for lithology	OL									
			2											
			4											
			6		SP									
			8											
			10											
			12											
			14											
			16		SP									
			18											
			20											
			22		SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm **Natural Resource Technology, Inc.**

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
			26											
			28		SP									
			30											
			32											
			34											
			36											
			38											
			40											
			42		SP									
			44											
			46											
			48											
			50											
			52											
			54	Bottom 6" of augers contained gray LEAN CLAY, reference SB-1 for description	CL									
			56	*End of Boring at 55 feet below ground surface*										
			58											
			60											
			62											

MONITORING WELL CONSTRUCTIC

Facility/Project Name: Consumers Energy / JH Campbell

Local Grid Location of Well ______ ft. ☐ N. ☐ S. ______ ft. ☐ E. ☐ W.

Well Name: RW - 2

Facility License, Permit or Monitoring No.

Local Grid Origin ☐ (estimated: ☐) or Well Location ☐

Lat. ____ ° ____ ' ____ " Long. ____ ° ____ ' ____ " or

Facility ID

St. Plane ______ ft. N, ______ ft. E. S/C/N

Date Well Installed: 04/09/2001 (m m d d y y y y)

Section Location of Waste/Source

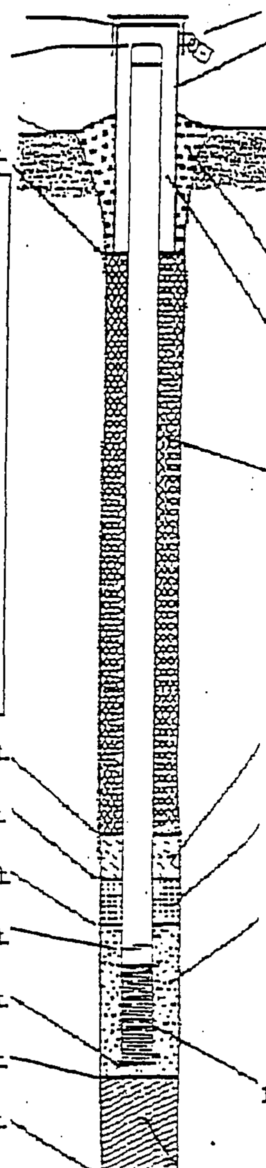
____ 1/4 of ____ 1/4 of Sec. ____, T. ____ N, R. ____ ☐ E ☐ W

Well Installed By: Name (first, last) and Fir: Sean Smith

Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known

Gov. Lot Number

Environmental Drilling + Const



A. Protective pipe, top elevation _______ ft. MSL

B. Well casing, top elevation _______ ft. MSL

C. Land surface elevation _______ ft. MSL

D. Surface seal, bottom ______ ft. MSL or 6.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☒ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top ______ ft. MSL or 3.0 ft.

F. Fine sand, top ______ ft. MSL or 22.0 ft.

G. Filter pack, top ______ ft. MSL or 23.0 ft.

H. Screen joint, top ______ ft. MSL or 25.0 ft.

I. Well bottom ______ ft. MSL or 55.0 ft.

J. Filter pack, bottom ______ ft. MSL or 55.0 ft.

K. Borehole, bottom ______ ft. MSL or 55.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.65 in.

N. I.D. well casing 8.63 in.

1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
a. Inside diameter: ___ in.
b. Length: ___ ft.
c. Material: Steel ☐ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:

3. Surface seal: Bentonite ☐ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: N/A
Bentonite ☐ Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☐
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. 40 % Bentonite . . . . . . Bentonite-~~cement~~ grout ☒
e. 20 Ft³ volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. Flat Rock 10-40
b. Volume added ______ ft³

8. Filter pack material: Manufacturer, product name & mesh size
a. Flat Rock Filter Sand #30
b. Volume added ______ ft³

9. Well casing: Flush threaded PVC schedule 40 ☐
Flush threaded PVC schedule 80 ☐
Black Carbon Steel Other ☒

10. Screen material: Stainless
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer Johnson
c. Slot size: 0.020 in.
d. Slotted length: 30.0 ft.

11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature] Firm: Natural Resource Technology, Inc.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
Consumers Energy / JH Campbell Plant	Ottawa	RW-2
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ______ ☐

3. Time spent developing well 300 min.

4. Depth of well (from top of well casisng) 54.3 ft.

5. Inside diameter of well 6.63 in.

6. Volume of water in filter pack and well casing ___.__ gal.

7. Volume of water removed from well 6800.0 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No (If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 32.2 ft.	32.5 ft.
Date	b. 04/10/2001 (mm dd yyyy)	04/10/2001 (mm dd yyyy)
Time	c. 9:15 ☒ a.m. ☐ p.m.	3:00 ☐ a.m. ☒ p.m.
12. Sediment in well bottom	__.__ inches	0.0 inches
13. Water clarity	Clear ☐ 10 Turbid ☒ 15	Clear ☒ 20 Turbid ☐ 25
(Describe)	H. Brown	

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Well developed by: Name (first, last) and Firm

First Name: Last Name:

Firm: Environmental Drilling and Contracting

17. Additional comments on development:

Name and Address of Facility Contact/Owner/Responsible Party

First Name: ______ Last Name: ______

Facility/Firm: Consumers Energy

Street: 212 West Michigan Avenue

City/State/Zip: Jackson MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature:

Print Name: Adam A. Shinyleduker

Firm: Natural Resource Technology, Inc.

Natural Resource Technology, Inc.
Standard Soil Boring Log

SOIL BORING LOG INFORMATION
Form - Non-WI#2 Rev. 8-2000

Facility/Project Name *Consumers Energy / J.H. Campbell Plant*	**License/Permit/Monitoring Number**	**Boring Number** *RW-3*

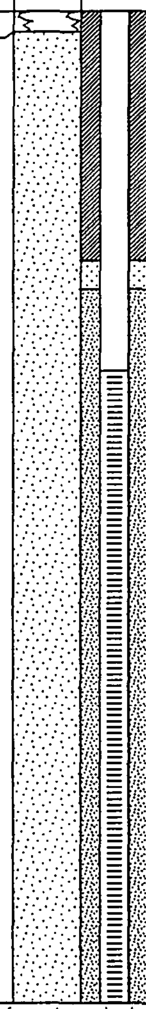
Boring Drilled By (Firm name and name of crew chief) *Environmental Drilling and Contracting, Inc.* *Sean Smith / Bob Miller / Jamie Bruarseme*	**Date Drilling Started** *04/11/01*	**Date Drilling Completed** *04/11/01*	**Drilling Method** *12-1/4" (ID) HSA*

Facility Well No.	**Unique Well No.**	**Common Well Name** *RW-4*	**Final Static Water Level** *Feet MSL*	**Surface Elevation** *Feet MSL*	**Borehole Diameter** *15.8 inches*

Boring Location **State Plane**	**Feet N** **Feet E**	**Lat** **Long**	**Local Grid Location (If applicable)** ☐ N ☐ E ☐ S ☐ W

County *Ottawa*		**Civil Town/City/ or Village** *Port Sheldon Township*

Sample									Soil Properties						
Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–24	Drilled without sampling - reference soil boring log for TW-2 for lithology	OL									
					SP									
			22	Bottom 2" of augers contained gray LEAN CLAY, reference TW-2 for description										
			24	*End of Boring at 24 feet below ground surface*										



I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm **Natural Resource Technology, Inc.**

MONITORING WELL CONSTRUCTIC

Facility/Project Name	Local Grid Location of Well	Well Name
CONSUMERS ENERGY / J.H. CAMPBELL	____ ft. ☐ N. ☐ S. ____ ft. ☐ E. ☐ W.	RW-3
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ____ ° ____ ' ____ " Long. ____ ° ____ ' ____ " or	
Facility ID	St. Plane ____ ft. N, ____ ft. E. S/C/N	Date Well Installed 04/11/2001 (m m d d y y y y)
	Section Location of Waste/Source ____ 1/4 of ____ 1/4 of Sec. ____, T. ____ N. R. ____ ☐ E ☐ W	Well Installed By: Name (first, last) and Fi[rm] SEAN SMITH
	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known; Gov. Lot Number	ENVIRONMENTAL DRILLING + CONST

A. Protective pipe, top elevation _ _ _ _ _ _ _ ft. MSL

B. Well casing, top elevation _ _ _ _ _ _ _ ft. MSL

C. Land surface elevation _ _ _ _ _ _ _ ft. MSL

D. Surface seal, bottom _ _ _ _ _ _ ft. MSL or _6.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☒ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top _ _ _ _ _ _ ft. MSL or _ _6.0 ft.

F. Fine sand, top _ _ _ _ _ _ ft. MSL or _ _6.5 ft.

G. Filter pack, top _ _ _ _ _ _ ft. MSL or _ _7.0 ft.

H. Screen joint, top _ _ _ _ _ _ ft. MSL or _ _9.0 ft.

I. Well bottom _ _ _ _ _ _ ft. MSL or _24.0 ft.

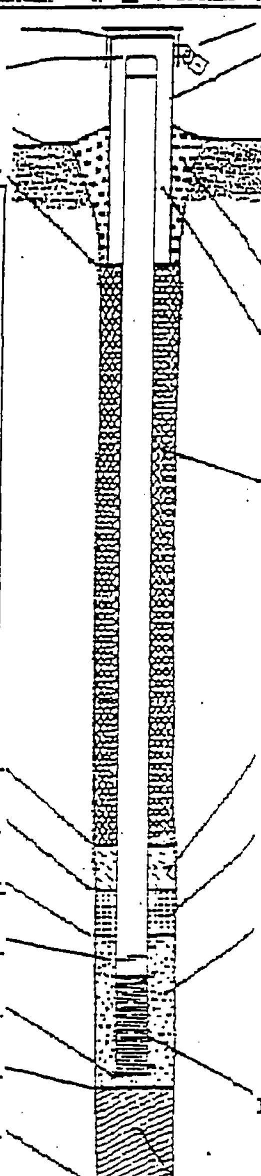
J. Filter pack, bottom _ _ _ _ _ _ ft. MSL or _24.0 ft.

K. Borehole, bottom _ _ _ _ _ _ ft. MSL or _24.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing _8.65 in.

N. I.D. well casing _8.63 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
a. Inside diameter: _ _ . _ in.
b. Length: _ _ . _ ft.
c. Material: Steel ☐ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:

3. Surface seal: Bentonite ☐ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: N/A
Bentonite ☐ Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☐
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. 46 % Bentonite . . . . . . Bentonite-~~cement~~ grout ☒
e. ____ Ft³ volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
c. ____ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. Flat Rock 10-40
b. Volume added ____ ft³

8. Filter pack material: Manufacturer, product name & mesh size
a. FLAT ROCK FILTER SAND, #30
b. Volume added ____ ft³

9. Well casing: Flush threaded PVC schedule 40 ☐
Flush threaded PVC schedule 80 ☐
Black Carbon Steel Other ☒

10. Screen material: ____
a. Screen type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer Johnson
c. Slot size: 0.020 in.
d. Slotted length: 15.0 ft.

11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
Consumers Energy / JH Campbell Plant	Ottawa	RW-3
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well 255 min.

4. Depth of well (from top of well casisng) 23.0 ft.

5. Inside diameter of well 6.63 in.

6. Volume of water in filter pack and well casing ___ gal.

7. Volume of water removed from well 9,700 gal.

8. Volume of water added (if any) 00 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No
    (If yes, attach results)

		Before Development	After Development
11. Depth to Water (from top of well casing)	a.	9.9 ft.	9.9 ft.
Date	b.	04/11/2001 (mm dd yyyy)	04/11/200 (mm dd yyyy)
Time	c.	11:00 ☒ a.m. ☐ p.m.	3:15 ☐ a.m. ☒ p.m.
12. Sediment in well bottom		___ inches	0.0 inches
13. Water clarity		Clear ☐ 10 Turbid ☒ 15	Clear ☒ 20 Turbid ☐ 25
		(Describe) Lt. Brown	(Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

	Before	After
14. Total suspended solids	___ mg/l	___ mg/l
15. COD	___ mg/l	___ mg/l

16. Well developed by: Name (first, last) and Firm
First Name: Last Name:
Firm: Environmental Drilling and Contracting

17. Additional comments on development:

Name and Address of Facility Contact/Owner/Responsible Party
First Name: ________ Last Name: ________
Facility/Firm: Consumers Energy
Street: 212 West Michigan Avenue
City/State/Zip: Jackson MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]
Print Name: Adam A. Stingledecker
Firm: Natural Resource Technology, Inc.

Natural Resource Technology, Inc.
Standard Soil Boring Log

SOIL BORING LOG INFORMATION
Form – Non-WI#2 Rev. 8-2000

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Consumers Energy / J.H. Campbell Plant		*RW-4*

Boring Drilled By (Firm name and name of crew chief)	Date Drilling Started	Date Drilling Completed	Drilling Method
Environmental Drilling and Contracting, Inc. *Sean Smith / Bob Miller / Jamie Bruarseme*	*03/07/01*	*03/07/01*	*12-1/4" (ID) HSA*

Facility Well No.	Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
		RW-4	*Feet MSL*	*Feet MSL*	*15.8 inches*

Boring Location State Plane		Lat / Long	Local Grid Location (If applicable)
	Feet N / Feet E	Lat · Long ·	☐ N ☐ S ☐ E ☐ W

County		Civil Town/City/ or Village
Ottawa		*Port Sheldon Township*

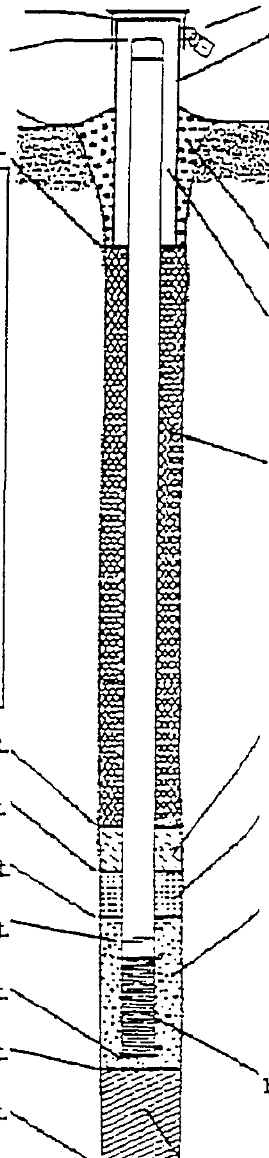
Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–23 (scale 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22)	drilled without sampling – reference soil boring log for TW-1	OL / SP									
				End of Boring at 23 feet below ground surface										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	**Natural Resource Technology, Inc.**

MONITORING WELL CONSTRUCTION

Facility/Project Name	Local Grid Location of Well	Well Name
JH CONSUMERS ENERGY / CAMPBELL PLANT	______ ft. ☐ N. ☐ S. ______ ft. ☐ E. ☐ W.	RW-4
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___ ° ___ ' ___ " Long. ___ ° ___ ' ___ " or	
Facility ID	St. Plane ______ ft. N, ______ ft. E. S/C/N	Date Well Installed 03/07/2001 m m d d y y y y
	Section Location of Waste/Source ___ 1/4 of ___ 1/4 of Sec. ___, T. ___ N, R. ___ ☐ E ☐ W	Well Installed By: Name (first, last) and Firm SEAN SMITH
	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known — Gov. Lot Number	ENVIRONMENTAL DRILLING + CONTRACT



A. Protective pipe, top elevation _ _ _ _ _ _ _ ft. MSL

B. Well casing, top elevation _ _ _ _ _ _ _ ft. MSL

C. Land surface elevation _ _ _ _ _ _ _ ft. MSL

D. Surface seal, bottom _ _ _ _ _ _ ft. MSL or 1.0 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☒ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top _ _ _ _ _ _ ft. MSL or 5.0 ft.

F. Fine sand, top _ _ _ _ _ _ ft. MSL or _ _ _ _ _ ft.

G. Filter pack, top _ _ _ _ _ _ ft. MSL or 6.0 ft.

H. Screen joint, top _ _ _ _ _ _ ft. MSL or 8.0 ft.

I. Well bottom _ _ _ _ _ _ ft. MSL or 23.0 ft.

J. Filter pack, bottom _ _ _ _ _ _ ft. MSL or 23.0 ft.

K. Borehole, bottom _ _ _ _ _ _ ft. MSL or 23.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.65 in.

N. I.D. well casing 8.63 in.

1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe: WELL VAULT
a. Inside diameter: _ _ . _ in.
b. Length: _ _ . _ ft.
c. Material: Steel ☐ Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:

3. Surface seal: Bentonite ☒ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ SAND Other ☒

5. Annular space seal: a. Granular/Chipped Bentonite ☒
b. ______ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ______ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. ______ % Bentonite . . . . . . Bentonite-cement grout ☐
e. ______ Ft³ volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
b. ☐1/4 in. ☐3/8 in. ☐1/2 in. Bentonite chips ☒
c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. N/A
b. Volume added ______ ft³

8. Filter pack material: Manufacturer, product name & mesh size
a. FLAT ROCK, FILTER SAND, #30
b. Volume added ______ ft³

9. Well casing: Flush threaded PVC schedule 40 ☐ Flush threaded PVC schedule 80 ☐
SCHEDULE 40 BLACK CARBON STEEL Other ☒

10. Screen material: STAINLESS STEEL WIRE WRAPPED
a. Screen type: Factory cut ☐ Continuous slot ☒ Other ☐
b. Manufacturer JOHNSON
c. Slot size: 0.020 in.
d. Slotted length: 15.0 ft.

11. Backfill material (below filter pack): None ☒ Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Rebecca J. Koyle	NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	RW-4
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well: 445 min.

4. Depth of well (from top of well casisng): 34.0 ft.

5. Inside diameter of well: 8.35 in.

Volume of water in filter pack and well casing: __ . __ gal.

7. Volume of water removed from well: 0.0 gal.

8. Volume of water added (if any): 0.0 gal.

9. Source of water added: N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No
   (If yes, attach results)

		Before Development	After Development
11. Depth to Water (from top of well casing)		a. __ . __ ft.	__ . __ ft.
	Date	b. 03/08/01 (mm dd yyyy)	03/08/01 (mm dd yyyy)
	Time	c. 08:25 ☒ a.m. ☐ p.m.	15:50 ☐ a.m. ☒ p.m.
12. Sediment in well bottom		3.1 inches	0.0 inches
13. Water clarity		Clear ☐ Turbid ☒ (Describe)	Clear ☒ Turbid ☐ (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

	Before Development	After Development
14. Total suspended solids	__ . __ mg/l	__ . __ mg/l
15. COD	__ . __ mg/l	__ . __ mg/l

16. Well developed by: Name (first, last) and Firm
   First Name: SEAN Last Name: SMITH
   Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

WELL WAS SURGED FOR ONE HOUR
PUMPED FOR ABOUT 2.5 HOURS @ ABOUT 35 GPM
WELL THEN SURGED FOR ABOUT 1-1/2 HOURS
PUMPED FOR REMAINDERING TIME @ ABOUT 75 GPM

Name and Address of Facility Contact /Owner/Responsible Party
First Name: ________ Last Name: ________
Facility/Firm: CONSUMERS ENERGY
Street: 212 WEST MICHIGAN AVENUE
City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.
Signature: Rebecca J Koepke
Print Name: REBECCA J. KOEPKE
Firm: NATURAL RESOURCE TECHNOLOGY, INC.

MONITORING WELL CONSTRUCTIC

Facility/Project Name	Local Grid Location of Well	Well Name
CONSUMERS ENERGY / JH CAMPBELL	______ ft. ☐ N. ☐ S. ______ ft. ☐ E. ☐ W.	RW-S
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___ ° ___ ' ___ " Long. ___ ° ___ ' ___ " or	
Facility ID	St. Plane ______ ft. N, ______ ft. E. S/C/N	Date Well Installed 04/11/2001 (m m d d y y y y)
	Section Location of Waste/Source ___ 1/4 of ___ 1/4 of Sec. ___, T. ___ N, R. ___ ☐ E ☐ W	Well Installed By: Name (first, last) and Fir SEAN SMITH
	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known Gov. Lot Number	ENVIRONMENTAL DRILLING + CONST

A. Protective pipe, top elevation _______ ft. MSL

B. Well casing, top elevation _______ ft. MSL

C. Land surface elevation _______ ft. MSL

D. Surface seal, bottom _______ ft. MSL or _____ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☒ MH ☐ CL ☒ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐
Hollow Stem Auger ☒
Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐
Drilling Mud ☐ 0 3 None ☐

16. Drilling additives used? ☐ Yes ☒ No

Describe N/A

17. Source of water (attach analysis, if required):

E. Bentonite seal, top _______ ft. MSL or _____ ft.

F. Fine sand, top _______ ft. MSL or _____ ft.

G. Filter pack, top _______ ft. MSL or 6.0 ft.

H. Screen joint, top _______ ft. MSL or 8.0 ft.

I. Well bottom _______ ft. MSL or 23.0 ft.

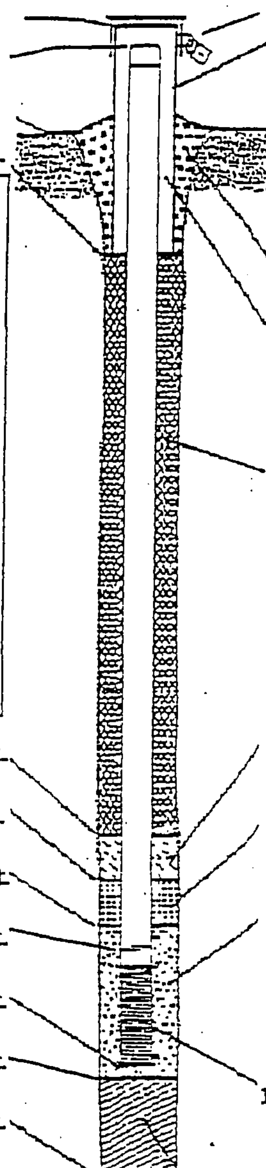
J. Filter pack, bottom _______ ft. MSL or 23.0 ft.

K. Borehole, bottom _______ ft. MSL or 23.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.65 in.

N. I.D. well casing 8.63 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe:
a. Inside diameter: ___ in.
b. Length: ___ ft.
c. Material: Steel ☐
Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe:

3. Surface seal: Bentonite ☒
Concrete ☐
Other ☐

4. Material between well casing and protective pipe: N/A
Bentonite ☐
Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☒
b. _____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. _____ Lbs/gal mud weight . . . . . Bentonite slurry ☐
d. _____ % Bentonite . . . . . . Bentonite-cement grout ☐
e. _____ Ft^3 volume added for any of the above
f. How installed: Tremie ☐
Tremie pumped ☐
Gravity ☒

6. Bentonite seal: a. Bentonite granules ☐
b. ☐ 1/4 in. ☐ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. —
b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. FLAT ROCK FILTER SAND, #30
b. Volume added ______ ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒
Flush threaded PVC schedule 80 ☐
Black Carbon Steel Other ☐

10. Screen material: Stainless
a. Screen type: Factory cut ☒
Continuous slot ☐
Other ☐
b. Manufacturer Johnson
c. Slot size: 0.020 in.
d. Slotted length: 15.0 ft.

11. Backfill material (below filter pack): None ☒
Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	NATURAL RESOURCE TECHNOLOGY, INC.

Natural Resource Technology, Inc.
Standard Soil Boring Log

SOIL BORING LOG INFORMATION
Form – Non-WI#2 Rev. 8-2000

acility/Project Name *onsumers Energy / J.H. Campbell Plant*	**License/Permit/Monitoring Number**	**Boring Number** *RW-5*

Boring Drilled By (Firm name and name of crew chief) *Environmental Drilling and Contracting, Inc.* *Sean Smith / Bob Miller / Jamie Bruarseme*	**Date Drilling Started** *04/11/01*	**Date Drilling Completed** *04/11/01*	**Drilling Method** *12-1/4" (ID) HSA*

Facility Well No.	**Unique Well No.**	**Common Well Name** *RW-5*	**Final Static Water Level** *Feet MSL*	**Surface Elevation** *Feet MSL*	**Borehole Diameter** *15.8 inches*

Boring Location **State Plane** **Feet N** **Feet E**	**Lat** **Long**	**Local Grid Location (If applicable)** ☐ *N* ☐ *E* ☐ *S* ☐ *W*

County *Ottawa*		**Civil Town/City/ or Village** *Port Sheldon Township*

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
					OL									
			2, 4, 6, 8, 10, 12, 14, 16, 18	Drilled without sampling – reference soil boring log for TW-3 for lithology	SP									
			20, 22	Driller indicated a slight pressure change at 20', possible clay/sand interface. Confirmed when augers were removed	CL									
				End of Boring at 23 feet below ground surface										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm **Natural Resource Technology, Inc.**

MONITORING WELL DEVELOPMENT

Facility/Project Name	County Name	Well Name
CONSUMERS ENERGY / JH CAMPBELL PLANT	OTTAWA	RW-5
Facility License, Permit or Monitoring Number		

1. Can this well be purged dry? ☐ Yes ☒ No

2. Well development method
   - surged with bailer and bailed ☐
   - surged with bailer and pumped ☐
   - surged with block and bailed ☐
   - surged with block and pumped ☒
   - surged with block, bailed and pumped ☐
   - compressed air ☐
   - bailed only ☐
   - pumped only ☐
   - pumped slowly ☐
   - Other ________ ☐

3. Time spent developing well 300 min.

4. Depth of well (from top of well casisng) 22.3 ft.

5. Inside diameter of well 8.63 in.

6. Volume of water in filter pack and well casing ___.__ gal.

7. Volume of water removed from well 9,600.__ gal.

8. Volume of water added (if any) __0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? N/A ☐ Yes ☐ No (If yes, attach results)

		Before Development	After Development
11. Depth to Water (from top of well casing)	a.	4.5 ft.	6.0 ft.
Date	b.	04/12/2001 (mm/dd/yyyy)	04/12/200 (mm/dd/yyyy)
Time	c.	8:00 ☒ a.m. ☐ p.m.	1:10 ☐ a.m. ☒ p.m.
12. Sediment in well bottom		___.__ inches	0.0 inches
13. Water clarity		Clear ☐ 10 Turbid ☒ 15 (Describe) V. Brown	Clear ☒ 20 Turbid ☐ 25 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Well developed by: Name (first, last) and Firm
First Name: Last Name:
Firm: ENVIRONMENTAL DRILLING AND CONTRACTING

17. Additional comments on development:

Name and Address of Facility Contact/Owner/Responsible Party
First Name: ________ Last Name: ________
Facility/Firm: CONSUMERS ENERGY
Street: 212 WEST MICHIGAN AVENUE
City/State/Zip: JACKSON MI 49201-2277

I hereby certify that the above information is true and correct to the best of my knowledge.
Signature: [signature]
Print Name: Adam A. Shingledecker
Firm: NATURAL RESOURCE TECHNOLOGY, INC.

NATURAL RESOURCE TECHNOLOGY

SOIL BORING LOG INFORMATION

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
J.H. Campbell RS Evaluation		RW-6

Boring Drilled By: Name of crew chief (first, last) and Firm	Date Drilling Started	Date Drilling Completed	Drilling Method
Sean Smith Environmental Drilling and Contracting	4/5/2010	4/5/2010	hollow stem auger

Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
RW-6	Feet (Site)	590.2 Feet (Site)	14.8 inches

Local Grid Origin ☒ (estimated: ☒) or Boring Location ☐		Local Grid Location
State Plane N, E S/C/N	Lat ° ' "	☐ N ☒ E
1/4 of 1/4 of Section , T N, R	Long ° ' "	403.26 Feet ☒ S 6654.02 Feet ☐ W

Facility ID	County	State	Civil Town/City/ or Village
	Ottawa	MI	West Olive

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0 - 1	0 - 1' **TOPSOIL:** dark brown, sandy.										
			1 - 24	1 - 24' **POORLY-GRADED SAND:** SP, light yellowish brown, poorly graded, medium sand.	SP									
	24		15											
	24		17											
	24		19											
	24		21											
	24		23											
			24 - 25	24 - 25' **LEAN CLAY:** CL, gray), low to medium toughness, low plasticity.	CL									
			25	25' End of Boring.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm	
Nadasdy	Natural Resource Technology, Inc. 23713 W. Paul Road, Ste. D Pewaukee, WI 53072	Tel: Fax:

SOIL BORING LOG INFORMATION

NATURAL RESOURCE TECHNOLOGY

Facility/Project Name	License/Permit/Monitoring Number	Boring Number	
J.H. Campbell RS Evaluation		RW-7	
Boring Drilled By: Name of crew chief (first, last) and Firm	**Date Drilling Started**	**Date Drilling Completed**	**Drilling Method**
Sean Smith Environmental Drilling and Contracting	4/5/2010	4/5/2010	hollow stem auger
Common Well Name	**Final Static Water Level**	**Surface Elevation**	**Borehole Diameter**
RW-7	Feet (Site)	588.0 Feet (Site)	14.8 inches
Local Grid Origin ☒ (estimated: ☒) or Boring Location ☐ State Plane N, E S/C/N 1/4 of 1/4 of Section , T N, R	Lat ° ' " Long ° ' "	Local Grid Location ☐ N ☒ E 492.83 Feet ☒ S 6609.51 Feet ☐ W	
Facility ID	**County**	**State**	**Civil Town/City/ or Village**
	Ottawa	MI	West Olive

Sample Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth In Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	U S C S	Graphic Log	Well Diagram	PID 10.6 eV Lamp	Compressive Strength	Moisture Content	Liquid Limit	Plasticity Index	P 200	RQD/ Comments
			0–1	0 - 1' **TOPSOIL:** dark brown, sandy.										
			1–23	1 - 23' **POORLY-GRADED SAND:** SP, light yellowish brown, poorly graded, medium sand.	SP									
	24		20											
	24		22											
			23–24	23 - 24' **LEAN CLAY:** CL, gray), medium toughness, medium plasticity, trace organics (roots).	CL									
			24	24' End of Boring.										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: TWadersky

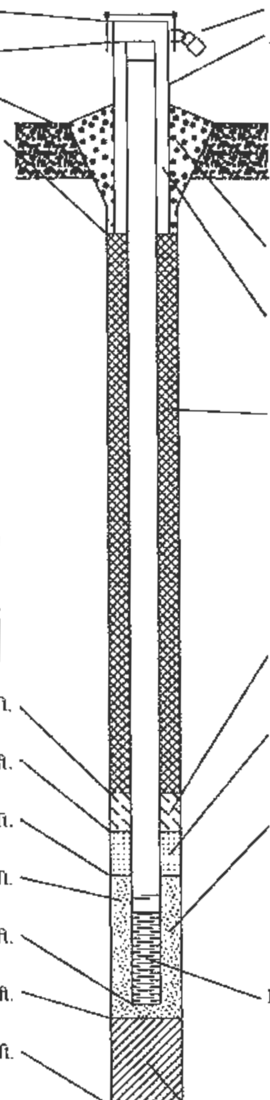
Firm: Natural Resource Technology, Inc.
23713 W. Paul Road, Ste. D Pewaukee, WI 53072
Tel:
Fax:

Template: SOIL BORING - Project: RS EVAL PIEZOMETERS.GPJ

NATURAL RESOURCE TECHNOLOGY

MONITORING WELL CONSTRUCTION

Facility/Project Name J.H. Campbell RS Evaluation	Local Grid Location of Well 403.26 ft. ☐ N. ☒ S. 6654.02 ft. ☒ E. ☐ W.	Well Name
Facility License, Permit or Monitoring No.	Local Grid Origin ☒ (estimated: ☒) or Well Location ☐ Lat. ° ' " Long. ° ' " or	RW-6
Facility ID	St. Plane ft. N, ft. E. S/C/N	Date Well Installed 04/05/2010
Type of Well	Section Location of Waste/Source 1/4 of 1/4 of Sec. T. N, R. ☐ E ☐ W	Well Installed By: (Person's Name and Firm) Sean Smith
Distance from Waste/ Source ft. | State MI	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known | Gov. Lot Number	Environmental Drilling and Contracting



A. Protective pipe, top elevation ____ ft. MSL

B. Well casing, top elevation 590.23 ft. MSL

C. Land surface elevation 590.2 ft. MSL

D. Surface seal, bottom ____ ft. MSL or ____ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☐ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☒

16. Drilling additives used? ☐ Yes ☒
Describe ____

17. Source of water (attach analysis, if required):
n/a

E. Bentonite seal, top 584.2 ft. MSL or 6.0 ft.

F. Fine sand, top 583.7 ft. MSL or 6.5 ft.

G. Filter pack, top 583.2 ft. MSL or 7.0 ft.

H. Screen joint, top 581.2 ft. MSL or 9.0 ft.

I. Well bottom 566.2 ft. MSL or 24.0 ft.

J. Filter pack, bottom 566.2 ft. MSL or 24.0 ft.

K. Borehole, bottom 565.2 ft. MSL or 25.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.63 in.

N. I.D. well casing 7.98 in.

1. Cap and lock? ☐ Yes ☒ No
2. Protective cover pipe:
   a. Inside diameter: ____ in.
   b. Length: ____ ft.
   c. Material: Steel ☐ Other ☐
   d. Additional protection? ☐ Yes ☒
   If yes, describe: ____
3. Surface seal: Bentonite ☐ Concrete ☐ Other ☐
4. Material between well casing and protective pipe: Bentonite ☐ Other ☐
5. Annular space seal: a. Granular/Chipped Bentonite ☐
   b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐
   c. ____ Lbs/gal mud weight . . . Bentonite slurry ☐
   d. ____ % Bentonite . . . Bentonite-cement grout ☐
   e. ____ Ft³ volume added for any of the above
   f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐
6. Bentonite seal: a. Bentonite granules ☐
   b. ☒ 1/4 in. ☐ 3/8 in. ☐ 1/2 in. Bentonite chips ☒
   c. ____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
   a. ____
   b. Volume added ____ ft³
8. Filter pack material: Manufacturer, product name & mesh size
   a. ____
   b. Volume added ____ ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ Flush threaded PVC schedule 80 ☐
   Black carbon steel Other ☒
10. Screen material: ____
   a. Screen Type: Factory cut ☒ Continuous slot ☐ Other ☐
   b. Manufacturer Johnson
   c. Slot size: 0.020 in.
   d. Slotted length: 15.0 ft.
11. Backfill material (below filter pack): None ☐
   Slough Other ☒

I hereby certify that the information on this form is true and correct to the best of my knowledge. Date Modified: 6/28/2010

Signature	Firm
R Nadasdy	Natural Resource Technology, Inc. 23713 W. Paul Road, Ste. D Pewaukee, WI 53072 Tel: Fax:

NATURAL RESOURCE TECHNOLOGY

MONITORING WELL CONSTRUCTION

Facility/Project Name: J.H. Campbell RS Evaluation	Local Grid Location of Well: 492.83 ft. ☐ N. ☒ S. 6609.51 ft. ☒ E. ☐ W.	Well Name: RW-7
Facility License, Permit or Monitoring No.	Local Grid Origin ☒ (estimated: ☒) or Well Location ☐ Lat. ° ' " Long. ° ' " or	
Facility ID	St. Plane ft. N, ft. E. S/C/N	Date Well Installed: 04/05/2010
Type of Well	Section Location of Waste/Source: 1/4 of 1/4 of Sec. T. N, R. ☐ E ☐ W	Well Installed By: (Person's Name and Firm) Sean Smith, Environmental Drilling and Contracting
Distance from Waste/Source: ft. State: MI	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☒ Downgradient n ☐ Not Known; Gov. Lot Number	

A. Protective pipe, top elevation ______ ft. MSL

B. Well casing, top elevation 588.04 ft. MSL

C. Land surface elevation 588.0 ft. MSL

D. Surface seal, bottom ______ ft. MSL or ______ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☐ No

14. Drilling method used: Rotary ☐ Hollow Stem Auger ☒ Other ☐

15. Drilling fluid used: Water ☐ 0 2 Air ☐ Drilling Mud ☐ 0 3 None ☒

16. Drilling additives used? ☐ Yes ☒
Describe ______

17. Source of water (attach analysis, if required): n/a

E. Bentonite seal, top 583.0 ft. MSL or 5.0 ft.

F. Fine sand, top 582.5 ft. MSL or 5.5 ft.

G. Filter pack, top 582.0 ft. MSL or 6.0 ft.

H. Screen joint, top 581.0 ft. MSL or 7.0 ft.

I. Well bottom 566.0 ft. MSL or 22.0 ft.

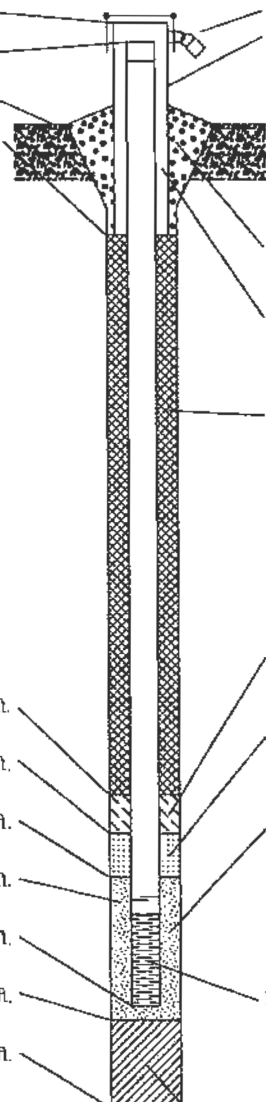
J. Filter pack, bottom 566.0 ft. MSL or 22.0 ft.

K. Borehole, bottom 564.0 ft. MSL or 24.0 ft.

L. Borehole, diameter 14.8 in.

M. O.D. well casing 8.63 in.

N. I.D. well casing 7.98 in.



1. Cap and lock? ☐ Yes ☒ No

2. Protective cover pipe:
a. Inside diameter: ______ in.
b. Length: ______ ft.
c. Material: Steel ☐ Other ☐
d. Additional protection? ☐ Yes ☒
If yes, describe: ______

3. Surface seal: Bentonite ☐ Concrete ☐ Other ☐

4. Material between well casing and protective pipe: Bentonite ☐ Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☐
b. ____Lbs/gal mud weight . . . Bentonite-sand slurry ☐
c. ____Lbs/gal mud weight . . . Bentonite slurry ☐
d. ____% Bentonite . . . Bentonite-cement grout ☐
e. ____Ft^3 volume added for any of the above
f. How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐

6. Bentonite seal: a Bentonite granules ☐
b. ☒ 1/4 in. ☐ 3/8 in ☐ 1/2 in. Bentonite chips ☒
c. ______ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a ______
b. Volume added ______ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. ______
b. Volume added ______ ft^3

9. Well casing: Flush threaded PVC schedule 40 ☐
Flush threaded PVC schedule 80 ☐
Black carbon steel Other ☒

10. Screen material: ______
a. Screen Type: Factory cut ☒ Continuous slot ☐ Other ☐
b. Manufacturer Johnson
c. Slot size: 0.020 in.
d. Slotted length: 15.0 ft.

11. Backfill material (below filter pack): None ☐
Slough Other ☒

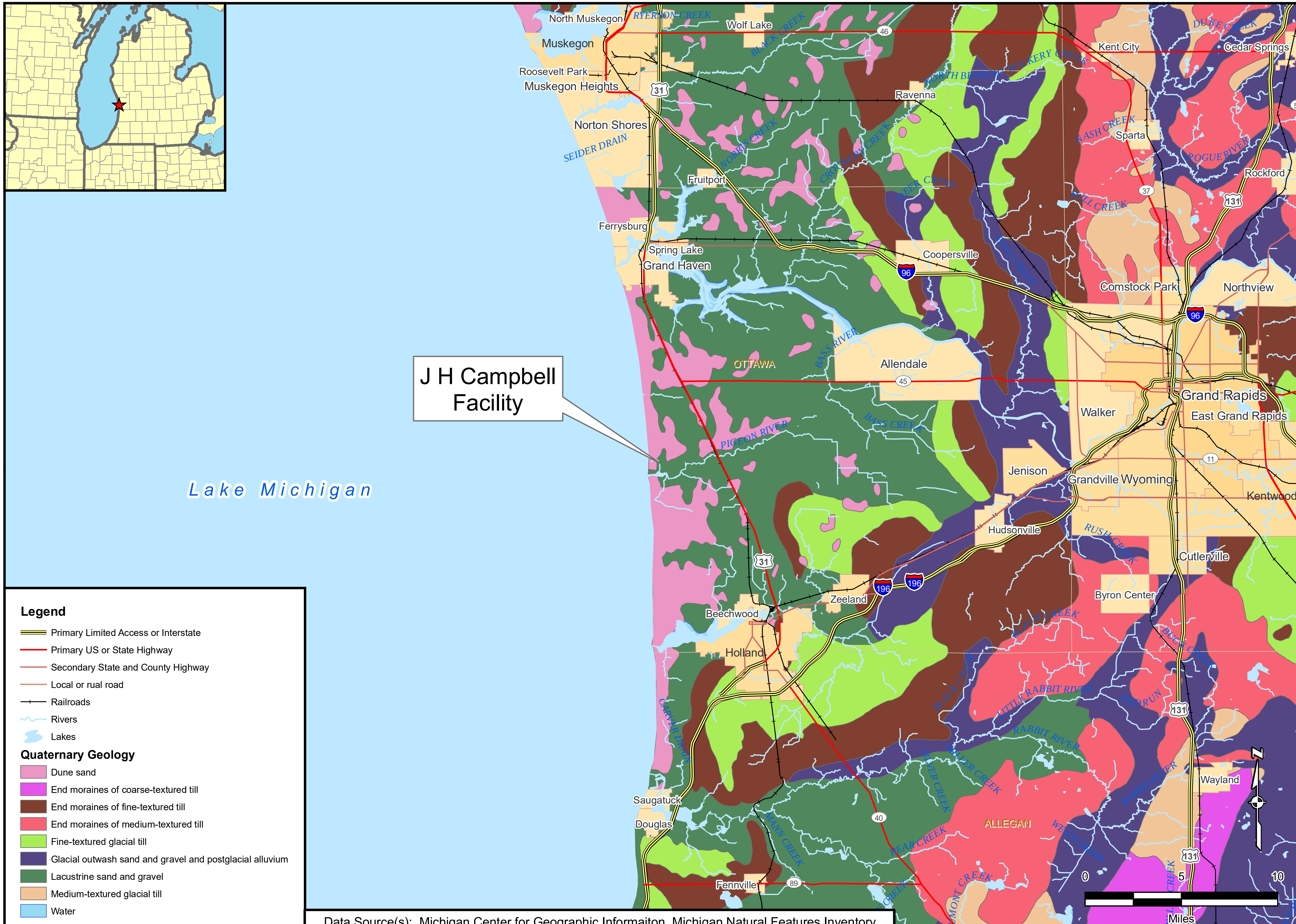
I hereby certify that the information on this form is true and correct to the best of my knowledge.

Date Modified: 6/28/2010

Signature: K Nadasdy

Firm: Natural Resource Technology, Inc.
23713 W. Paul Road, Ste. D Pewaukee, WI 53072
Tel:
Fax:

Appendix B
Aquifer Thickness and Bedrock Conditions

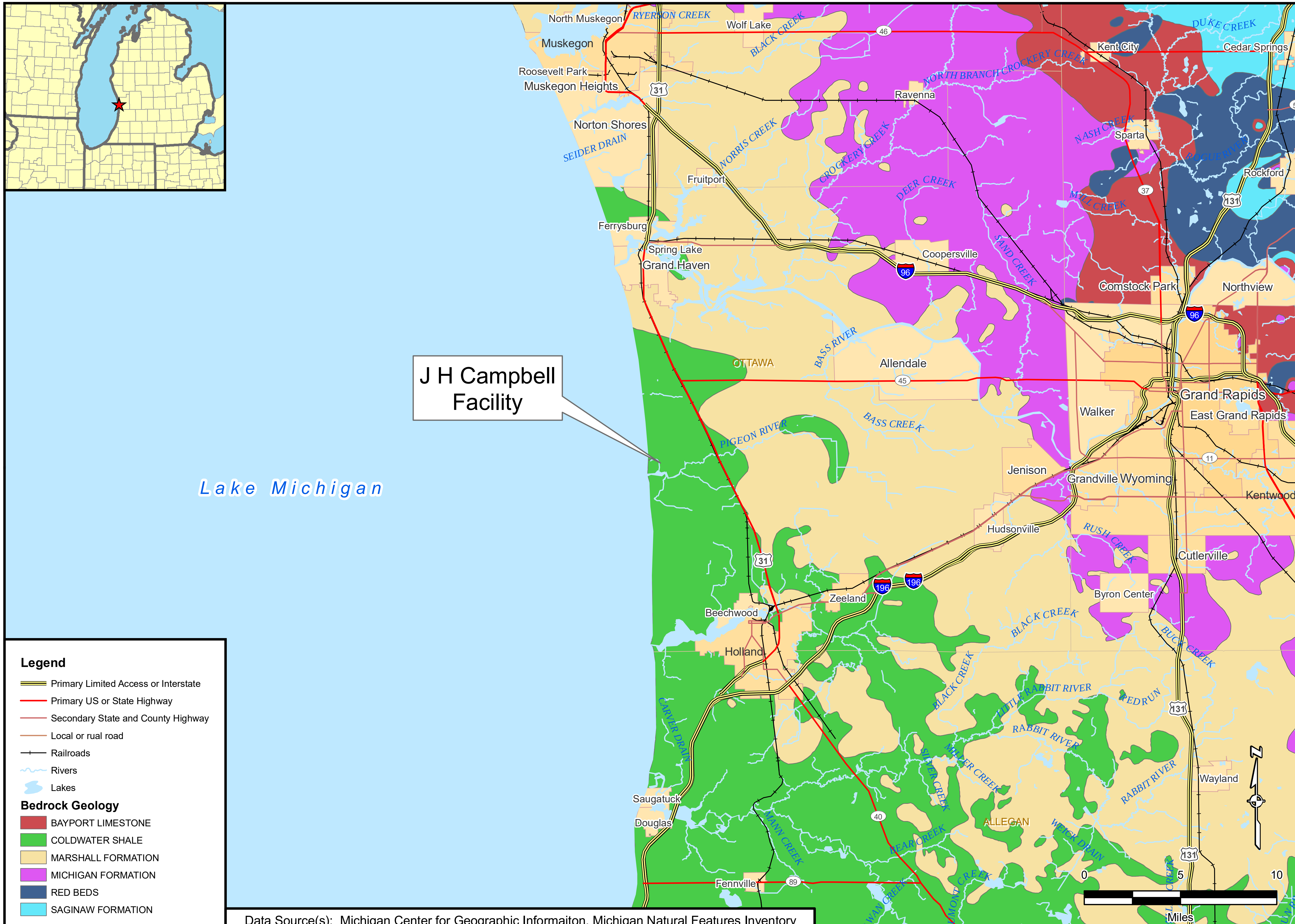


AECOM

www.aecom.com

QUATERNARY GEOLOGY
CONSUMERS ENERGY COMPANY
J H CAMPBELL FACILITY
OTTAWA COUNTY, MICHIGAN

Drawn:	JWW	10/19/2009
Approved:	AH	10/19/2009
Scale:	AS SHOWN	
PROJECT NUMBER	60100985	
FIGURE NUMBER	12	



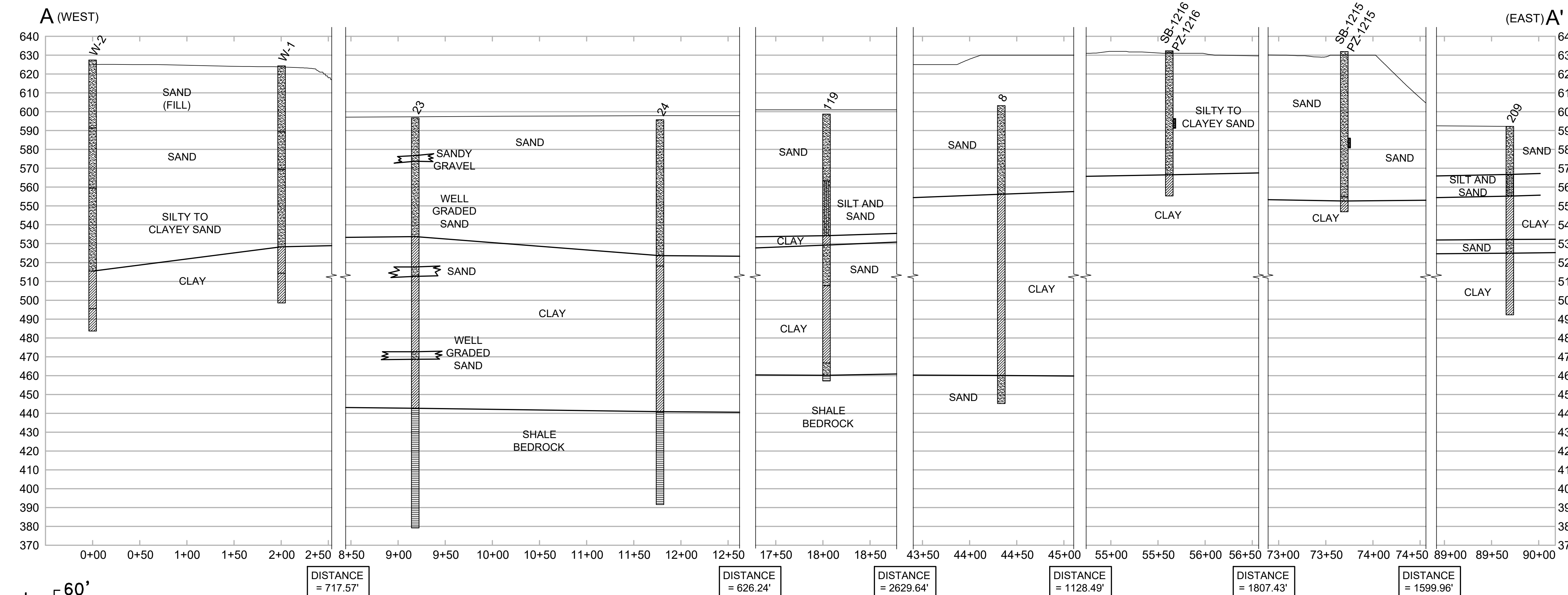
Data Source(s): Michigan Center for Geographic Informaiton, Michigan Natural Features Inventory

AECOM

www.aecom.com

BEDROCK GEOLOGY
CONSUMERS ENERGY COMPANY
J H CAMPBELL FACILITY
OTTAWA COUNTY, MICHIGAN

Drawn:	JWW	10/19/2009
Approved:	AH	10/19/2009
Scale:	AS SHOWN	
PROJECT NUMBER	60100985	
FIGURE NUMBER	13	



SECTION A-A'

VERTICAL SCALE IN FEET 60'

HORIZONTAL SCALE IN FEET 120'

VERTICAL EXAGGERATION = 2

Legend
SAND
SILTY SAND
SILT
SILTY CLAY
CLAY
SHALE
PIEZOMETER SCREEN

TRANSECT LOCATOR MAP

DRAWN BY: DMD	DATE: 02/11/15
CHECKED BY: SJC	DATE: 12/04/15
APPROVED BY: SJC	DATE: 12/04/15
DRAWING NO: 2229-1-B7	
REFERENCE: .	

CROSS SECTION A-A'

J.H. CAMPBELL POWER PLANT
CONSUMERS ENERGY
PORT SHELDON TOWNSHIP, OTTAWA COUNTY, MICHIGAN

NATURAL RESOURCE TECHNOLOGY

PROJECT NO. 2229/1.0

FIGURE NO. 7

Dec 04, 2015 3:55pm PLOTTED BY: dduda SAVED BY: dduda
Y:\Mapping\Projects\22\2229\CAD\1-0\2229-1-B7.dwg Layout1
IMAGES: Y:\Mapping\Projects\22\2229\Imagery\Earl_Imagery_12.5k.jpg;
XREFS:

Engineering & Environmental Solutions, LLC

400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

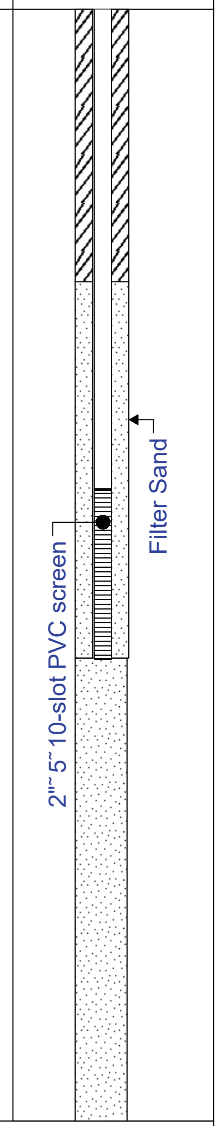
Log of Borehole: PZ/SB-1215

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 8-21-12
Project Number: 005-12-003	End Date: 8-22-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA/Mud Rotary	Crew C˜ief: Da˜e Mokma
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 43
Ground Ele˜ation ˜feet˜: 631.9	Easting: 6202.4
Top of Casing Ele˜ation ˜feet˜: 631.25	Nort˜ing: 37.0
Logged By: Kurt Van Appledorn	
Comments:	

S˜BS˜RFACE PROFILE			SAMPLE			
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
35	Lig˜t brown below 35˜	598.4 / 35.0				
36			2	1.3	2-3-4-5	7
41			2	1.4	1-3-4-5	7
43	Wet at 43˜	590.4 / 43.0				
45	Little medium sand˜ tracet coarse sand at 45 to 47˜.	588.4 / 45.0				
46			2	0.8	2-4-4-7	8
48	Switc˜ed to mud rotary					
50	Some medium sand wit˜ 1/2" medium and coarse sand seam at 50.5˜.	583.4 / 50.0				
51			2	1.3	8-11-15-17	26
55			2	1.7	10-22-30-32	52
59	3" of ˜ery fine sand at 59.7˜	574.4 / 59.0				
60			2	1.0	13-16-16-20	32

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



Engineering & Environmental Solutions, LLC

400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜ od: 8.25" OD HSA/Mud Rotary
Sampling Met˜ od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 631.9
Top of Casing Ele˜ation ˜feet˜: 631.25
Logged By: Kurt Van Appledorn
Comments:

Log of Borehole: PZ/SB-1215

Start Date: 8-21-12
End Date: 8-22-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ ief: Da˜ e Mokma
Dept˜ to Water ˜ft BGS during drilling˜: 43
Easting: 6202.4
Nort˜ ing: 37.0

S˜ BS˜ RFACE PROFILE				SAMPLE					
Dept˜ ˜feet BGS˜	Symbol	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	Well Completion Details
65				2	1.2	10-15-21-26	36		
70				2	1.5	11-22-22-22	44		
75				2	1.4	13-18-21-31	39		
77		77-79.3˜ Gray silty fine SAND˜ wet.	556.4 / 77.0						Filter Sand
79.3		79.3-85.0˜ Gray silty CLAY˜ moist.	554.1 / 79.3						
80				2	1.8	9-10-10-13	20	•	
82				2		S˜ elby			
84				2		S˜ elby			
85		End of Boring	548.4 / 85.0						

Engineering & Environmental Solutions, LLC

400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

Log of Borehole: PZ/SB-1216

Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	8-22-12
Project Number:	005-12-003	End Date:	8-23-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜od:	8.25" OD HSA	Crew C˜ief:	Da˜e Mokma
Sampling Met˜od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	34
Ground Ele˜ation ˜feet˜:	632.3	Easting:	4398.8
Top of Casing Ele˜ation ˜feet˜:	631.90	Nort˜ing:	132.1
Logged By:	Kurt Van Appledorn		
Comments:			

S˜BS˜RFACE PROFILE

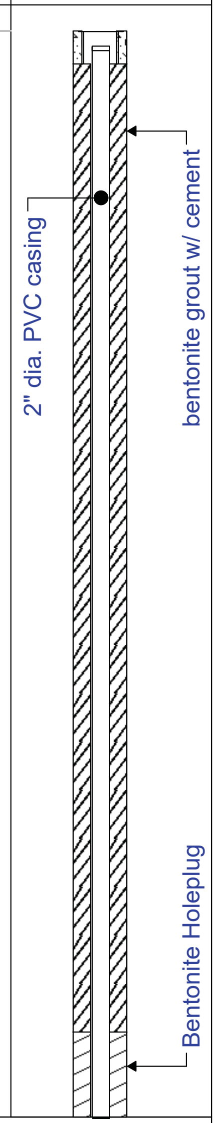
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.
	Ground Surface	633.4
0	0-0.7˜ Black silty˜ sand si˜e ASH˜ dry.	0.0
0.7	0.7-21.1˜ Brown fine SAND˜ slig˜tly moist˜ dark brown 0.7-1.8˜.	
8	Dark brown at 8 to 10˜ wit˜ 1/2" wood branc˜ at 8.8˜	625.4 / 8.0
10	Yellowis˜ brown silty fine sand at 10 to 12˜. Wood branc˜ at 11.2˜.	623.4 / 10.0
14	Yellowis˜ brown at 14 to 14.4˜.	619.4 / 14.0
16.5	Dark brown˜ trace silt	616.9 / 16.5
21.1	21.1-22.0˜ Dark brown silty fine SAND˜ slig˜tly moist.	612.3 / 21.1
22.0	22.0-65.8˜ Yellowis˜ brown fine SAND˜ slig˜tly moist.	
24	Brown below 24˜	
26	trace medium sand at 26 to 28˜	607.4 / 26.0

SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	2.0	4-6-10-11	16
2	1.4	10-13-17-18	30
2	1.2	4-11-13-13	24
2	1.6	2-5-8-14	13
2	1.7	4-16-26-32	42
2	1.7	2-12-17-17	29
2	1.2	1-2-3-4	5
2	1.7	1-1-2-3	3
2	1.3	0-0-1-2	1
2	1.2	0-1-1-1	2
2	1.4	0-1-1-1	2
2	1.3	1-2-4-4	6
2	1.4	1-2-3-4	5
2	1.3	1-2-3-3	5
2	1.4	2-4-5-5	9

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



Engineering & Environmental Solutions, LLC

400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

Log of Borehole: PZ/SB-1216

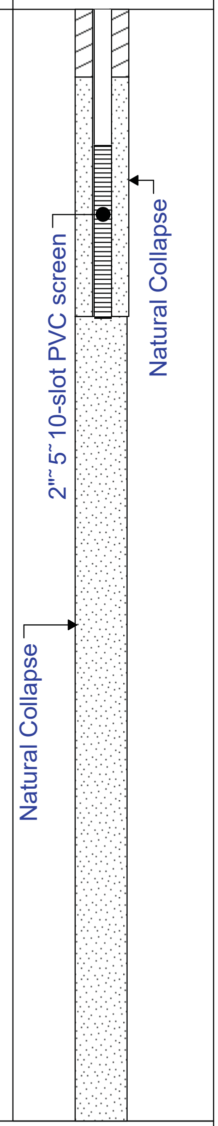
Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	8-22-12
Project Number:	005-12-003	End Date:	8-23-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜od:	8.25" OD HSA	Crew C˜ief:	Da˜e Mokma
Sampling Met˜od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	34
Ground Ele˜ation ˜feet˜:	632.3	Easting:	4398.8
Top of Casing Ele˜ation ˜feet˜:	631.90	Nort˜ ing:	132.1
Logged By:	Kurt Van Appledorn		
Comments:			

S˜ BS˜ RFACE PROFILE / **SAMPLE**

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
34	Wet at 34˜	599.4 / 34.0				
35	little medium˜ trace coarse sand at 35 to 37˜					
35–37			2	0.9	2-2-2-3	4
40	trace medium sand at 40 to 47˜	593.4 / 40.0				
40–42			2	0.6	3-3-6-8	9
45–47			2	0.3	5-9-19-29	28
50–52			2	1.4	7-14-26-38	40
55	trace medium and coarse sand	578.4 / 55.0				
55–57			2	0.7	4-8-16-23	24
60–62			2	0.4	0-4-7-14	11

Water Content ˜Percent˜: 10 30 50

Well Completion Details



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Phone/Fax: (616) 994-6541
www.goEESolutions.com

Log of Borehole: PZ/SB-1216

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 8-22-12
Project Number: 005-12-003	End Date: 8-23-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜ od: 8.25" OD HSA	Crew C˜ ief: Da˜e Mokma
Sampling Met˜ od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 34
Ground Ele˜ation ˜feet˜: 632.3	Easting: 4398.8
Top of Casing Ele˜ation ˜feet˜: 631.90	Nort˜ ing: 132.1
Logged By: Kurt Van Appledorn	
Comments:	

S˜ BS˜ RFACE PROFILE				SAMPLE					
Dept˜ ˜feet BGS˜	Symbol	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	Well Completion Details
65		Grayis˜ brown	568.4 / 65.0						
66		65.8-77.0˜ Gray silty CLAY˜ slig˜ tly moist.		2	1.1	0-20-45-50+	65		Bentonite Holeplug
70–71				1		S˜ elby			
75–76				2		S˜ elby			
77		End of Boring	556.4 / 77.0						

Depth scale: 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

Appendix C
Hydraulic Conductivity Tests

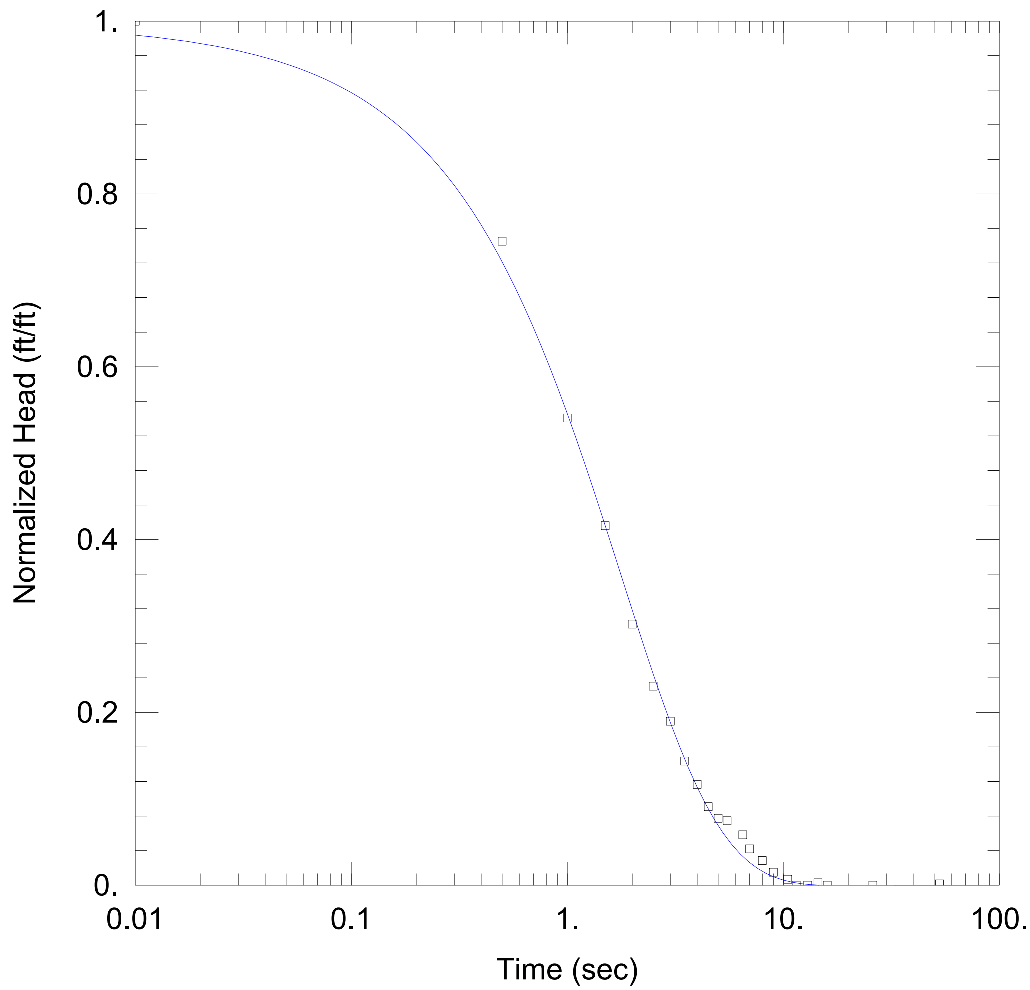
Table 3
Estimated Hydraulic Conductivity (K) Values
Consumers Energy Co.
J.H. Campbell Generating Facility
West Olive, Michigan

Well ID	Test	H^0 (ft)	H^* (ft)	K (ft/d)	K (cm/sec)	Slug Test Solution
JHC MW-15005	2	0.738	0.844	61	2.15E-02	KGS Model (Hyder et. al, 1994)
	3	1.422	1.69	58	2.05E-02	KGS Model (Hyder et. al, 1994)
	Average			*60*	*2.10E-02*	
JHC MW-15036	2	0.777	0.844	118	4.16E-02	KGS Model (Hyder et. al, 1994)
	3	1.219	1.69	139	4.90E-02	KGS Model (Hyder et. al, 1994)
	Average			*129*	*4.53E-02*	
JHC MW-15007	1	0.629	0.844	130	4.59E-02	KGS Model (Hyder et. al, 1994)
JHC MW-15015	2	0.879	1.15	22	7.76E-03	KGS Model (Hyder et. al, 1994)
	3	1.98	2.31	21	7.41E-03	KGS Model (Hyder et. al, 1994)
	Average			*22*	*7.59E-03*	
JHC MW-15024	2	0.801	0.844	49	1.73E-02	KGS Model (Hyder et. al, 1994)
	3	1.534	1.69	45	1.59E-02	KGS Model (Hyder et. al, 1994)
	Average			*47*	1.66E-02	
JHC MW-15028	1	0.704	0.844	104	3.67E-02	KGS Model (Hyder et. al, 1994)
	3	1.515	1.69	86	3.03E-02	KGS Model (Hyder et. al, 1994)
	Average			*95*	*3.35E-02*	
JHC MW-15033	2	0.669	0.844	*74*	*2.61E-02*	KGS Model (Hyder et. al, 1994)
JHC MW-15030	2	0.701	0.844	*100*	*3.53E-02*	Bouwer-Rice (1976)
	3	1.194	1.69	*87*	*3.07E-02*	Bouwer-Rice (1976)
	Average			*94*	*3.30E-02*	
JHC MW-15018	1	0.732	0.844	*34*	*1.20E-02*	KGS Model (Hyder et. al, 1994)
	3	1.486	1.69	*33*	*1.16E-02*	KGS Model (Hyder et. al, 1994)
	Average			*34*	*1.18E-02*	
Over all Average				***73***	***2.56E-02***	
Over all Geometric mean				***62***	***2.19E-02***	
Minimum				***21***	***7.41E-03***	
Maximum				***139***	***4.90E-02***	

Note:
H^0 = initial displacement
H^* = expected (calculated) displacement
cm/sec = centimeters per second
ft = feet
ft/d = feet per day

Slug Test Analysis Result for JHC MW-15005 - Test 2

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 61. ft/day   Ss = 3.7E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 19.82 ft

WELL DATA (JHC MW-15005)

Initial Displacement: 0.738 ft
Static Water Column Height: 6.82 ft
Total Well Penetration Depth: 6.82 ft
Screen Length: 6.82 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

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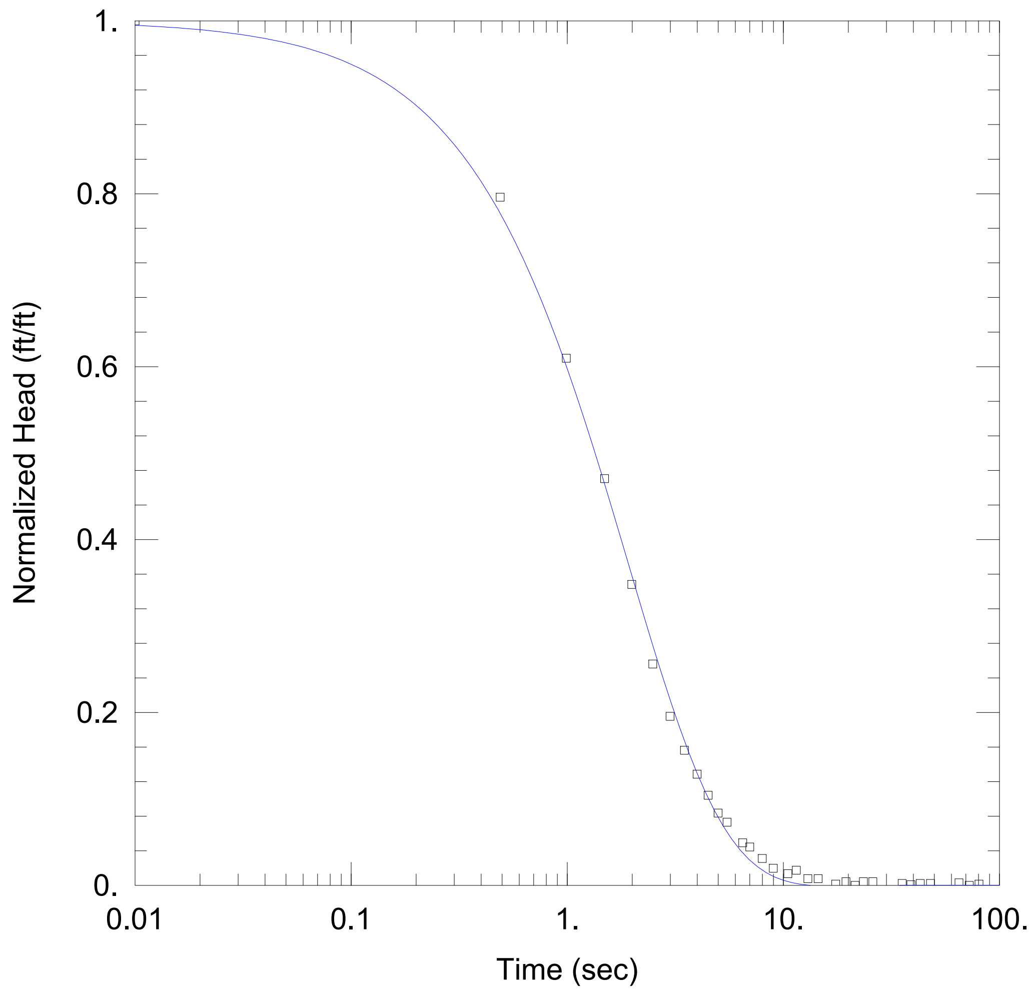
Slug Test Analysis Result for JHC MW-15005 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 58. ft/day   Ss = 5.05E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 19.82 ft

WELL DATA (JHC MW-15005)

Initial Displacement: 1.422 ft
Static Water Column Height: 6.82 ft
Total Well Penetration Depth: 6.82 ft
Screen Length: 6.82 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

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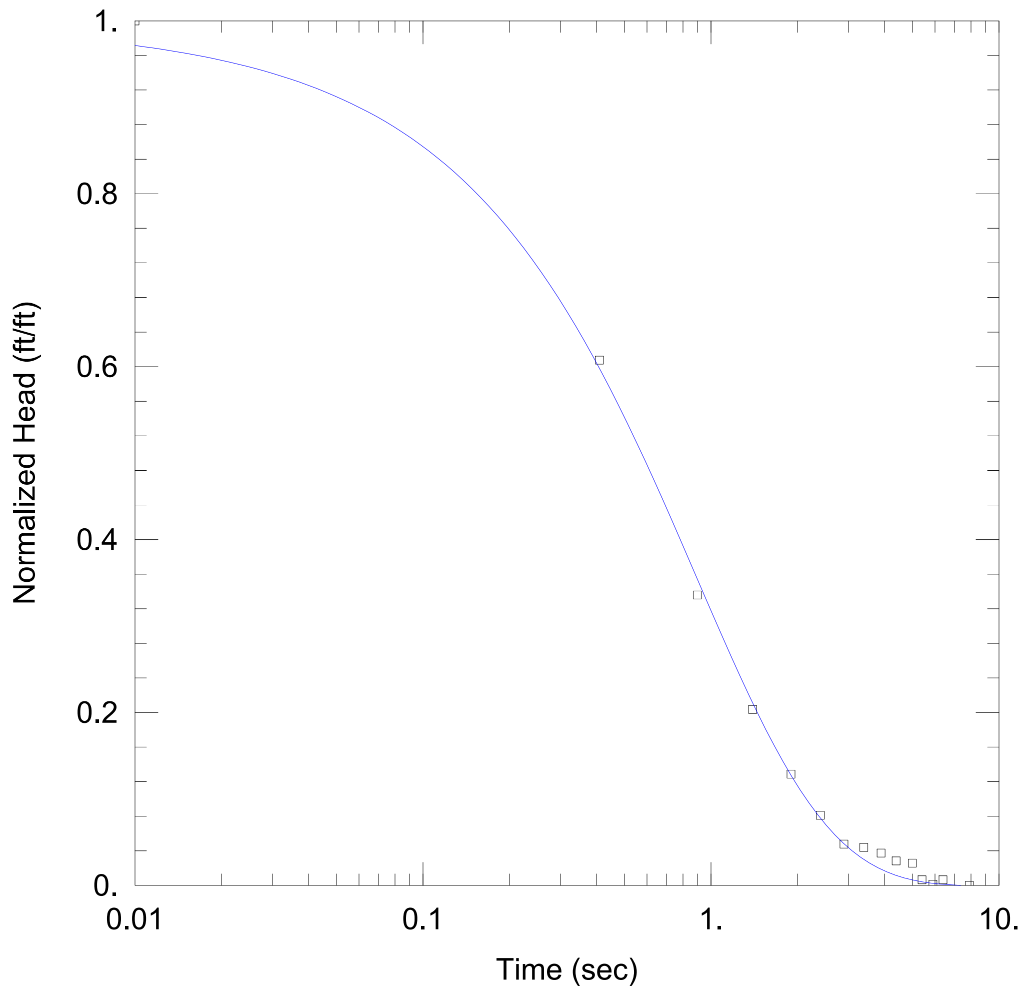
Slug Test Analysis Result for JHC MW-B6 - Test 2

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 118. ft/day Ss = 6.03E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 25.71 ft

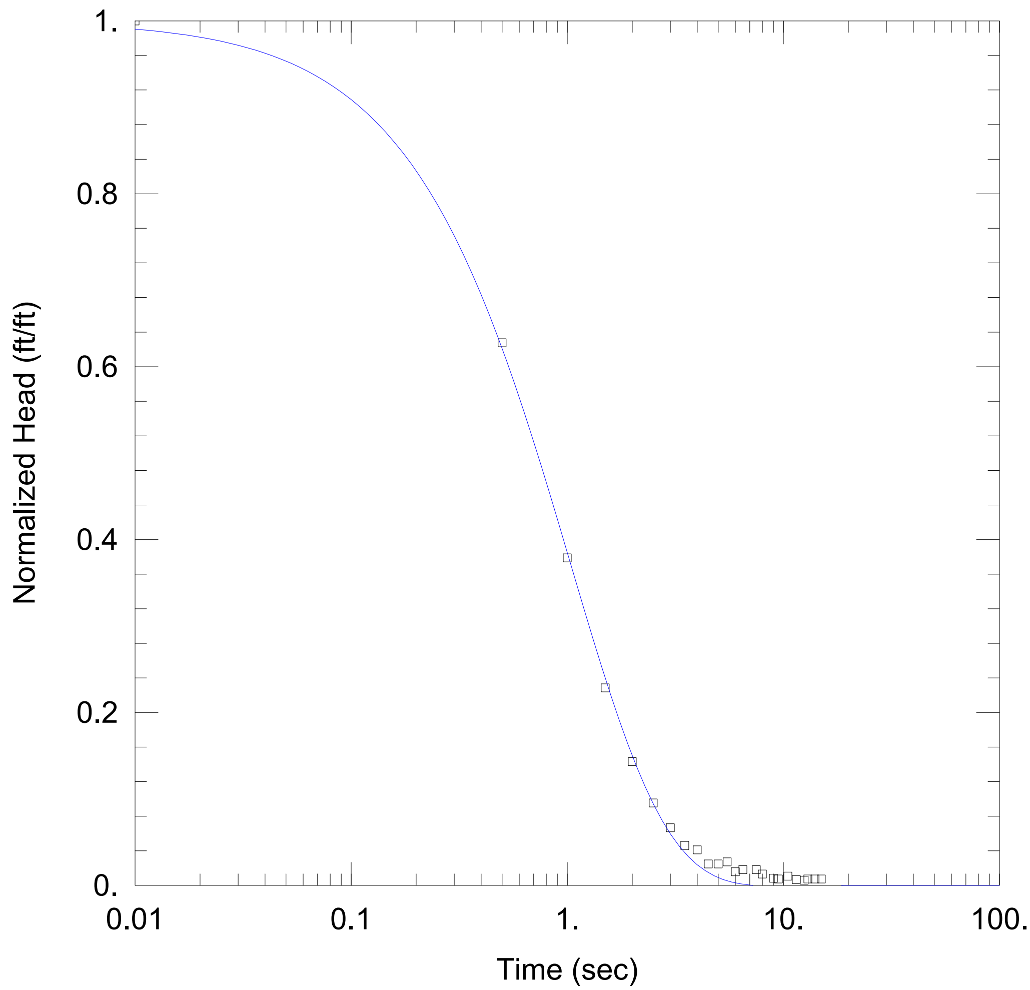
WELL DATA (JHC MW-B6)

Initial Displacement: 0.777 ft
Static Water Column Height: 5.71 ft
Total Well Penetration Depth: 5.71 ft
Screen Length: 5.71 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-B6 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 139. ft/day   Ss = 5.05E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 25.71 ft

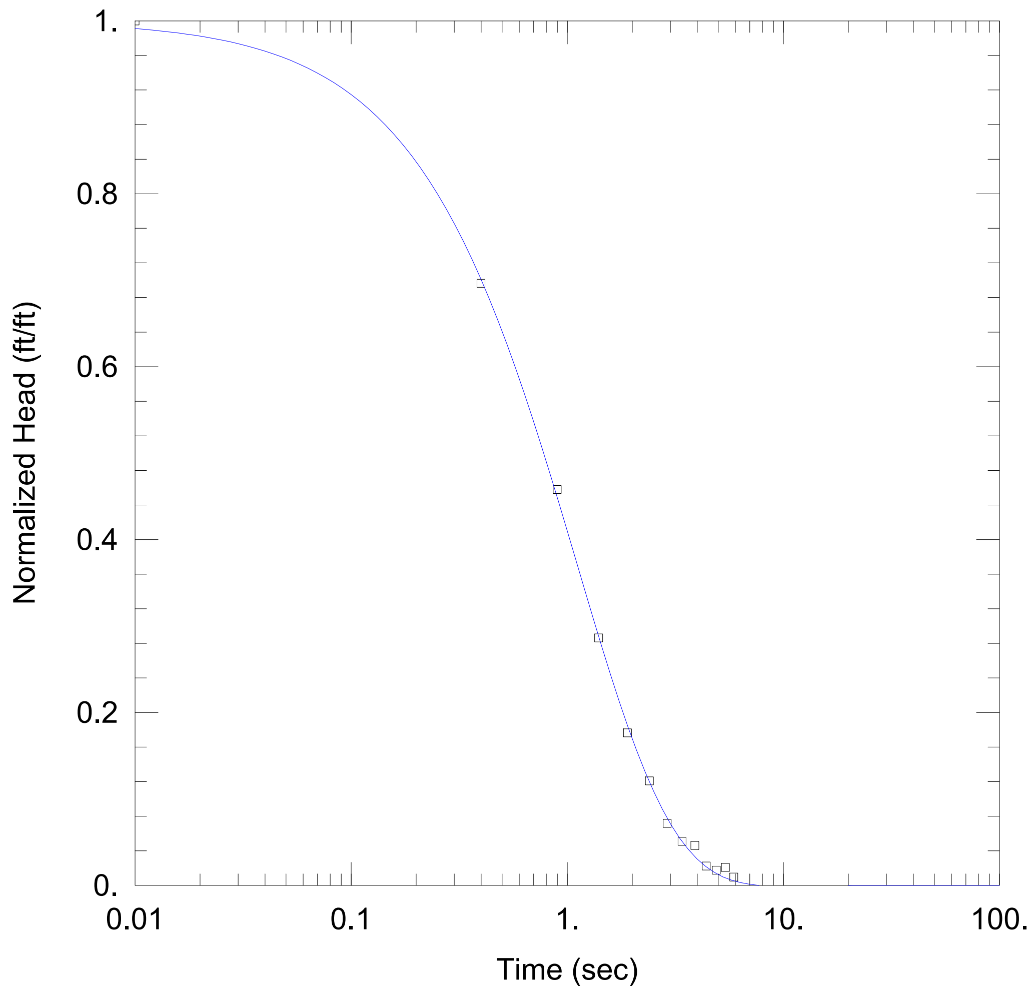
WELL DATA (JHC MW-B6)

Initial Displacement: 1.217 ft
Static Water Column Height: 5.71 ft
Total Well Penetration Depth: 5.71 ft
Screen Length: 5.71 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15007 - Test 1

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 130. ft/day   Ss = 5.05E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 23.37 ft

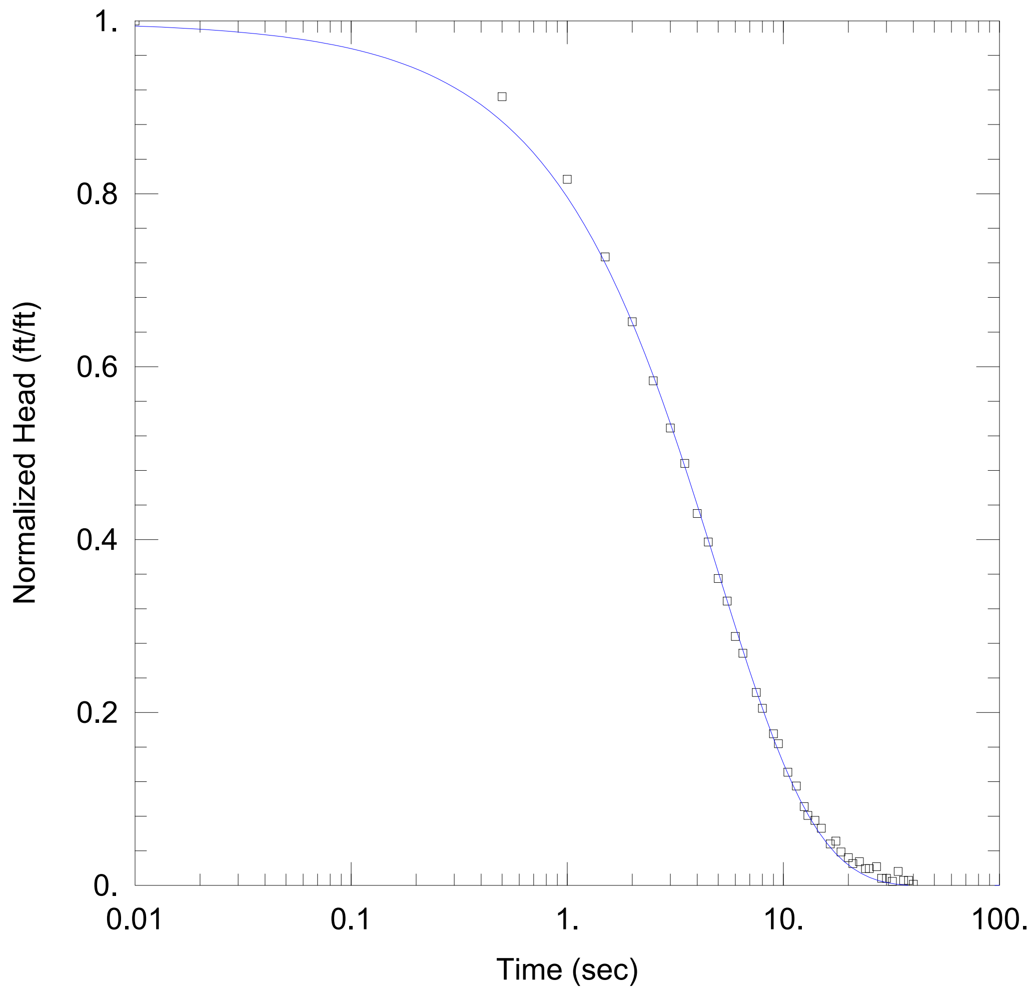
WELL DATA (JHC MW-15007)

Initial Displacement: 0.629 ft
Static Water Column Height: 5.37 ft
Total Well Penetration Depth: 5.37 ft
Screen Length: 5.37 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15015 - Test 2

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 22. ft/day   Ss = 7.0E-6 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 24.57 ft

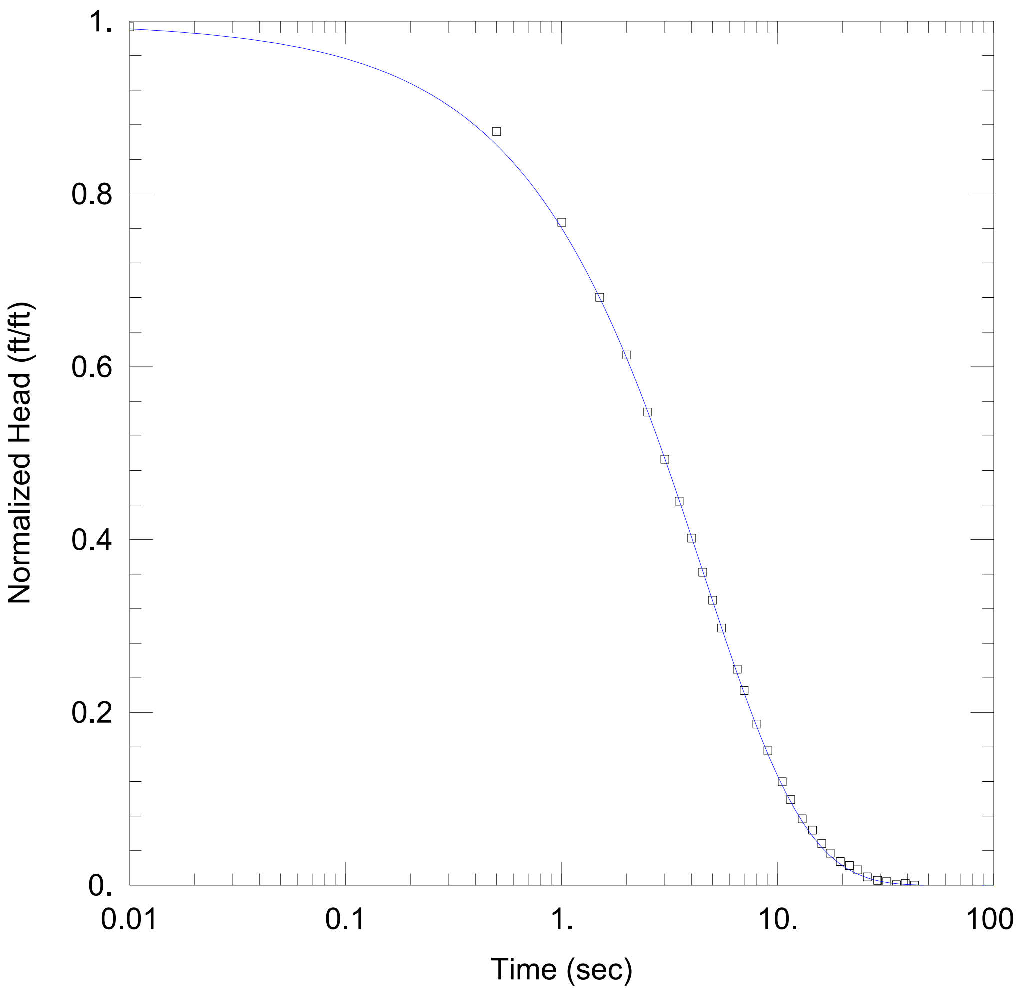
WELL DATA (JHC MW-15015)

Initial Displacement: 0.879 ft
Static Water Column Height: 12.57 ft
Total Well Penetration Depth: 12.57 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15015 - Test 3

Prepared By:	Prepared For:
Arcadis	Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 21. ft/day   Ss = 1.9E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 24.57 ft

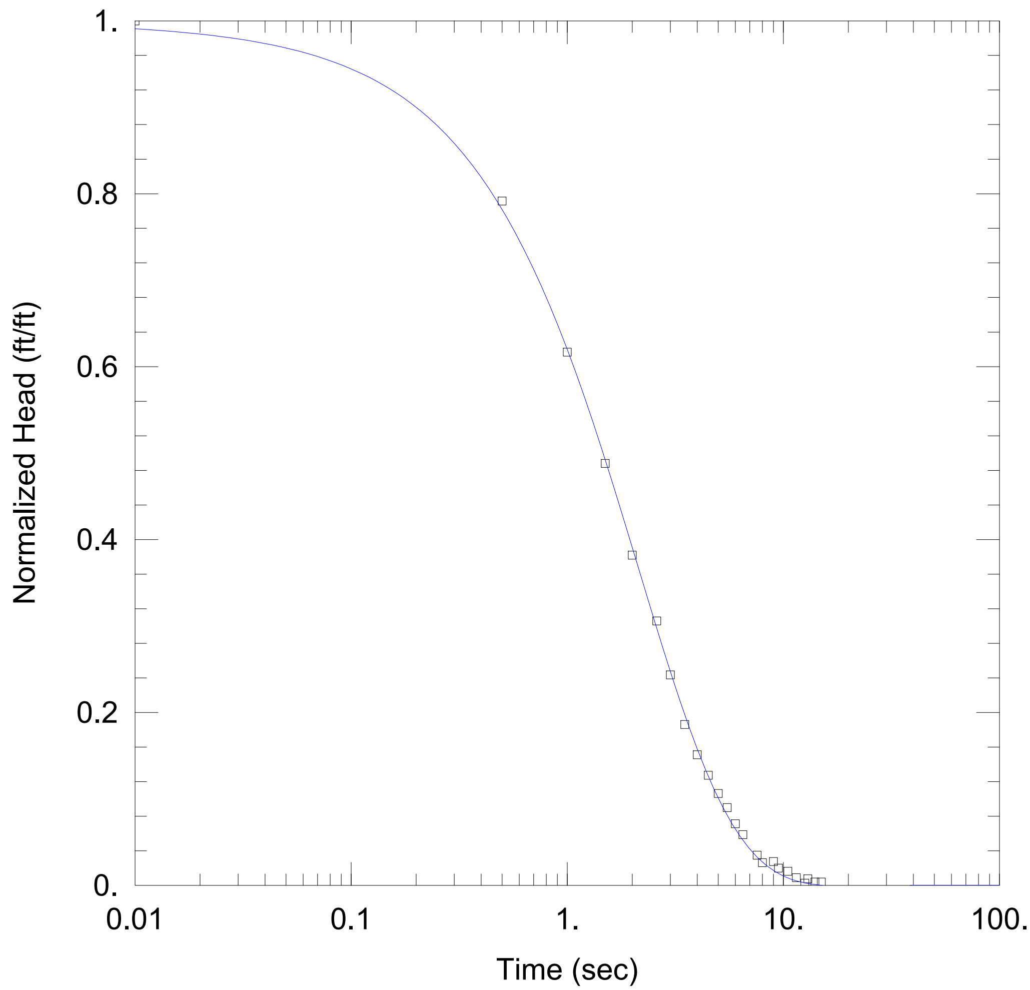
WELL DATA (JHC MW-15015)

Initial Displacement: 1.98 ft
Static Water Column Height: 12.57 ft
Total Well Penetration Depth: 12.57 ft
Screen Length: 10. ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15024 - Test 2

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 49. ft/day
Ss = 9.8E-6 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 38.71 ft

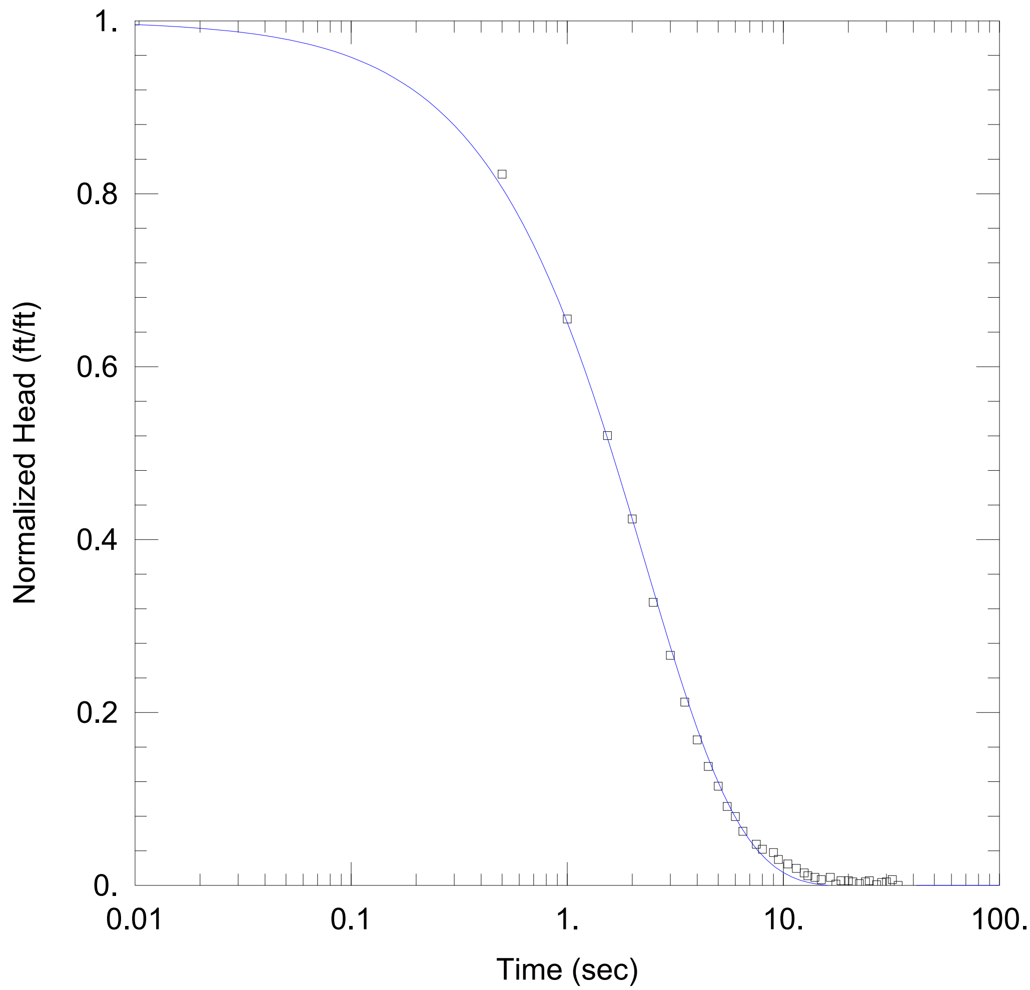
WELL DATA (JHC MW-15024)

Initial Displacement: 0.801 ft
Static Water Column Height: 5.71 ft
Total Well Penetration Depth: 5.71 ft
Screen Length: 5.71 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15024 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 45. ft/day
Ss = 5.05E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 38.71 ft

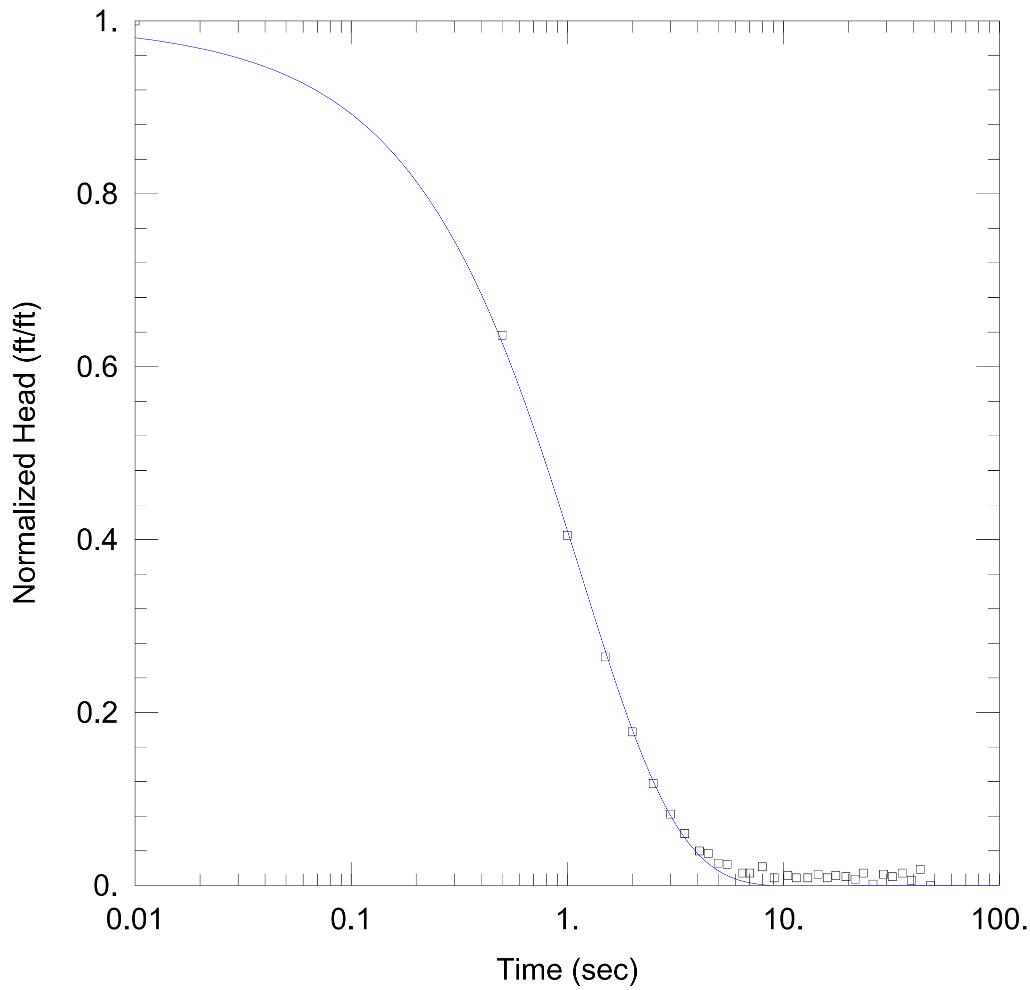
WELL DATA (JHC MW-15024)

Initial Displacement: 1.534 ft
Static Water Column Height: 5.71 ft
Total Well Penetration Depth: 5.71 ft
Screen Length: 5.71 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15028 - Test 1

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 104. ft/day   Ss = 3.1E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 38.22 ft

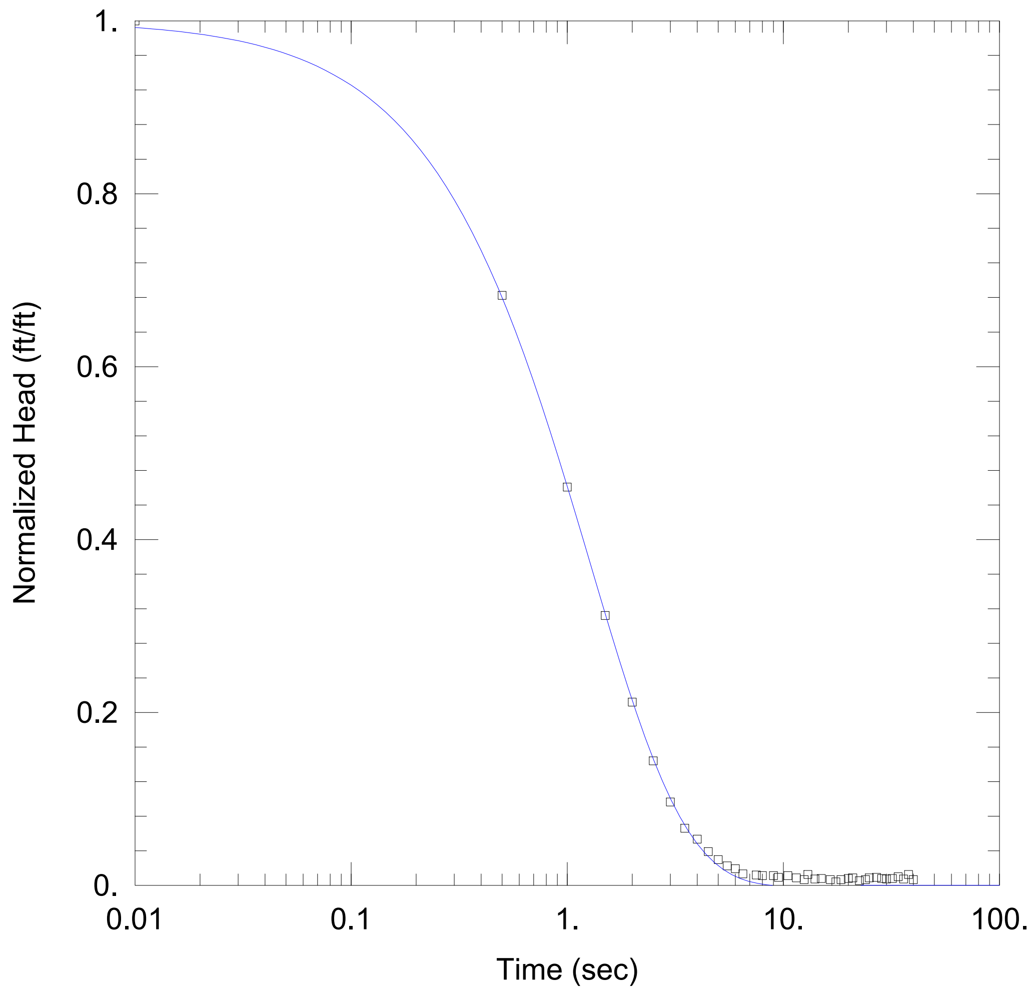
WELL DATA (JHC MW-15028)

Initial Displacement: 0.704 ft
Static Water Column Height: 6.22 ft
Total Well Penetration Depth: 6.22 ft
Screen Length: 6.22 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15028 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 86. ft/day   Ss = 5.05E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 38.22 ft

WELL DATA (JHC MW-15028)

Initial Displacement: 1.515 ft
Static Water Column Height: 6.22 ft
Total Well Penetration Depth: 6.22 ft
Screen Length: 6.22 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

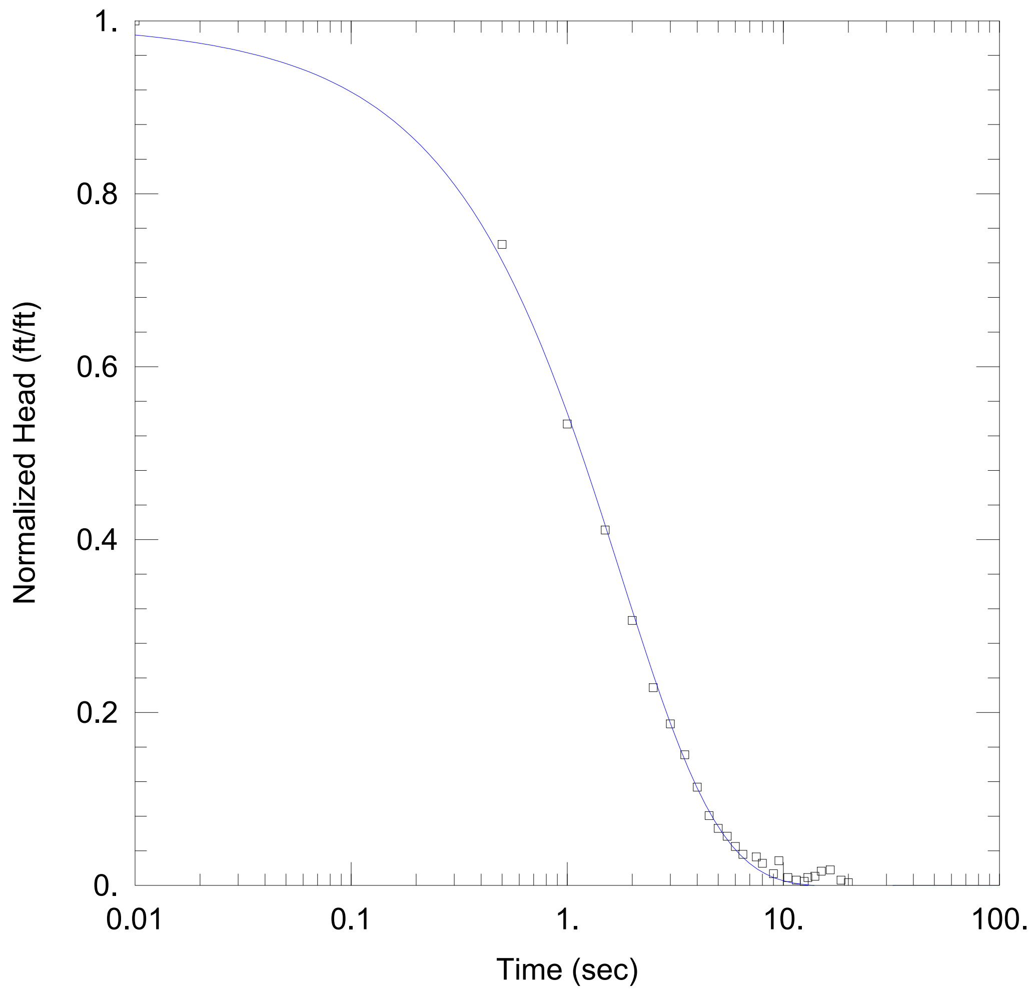
Slug Test Analysis Result for JHC MW-15033 - Test 2

Prepared By:
Arcadis

Prepared For:
Consumer Energy

Project:

Location:
West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 74. ft/day
Ss = 5.3E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

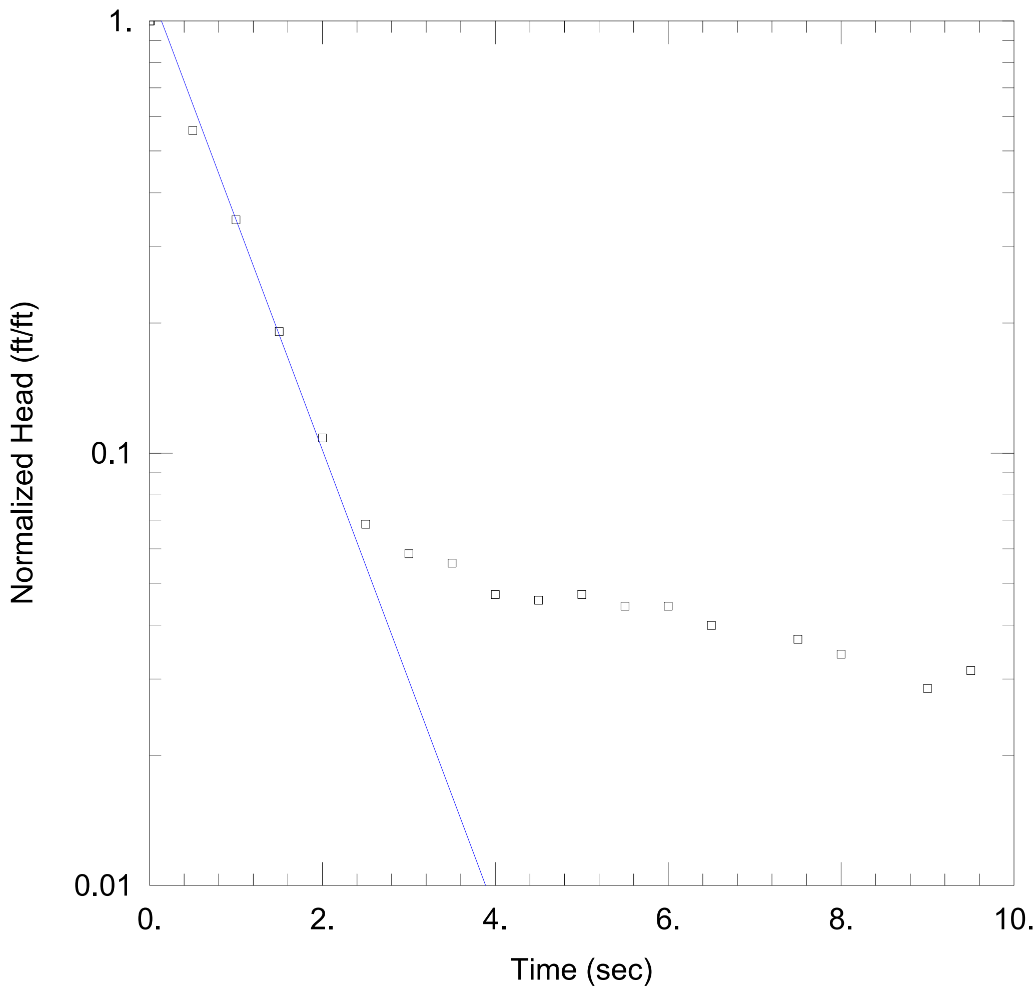
Saturated Thickness: 29.83 ft

WELL DATA (JHC MW-15033)

Initial Displacement: 0.669 ft
Static Water Column Height: 5.83 ft
Total Well Penetration Depth: 5.83 ft
Screen Length: 5.83 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

Slug Test Analysis Result for JHC MW-15030 - Test 2

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 100. ft/day y0 = 0.83 ft

AQUIFER DATA

Saturated Thickness: 45.12 ft

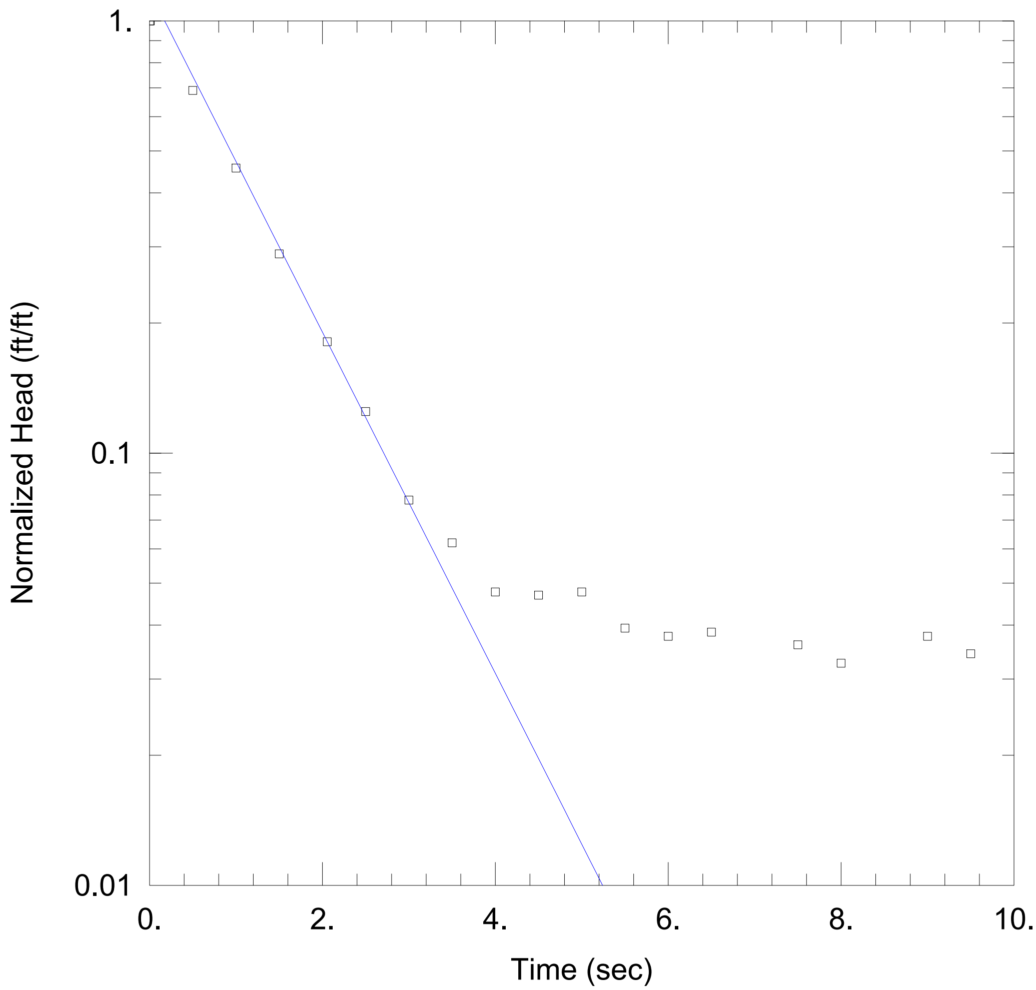
WELL DATA (JHC MW-15030)

Initial Displacement: 0.701 ft
Static Water Column Height: 9.12 ft
Total Well Penetration Depth: 9.12 ft
Screen Length: 9.12 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15030 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 87. ft/day   y0 = 1.4 ft

AQUIFER DATA

Saturated Thickness: 45.12 ft

WELL DATA (JHC MW-15030)

Initial Displacement: 1.194 ft
Static Water Column Height: 9.12 ft
Total Well Penetration Depth: 9.12 ft
Screen Length: 9.12 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

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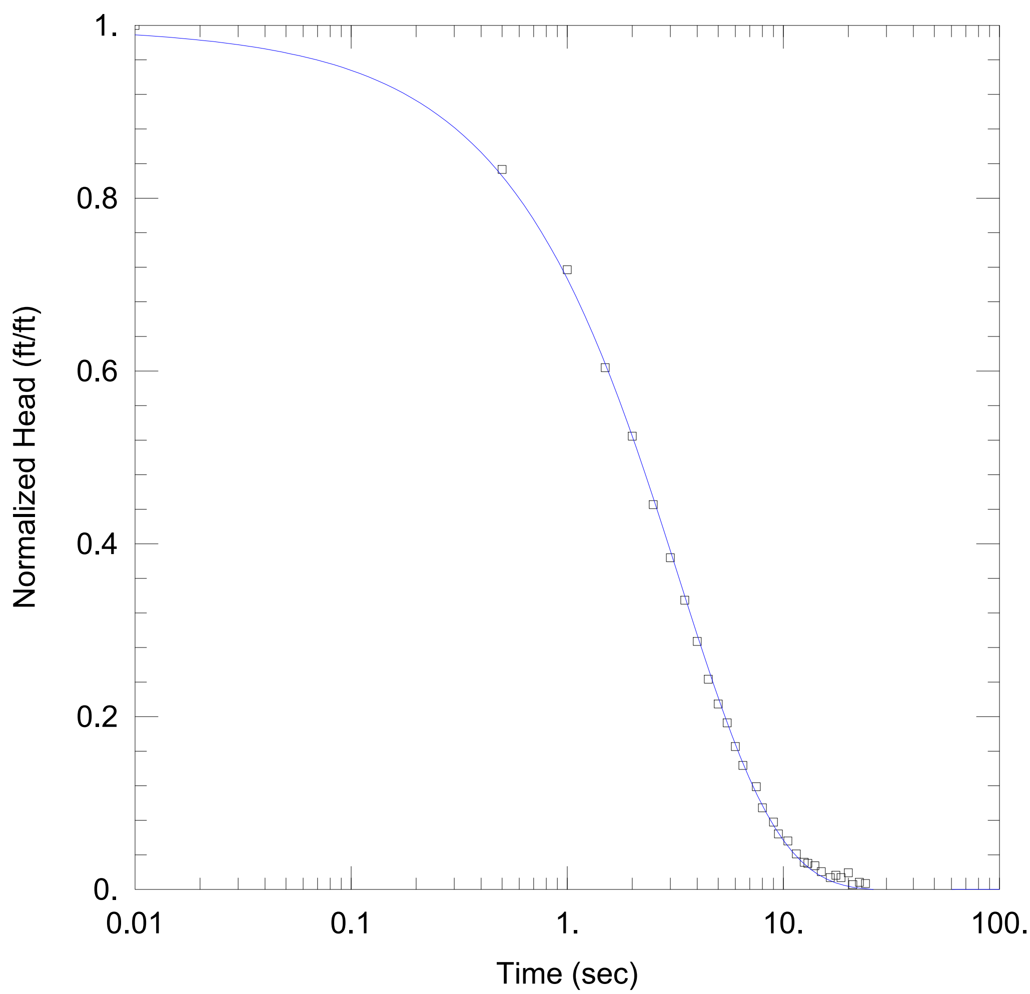
Slug Test Analysis Result for JHC MW-15018 - Test 1

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 34. ft/day
Ss = 4.0E-5 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 36.5 ft

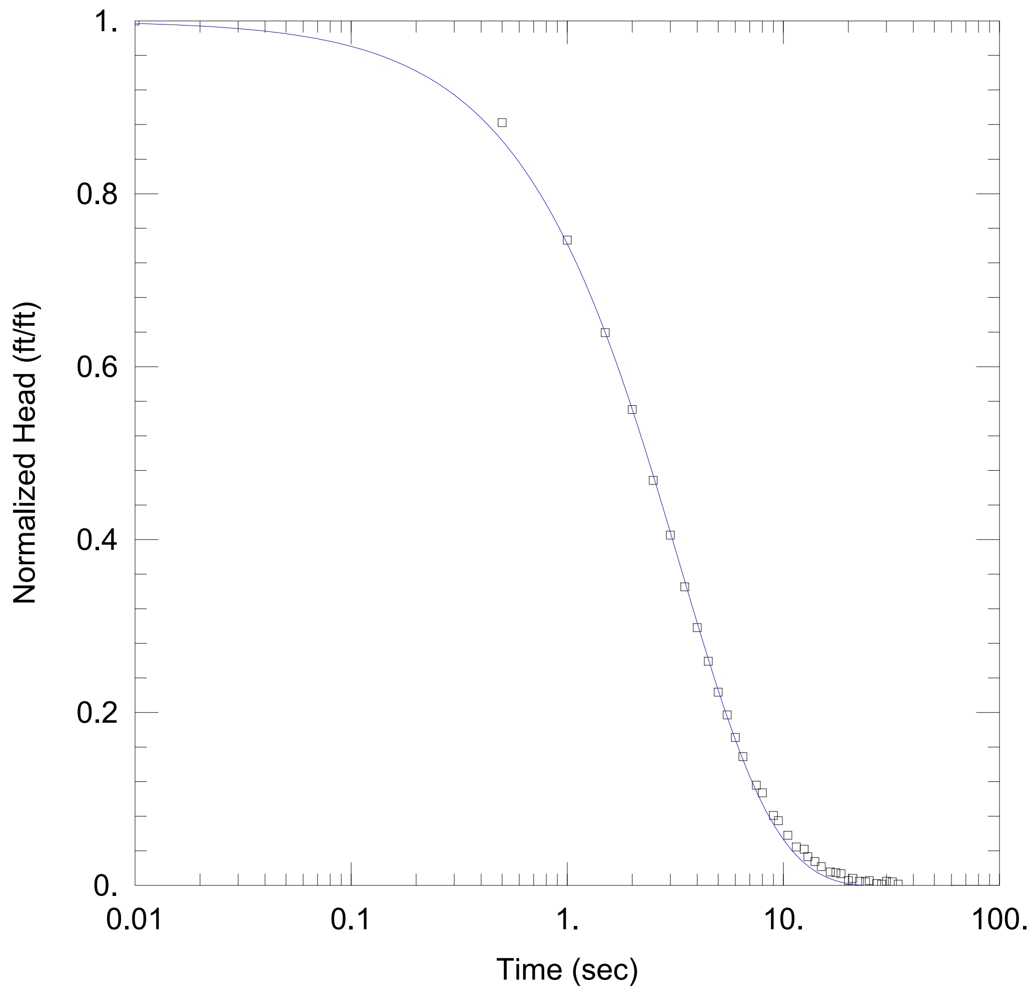
WELL DATA (JHC MW-15018)

Initial Displacement: 0.732 ft
Static Water Column Height: 6.5 ft
Total Well Penetration Depth: 6.5 ft
Screen Length: 6.5 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Slug Test Analysis Result for JHC MW-15018 - Test 3

Prepared By: Arcadis	Prepared For: Consumer Energy
Project:	Location: West Olive, MI



SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 33. ft/day   Ss = 6.2E-12 ft^{-1}
Kz/Kr = 1.

AQUIFER DATA

Saturated Thickness: 36.5 ft

WELL DATA (JHC MW-15018)

Initial Displacement: 1.486 ft
Static Water Column Height: 6.5 ft
Total Well Penetration Depth: 6.5 ft
Screen Length: 6.5 ft
Casing Radius: 0.083 ft
Well Radius: 0.33 ft

ARCADIS

Appendix D
Groundwater Quality Data

Table 1
Summary of Groundwater Analytical Data
Second Quarter 2020 Quarterly Report
JH Campbell Plant Solid Waste Disposal Area, West Olive, Michigan

Analyte		Antimony	Arsenic	Boron	Chromium	Lithium	Molybdenum	Nickel	Selenium	Vanadium
Residential Drinking Water Criteria		6.0	10	500	100	170	73	100	50	4.5
Generic GSI Criteria		130(1)	10	7,200(1)	11(2)	440	3,200(1)	73(3)	5.0(4)	27
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cells 1-9 Upgradient Wells										
MW-1	8/13/2019	< 1	< 1	< 20	< 1	< 10	< 5	**3**	< 1	< 2
	10/10/2019	< 1	< 1	< 20	**2**	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	< 20	< 1	< 10	< 5	< 2	< 1	< 2
	4/14/2020	< 1	< 1	< 20	< 1	< 10	< 5	< 2	< 1	< 2
MW-3	8/13/2019	< 1	< 1	< 20	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	**25**	**1**	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**26**	< 1	< 10	< 5	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**26**	< 1	< 10	< 5	< 2	< 1	< 2
MW-4	8/13/2019	< 1	< 1	< 20	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	< 20	< 1	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**21**	< 1	< 10	< 5	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**25**	< 1	< 10	< 5	< 2	< 1	< 2
MW-5	8/13/2019	< 1	< 1	**40**	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	**50**	< 1	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**54**	< 1	< 10	< 5	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**44**	< 1	< 10	< 5	< 2	< 1	< 2

Notes:
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Analyte		Antimony	Arsenic	Boron	Chromium	Lithium	Molybdenum	Nickel	Selenium	Vanadium
Residential Drinking Water Criteria		6.0	10	500	100	170	73	100	50	4.5
Generic GSI Criteria		130(1)	10	7,200(1)	11(2)	440	3,200(1)	73(3)	5.0(4)	27
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cell 1 Downgradient Wells										
MW-A1	8/14/2019	< 1	< 1	**288**	**2**	< 10	**22**	< 2	**18**	< 2
	10/10/2019	< 1	< 1	**303**	< 1	< 10	**27**	< 2	**16**	< 2
	2/11/2020	< 1	< 1	**326**	< 1	< 10	**30**	< 2	**20**	< 2
	4/14/2020	< 1	< 1	**310**	< 1	< 10	**12**	< 2	**18**	< 2
MW-A2	8/14/2019	< 1	< 1	**97**	< 1	< 10	< 5	**3**	**7**	< 2
	10/10/2019	< 1	< 1	**122**	< 1	< 10	< 5	**3**	**7**	< 2
	2/11/2020	< 1	< 1	**132**	< 1	< 10	< 5	**2**	**9**	< 2
	4/14/2020	< 1	< 1	**116**	< 1	< 10	< 5	< 2	**7**	< 2
MW-A3	8/14/2019	< 1	< 1	**338**	**1**	< 10	< 5	< 2	**2**	< 2
	10/10/2019	< 1	< 1	**231**	< 1	< 10	< 5	< 2	**2**	< 2
	2/11/2020	< 1	< 1	**324**	< 1	< 10	< 5	< 2	**4**	< 2
	4/14/2020	< 1	< 1	**275**	< 1	< 10	< 5	< 2	**2**	< 2

Notes:
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Residential Drinking Water Criteria		6.0	10	500	100	170	73	100	50	4.5
Generic GSI Criteria		130(1)	10	7,200(1)	11(2)	440	3,200(1)	73(3)	5.0(4)	27
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cells 1-9 Downgradient Wells										
MW-B4	8/13/2019	< 1	< 1	**223**	< 1	< 10	< 5	< 2	**3**	< 2
	10/10/2019	< 1	< 1	**241**	< 1	< 10	< 5	< 2	**2**	< 2
	2/11/2020	< 1	< 1	**260**	< 1	< 10	< 5	< 2	**4**	< 2
	4/14/2020	< 1	< 1	**216**	< 1	< 10	< 5	< 2	**3**	< 2
MW-B5	8/13/2019	< 1	< 1	**75**	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	**80**	**1**	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**57**	< 1	< 10	< 5	< 2	**2**	< 2
	4/14/2020	< 1	< 1	**60**	**2**	< 10	< 5	< 2	< 1	< 2
MW-B6	8/13/2019	< 1	< 1	**65**	< 1	< 10	< 5	< 2	**2**	< 2
	10/10/2019	< 1	< 1	**72**	**2**	< 10	< 5	< 2	**2**	< 2
	2/11/2020	< 1	< 1	**89**	< 1	< 10	< 5	< 2	**1**	< 2
	4/14/2020	< 1	< 1	**65**	< 1	< 10	< 5	< 2	< 1	< 2
MW-B7	8/13/2019	< 1	< 1	**242**	< 1	< 10	< 5	< 2	**18**	< 2
	10/10/2019	< 1	< 1	**367**	**2**	< 10	< 5	< 2	**21**	< 2
	2/11/2020	< 1	< 1	**271**	**1**	< 10	< 5	< 2	**9**	< 2
	4/14/2020	< 1	< 1	**225**	< 1	< 10	< 5	< 2	**8**	< 2

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Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Sentinel Wells - 8-Series										
MW-8	8/13/2019	< 1	< 1	**160**	< 1	< 10	< 5	< 2	**7**	< 2
	10/10/2019	< 1	< 1	**115**	< 1	< 10	< 5	< 2	**3**	< 2
	2/11/2020	< 1	< 1	**119**	< 1	< 10	< 5	< 2	**10**	< 2
	4/14/2020	< 1	< 1	**167**	< 1	< 10	< 5	< 2	**9**	< 2
MW-8b	8/13/2019	< 1	< 1	**29**	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	**32**	< 1	< 10	< 5	< 2	< 1	< 2
	2/11/2020(6)	NS	NS	NS	NS	NS	NS	NS	NS	NS
	4/14/2020(6)	NS	NS	NS	NS	NS	NS	NS	NS	NS
MW-8c	8/13/2019	< 1	**3**	**21**	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	**3**	**23**	**1**	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	**3**	**22**	< 1	< 10	< 5	< 2	< 1	< 2
	4/14/2020	< 1	**4**	**22**	< 1	< 10	< 5	**10**	< 1	< 2

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Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Sentinel Wells - B-Series										
MW-B1	8/13/2019	< 1	< 1	**61**	< 1	< 10	< 5	< 2	**18**	< 2
	10/10/2019	< 1	< 1	**93**	**2**	< 10	**5**	< 2	**36**	< 2
	2/11/2020	< 1	< 1	**80**	< 1	< 10	< 5	< 2	**57**	< 2
	4/14/2020	< 1	< 1	**58**	< 1	< 10	< 5	< 2	**33**	< 2
MW-B2	8/13/2019	**1**	< 1	**142**	< 1	< 10	**27**	< 2	**83**	**2**
	10/10/2019	**2**	< 1	**315**	< 1	< 10	**30**	< 2	**42**	**3**
	2/11/2020	**2**	< 1	**165**	< 1	< 10	**31**	< 2	**75**	**2**
	4/14/2020	**1**	< 1	**145**	< 1	< 10	**30**	< 2	**99**	< 2
MW-B3	8/13/2019	< 1	< 1	**36**	< 1	< 10	**8**	< 2	**38**	**2**
	10/10/2019	**2**	< 1	**48**	< 1	< 10	**9**	< 2	**13**	**2**
	2/11/2020	**2**	< 1	**40**	< 1	< 10	**10**	< 2	**13**	**2**
	4/14/2020	**1**	< 1	**41**	< 1	< 10	**8**	< 2	**20**	**2**

Notes:
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Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cells B-K Downgradient Wells										
MW-11A	8/14/2019	< 1	**3**	**35**	**1**	< 10	**21**	**6**	**3**	< 2
	10/11/2019	< 1	**6**	**42**	**1**	< 10	< 5	**4**	< 1	< 2
	2/11/2020	< 1	< 1	**56**	< 1	< 10	**6**	**2**	**4**	< 2
	4/14/2020	**1**	**1**	**68**	< 1	< 10	**6**	**2**	< 1	< 2
MW-12	8/12/2019	< 1	< 1	**96**	**2**	< 10	**8**	< 2	< 1	< 2
	10/8/2019	< 1	< 1	**91**	**2**	< 10	< 5	< 2	< 1	**2**
	2/10/2020	< 1	< 1	**39**	**2**	< 10	< 5	< 2	< 1	**5**
	4/13/2020	**2**	< 1	**38**	< 1	< 10	< 5	< 2	< 1	< 2
MW-13	8/12/2019(5)	NS	NS	NS	NS	NS	NS	NS	NS	NS
	10/10/2019(5)	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2/11/2020	< 1	< 1	**37**	< 1	**17**	< 5	**7**	**5**	< 2
	4/13/2020	< 1	< 1	**20**	< 1	**20**	< 5	**9**	**2**	< 2
MW-14	8/13/2019	< 1	< 1	**81**	< 1	< 10	< 5	< 2	< 1	< 2
	10/10/2019	< 1	< 1	**77**	< 1	< 10	< 5	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**62**	< 1	< 10	**5**	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**67**	< 1	< 10	< 5	< 2	< 1	< 2

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Generic GSI Criteria		130[(1)]	10	7,200[(1)]	11[(2)]	440	3,200[(1)]	73[(3)]	5.0[(4)]	27
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	N/A
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	N/A
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Cells B-K Downgradient Piezometers										
PZ-23	8/13/2019	< 1	< 1	**198**	< 1	< 10	**10**	< 2	**1**	< 2
	10/9/2019	< 1	< 1	**218**	< 1	< 10	**7**	**8**	**3**	< 2
	2/11/2020	< 1	< 1	**158**	< 1	< 10	**7**	**3**	**4**	< 2
	4/14/2020	< 1	< 1	**156**	**2**	< 10	**7**	**3**	**3**	< 2
PZ-24	8/13/2019	< 1	< 1	**162**	**2**	< 10	**10**	< 2	< 1	**3**
	10/9/2019	< 1	< 1	**176**	< 1	< 10	**11**	< 2	< 1	**2**
	2/11/2020	< 1	< 1	**198**	< 1	< 10	**9**	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**190**	**2**	< 10	**13**	< 2	< 1	**3**
PZ-37	8/12/2019	< 1	< 1	**1,010**	< 1	< 10	**10**	< 2	**1**	**3**
	10/9/2019	< 1	< 1	**1,170**	< 1	< 10	**7**	< 2	**2**	**22**
	2/10/2020	< 1	< 1	**734**	< 1	< 10	**6**	< 2	**3**	**31**
	4/14/2020	< 1	< 1	**616**	< 1	< 10	**5**	< 2	**2**	**28**
PZ-40	8/13/2019	< 1	< 1	**165**	< 1	< 10	**7**	< 2	< 1	< 2
	10/9/2019	< 1	< 1	**186**	**2**	< 10	**7**	< 2	< 1	< 2
	2/11/2020	< 1	< 1	**175**	< 1	< 10	**9**	< 2	< 1	< 2
	4/14/2020	< 1	< 1	**170**	< 1	< 10	**7**	< 2	< 1	< 2

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Table 2
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2019 RAP Annual Report
JH Campbell Plant Solid Waste Disposal Area, West Olive, Michigan

Analyte		Antimony	Boron	Lithium	Selenium
Residential Drinking Water Criteria		6.0	500	170	50
Generic GSI Criteria		130(1)	7,200(1)	440	5.0(2)
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	47
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	120
Units		µg/L	µg/L	µg/L	µg/L
GSI Wells					
MW-11a	7/18/2018	**4**	**54**	<10	**2**
	10/9/2018	**1**	**45**	<10	**2**
	2/12/2019	**1**	**73**	<10	**18**
	4/18/2019	**1**	**73**	<10	**8**
MW-12	7/18/2018(3)	<1	**127**	<10	<1
	10/9/2018	<1	**444**	<10	<1
	2/12/2019	<1	**123**	<10	<1
	4/16/2019	<1	**73**	<10	<1
MW-13	7/19/2018(5)	**1**	**469**	**28**	**8**
	10/9/2018	**2**	**118**	**26**	**10**
	2/12/2019	**2**	**40**	**12**	**8**
	4/16/2019(5)	**1**	**43**	**15**	**4**
MW-14	7/19/2018	<1	**91**	<10	<1
	10/9/2018	<1	**89**	<10	<1
	2/12/2019	<1	**105**	<10	<1
	4/18/2019	<1	**65**	<10	<1
Interior Wells					
MW-A1	7/18/2018	<1	**635**	<10	**47**
	10/9/2018	<1	**594**	<10	**45**
	2/13/2019	<1	**405**	<10	**37**
	4/17/2019	<1	**420**	<10	**33**
MW-B1	7/18/2018	<1	**42**	**10**	**3**
	10/9/2018	**1**	**60**	<10	<1
	2/13/2019(4)	NU	NU	NU	NU
	4/17/2019	<1	**42**	<10	**25**
MW-B2	7/18/2018	<1	**81**	<10	**120**
	10/9/2018	**2**	**148**	<10	**46**
	2/13/2019	**1**	**200**	<10	**67**
	4/17/2019	**1**	**184**	<10	**112**

Notes:

Residential Drinking Water Criteria and Groundwater Surface Water Interface (GSI) Criteria from Michigan Part 201 Generic Cleanup Criteria and Screening Levels as promulgated on December 30, 2013.

Mixing Zone GSI Criteria from Michigan Department of Environmental Quality (MDEQ) approval letter dated July 23, 2015 - Corrected August 4, 2015.

µg/L = micrograms per Liter

N/A = Not Applicable

NU = Not Used

Bold font denotes concentrations detected above laboratory reporting limits

Denotes concentrations above one or more applicable GSI criteria

1) Criterion is not protective for surface water used as a drinking water source as described in Footnote {X} of Michigan Part 201 Criteria tables.

2) Selenium data are compared to site-specific Mixing Zone GSI Criteria.

3) Grab groundwater sample collected; insufficient groundwater volume for low-flow methods.

4) Data was determined to be unusable due to well conditions that prevented adequate purging prior to groundwater sample collection.

Table 2
Summary of Groundwater Analytical Data
2019 RAP Annual Report
JH Campbell Plant Solid Waste Disposal Area, West Olive, Michigan

Analyte		Antimony	Boron	Lithium	Selenium
Residential Drinking Water Criteria		6.0	500	170	50
Generic GSI Criteria		130(1)	7,200(1)	440	5.0(2)
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	47
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	120
Units		µg/L	µg/L	µg/L	µg/L
Sentinel Wells					
MW-9b	7/18/2018	**3**	**2,790**	**74**	**22**
	10/9/2018	**3**	**2,050**	**72**	**9**
	2/12/2019	**4**	**1,430**	**65**	**89**
	4/19/2019	**3**	**2,630**	**66**	**118**
MW-9c	7/18/2018	**4**	**4,770**	**24**	<1
	10/9/2018	**4**	**3,490**	**23**	<1
	2/12/2019	**4**	**1,360**	**22**	<1
	4/19/2019	**4**	**1,990**	**22**	<1
MW-9d	7/18/2018	<1	**607**	**27**	<1
	10/9/2018	<1	**514**	**27**	<1
	2/12/2019	<1	**562**	**24**	<1
	4/19/2019	<1	**502**	**25**	<1
MW-10b	7/18/2018	**1**	**99**	<10	**5**
	10/9/2018	**1**	**106**	<10	**8**
	2/12/2019	**1**	**116**	<10	**1**
	4/19/2019	**1**	**132**	<10	<1
MW-15	7/18/2018	<1	**63**	<10	**2**
	10/9/2018	<1	**114**	<10	**2**
	2/12/2019	<1	**115**	<10	**4**
	4/18/2019	<1	**727**	<10	**50**

Notes:

Residential Drinking Water Criteria and Groundwater Surface Water Interface (GSI) Criteria from Michigan Part 201 Generic Cleanup Criteria and Screening Levels as promulgated on December 30, 2013.

Mixing Zone GSI Criteria from Michigan Department of Environmental Quality (MDEQ) approval letter dated July 23, 2015 - Corrected August 4, 2015.

µg/L = micrograms per Liter

N/A = Not Applicable

NU = Not Used

Bold font denotes concentrations detected above laboratory reporting limits

Denotes concentrations above one or more applicable GSI criteria

1) Criterion is not protective for surface water used as a drinking water source as described in Footnote {X} of Michigan Part 201 Criteria tables.

2) Selenium data are compared to site-specific Mixing Zone GSI Criteria

3) Grab groundwater sample collected; insufficient groundwater volume for low-flow methods.

4) Data was determined to be unusable due to well conditions that prevented adequate purging prior to groundwater sample collection.

Table 2
Summary of Groundwater Analytical Data
2019 RAP Annual Report
JH Campbell Plant Solid Waste Disposal Area, West Olive, Michigan

Analyte		Antimony	Boron	Lithium	Selenium
Residential Drinking Water Criteria		6.0	500	170	50
Generic GSI Criteria		130[(1)]	7,200[(1)]	440	5.0[(2)]
Chronic-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	47
Acute-Based Mixing Zone GSI Criteria		N/A	N/A	N/A	120
Units		µg/L	µg/L	µg/L	µg/L
Extraction Wells: collected directly from extraction wells					
RW-1	7/17/2018	**5**	**1,130**	**28**	**146**
	10/8/2018	<1	**278**	**15**	**10**
	2/11/2019	**4**	**971**	**38**	**169**
	4/16/2019	**5**	**1,330**	**59**	**249**
RW-2	7/17/2018	**5**	**1,590**	**61**	**139**
	10/8/2018	**5**	**788**	**33**	**57**
	2/11/2019	<1	**333**	**14**	**1**
	4/16/2019	<1	**341**	**16**	<1
RW-3	7/17/2018	**3**	**3,260**	**56**	**209**
	10/8/2018	**3**	**2,940**	**41**	**72**
	2/11/2019	**4**	**2,880**	**49**	**112**
	4/16/2019	**3**	**2,710**	**82**	**346**
RW-4	7/17/2018	<1	**325**	**21**	**17**
	10/8/2018	**1**	**1,680**	**33**	**29**
	2/11/2019	**2**	**1,360**	**25**	**77**
	4/16/2019	**1**	**2,100**	**36**	**100**
RW-5	7/17/2018	**3**	**2,250**	**58**	**24**
	10/8/2018	**3**	**2,320**	**68**	**20**
	2/11/2019	**3**	**3,030**	**70**	**51**
	4/16/2019	**2**	**2,670**	**58**	**59**
RW-6	7/17/2018	<1	**751**	**21**	<1
	10/8/2018	<1	**770**	**27**	**3**
	2/11/2019	<1	**1,650**	**26**	<1
	4/16/2019	<1	**2,080**	**27**	<1
RW-7	7/17/2018	**2**	**2,020**	**40**	**40**
	10/8/2018	<1	**696**	**24**	**2**
	2/11/2019	<1	**550**	**11**	**6**
	4/16/2019	**1**	**1,560**	**30**	**52**

Notes:

Residential Drinking Water Criteria and Groundwater Surface Water Interface (GSI) Criteria from Michigan Part 201 Generic Cleanup Criteria and Screening Levels as promulgated on December 30, 2013.

Mixing Zone GSI Criteria from Michigan Department of Environmental Quality (MDEQ) approval letter dated July 23, 2015 - Corrected August 4, 2015.

µg/L = micrograms per Liter

N/A = Not Applicable

NU = Not Used

Bold font denotes concentrations detected above laboratory reporting limits

Denotes concentrations above one or more applicable GSI criteria

1) Criterion is not protective for surface water used as a drinking water source as described in Footnote {X} of Michigan Part 201 Criteria tables.

2) Selenium data are compared to site-specific Mixing Zone GSI Criteria

3) Grab groundwater sample collected; insufficient groundwater volume for low-flow methods.

4) Data was determined to be unusable due to well conditions that prevented adequate purging prior to groundwater sample collection.

Table 3
Summary of Background Well Groundwater Sampling Results (Analytical): April 2019 - October 2019
JH Campbell Background – RCRA CCR Monitoring Program
West Olive, Michigan

					Sample Location:	**JHC-MW-15023**		**JHC-MW-15024**		**JHC-MW-15025**		**JHC-MW-15026**		**JHC-MW-15027**		**JHC-MW-15028**	
					Sample Date:	4/23/2019	10/8/2019	4/23/2019	10/8/2019	4/23/2019	10/8/2019	4/22/2019	10/7/2019	4/22/2019	10/7/2019	4/22/2019	10/7/2019
Constituent	Unit	EPA MCL	MI Residential*	MI Non-Residential*	MI GSI^	Background											
Appendix III																	
Boron	ug/L	NC	500	500	7,200	54	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Calcium	mg/L	NC	NC	NC	500	9.5	9.5	29	29	13	23	12	13	7.4	7.9	10	10
Chloride	mg/L	250**	250	250	500	3.1	3.7	30	13	11	35	8.8	5.4	2.0	< 2.0	< 2.0	< 2.0
Fluoride	ug/L	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Sulfate	mg/L	250**	250	250	500	12	12	7.5	7.5	8.5	10	8.6	8.4	7.5	12	5.5	5.5
Total Dissolved Solids	mg/L	500**	500	500	500	75	91	180	270	75	210	140	100	< 50	62	< 50	76
pH, Field	SU	**6.5 - 8.5****	**6.5 - 8.5**	**6.5 - 8.5**	**6.5 - 9.0**	**5.9**	**6.2**	7.2	7.4	6.7	8.1	6.9	7.3	6.5	**6.3**	7.6	7.2
Appendix IV																	
Antimony	ug/L	6	6.0	6.0	130	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Arsenic	ug/L	10	10	10	10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Barium	ug/L	2,000	2,000	2,000	820	22	21	17	16	20	8.6	14	11	23	39	5.4	7.2
Beryllium	ug/L	4	4.0	4.0	18	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	5	5.0	5.0	3.5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Chromium	ug/L	100	100	100	11	< 1.0	1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3.6
Cobalt	ug/L	NC	40	100	100	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0
Fluoride	ug/L	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Lead	ug/L	NC	4.0	4.0	39	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	NC	170	350	440	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Mercury	ug/L	2	2.0	2.0	0.20#	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	NC	73	210	3,200	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Radium-226	pCi/L	NC	NC	NC	NC	0.108	< 0.147	< 0.0821	0.173	< 0.0726	< 0.124	< 0.0974	0.139	< 0.103	0.249	< 0.0933	0.125
Radium-228	pCi/L	NC	NC	NC	NC	< 0.355	< 0.390	< 0.349	0.379	< 0.353	< 0.348	< 0.355	< 0.387	< 0.340	< 0.348	< 0.308	< 0.349
Radium-226/228	pCi/L	5	NC	NC	NC	< 0.355	< 0.390	< 0.349	0.552	< 0.353	0.381	< 0.355	< 0.387	< 0.340	0.394	< 0.308	< 0.349
Selenium	ug/L	50	50	50	5.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Thallium	ug/L	2	2.0	2.0	3.7	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units; pH is a field parameter.
pCi/L - picocuries per liter.
MCL - Maximum Contaminant Level, EPA Drinking Water Standards and Health Advisories, April 2012.
NC - no criteria.
* - Michigan Part 201 Generic Drinking Water Cleanup Criteria, December 30, 2013.
** - Secondary Maximum Contaminant Level (SMCL), EPA Secondary Drinking Water Regulations (SDWR), April 2012.
^ - Michigan Part 201 Groundwater Surface Water Interface (GSI) Criteria. Hardness-dependent criteria calculated using site-specific hardness of 180 mg CaCO3/L as measured at surface water sample SW-01 collected on April 9, 2018 from the Pigeon River. Chromium GSI criterion based on hexavalent chromium per footnote {H}.
# - If detected above 0.20 ug/L, further evaluation of low-level mercury may be necessary to evaluate the GSI pathway per Michigan Part 201 and MDEQ policy and procedure 09-014 dated June 20, 2012.
BOLD value indicates an exceedance of one or more of the listed criteria.
RED value indicates an exceedance of the MCL.
All metals were analyzed as total unless otherwise specified.

Table 4
Summary of Groundwater Sampling Results (Analytical): April 2019 - October 2019
JH Campbell Dry Ash Landfill – RCRA CCR Monitoring Program
West Olive, Michigan

						Sample Location:	JHC-MW-15017		JHC-MW-15018		JHC-MW-15019		JHC-MW-15022			JHC-MW-15031		JHC-MW-15032	
						Sample Date:	4/23/2019	10/8/2019	4/23/2019	10/8/2019	4/23/2019	10/8/2019	4/24/2019	6/21/2019	10/9/2019	4/24/2019	10/9/2019	4/24/2019	10/8/2019
Constituent	Unit	UTL	EPA MCL	MI Residential*	MI Non-Residential*	MI GSI^	downgradient												
Appendix III																			
Boron	ug/L	51	NC	500	500	7,200	340	350	130	170	150	150	360	--	330	79	85	< 50	58
Calcium	mg/L	46	NC	NC	NC	500	81	77	58	48	45	34	110	--	130	59	57	9.4	7.9
Chloride	mg/L	43	250**	250	250	500	120	60	43	44	14	6.0	2.7	--	< 2.0	24	28	2.6	2.3
Fluoride	ug/L	1,000	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	--	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Sulfate	mg/L	14	250**	250	250	500	100	92	61	84	25	23	37	--	37	25	26	11	12
Total Dissolved Solids	mg/L	258	**500****	**500**	**500**	**500**	**520**	280	320	370	200	280	410	--	**540**	280	220	53	68
pH, Field	SU	4.8 - 9.2	**6.5 - 8.5****	**6.5 - 8.5**	**6.5 - 8.5**	**6.5 - 9.0**	**6.1**	**6.3**	**6.4**	**6.0**	6.5	**6.4**	7.0	7.1	7.0	6.9	6.9	**6.3**	**6.3**
Appendix IV																			
Antimony	ug/L	2	6	6.0	6.0	130	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Arsenic	ug/L	1	10	10	10	10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Barium	ug/L	35	2,000	2,000	2,000	820	70	47	80	130	46	58	23	--	26	14	17	8.3	7.9
Beryllium	ug/L	1	4	4.0	4.0	18	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	0.2	5	5.0	5.0	3.5	0.57	0.24	< 0.20	0.29	< 0.20	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Chromium	ug/L	2	**100**	**100**	**100**	**11**	**12**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**82**	2.2(1)	5.9	5.4	1.9	< 1.0	< 1.0
Cobalt	ug/L	15	NC	40	100	100	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	--	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0
Fluoride	ug/L	1,000	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	--	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Lead	ug/L	1	NC	4.0	4.0	39	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	10	NC	170	350	440	< 10	< 10	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10	< 10	< 10
Mercury	ug/L	0.2	2	2.0	2.0	0.20#	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	5	NC	73	210	3,200	11	10	< 5.0	< 5.0	12	16	7.2	--	5.2	< 5.0	< 5.0	< 5.0	< 5.0
Radium-226	pCi/L	NA	NC	NC	NC	NC	0.176	0.259	0.217	0.348	0.124	0.187	< 0.0968	--	0.190	0.102	0.199	< 0.118	0.157
Radium-228	pCi/L	NA	NC	NC	NC	NC	0.827	0.384	< 0.476	0.390	< 0.465	< 0.295	< 0.505	--	< 0.480	< 0.427	0.600	< 0.395	< 0.347
Radium-226/228	pCi/L	1.93	5	NC	NC	NC	1.00	0.643	< 0.476	0.739	< 0.465	0.327	< 0.505	--	< 0.480	0.466	0.798	< 0.395	0.427
Selenium	ug/L	5	50	50	50	**5.0**	**16**	**14**	**12**	**15**	**11**	**11**	**7.2**	--	**6.4**	< 1.0	< 1.0	< 1.0	< 1.0
Thallium	ug/L	2	2	2.0	2.0	3.7	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	--	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units; pH is a field parameter.
pCi/L - picocuries per liter.
MCL - Maximum Contaminant Level, EPA Drinking Water Standards and Health Advisories, April 2012.
NC - no criteria.
-- - not analyzed.
* - Michigan Part 201 Generic Drinking Water Cleanup Criteria, December 30, 2013.
** - Secondary Maximum Contaminant Level (SMCL), EPA Secondary Drinking Water Regulations (SDWR), April 2012.
^ - Michigan Part 201 Groundwater Surface Water Interface (GSI) Criteria. Hardness-dependent criteria calculated using site-specific hardness of 180 mg CaCO3/L as measured at surface water sample SW-01 collected on April 9, 2018 from the Pigeon River. Chromium GSI criterion based on hexavalent chromium per footnote {H}.
\# - If detected above 0.20 ug/L, further evaluation of low-level mercury may be necessary to evaluate the GSI pathway per Michigan Part 201 and EGLE policy and procedure 09-014 dated June 20, 2012.
Indicates that the concentration in one or more wells exceeds the background level. If concentrations of all Appendix III and Appendix IV constituents are below the background level for two consecutive events, the unit may return to detection monitoring.
BOLD value indicates an exceedance of one or more of the listed criteria.
RED value indicates an exceedance of the MCL.
All metals were analyzed as total unless otherwise specified.
(1) - Due to anomalous chromium result and uncertainty that associated data quality objectives were met for the April 2019 analysis, a resample was collected June 21, 2019. The June 2019 result met data quality objectives and did not confirm the April 2019 result; therefore the June 2019 result is used for assessment monitoring in place of the April 2019 data.

Table 4
Summary of Groundwater Sampling Results (Analytical): April 2019 - October 2019
JH Campbell Dry Ash Landfill – RCRA CCR Monitoring Program
West Olive, Michigan

						Sample Location:	**JHC-MW-15033**		**JHC-MW-15034**		**JHC-MW-15035**			**JHC-MW-15036**		**JHC-MW-15037**	
						Sample Date:	4/24/2019	10/8/2019	4/24/2019	10/8/2019	4/24/2019	6/21/2019	10/9/2019	4/24/2019	10/8/2019	4/24/2019	10/8/2019
Constituent	Unit	UTL	EPA MCL	MI Residential*	MI Non-Residential*	MI GSI^	downgradient										
Appendix III																	
Boron	ug/L	51	NC	500	500	7,200	< 50	51	51	68	91	--	78	80	71	150	280
Calcium	mg/L	46	NC	NC	NC	500	10	11	5.4	5.4	98	--	84	50	55	73	110
Chloride	mg/L	43	250**	250	250	500	< 2.0	2.6	2.1	< 2.0	23	--	24	14	13	6.3	4.4
Fluoride	ug/L	1,000	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	--	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Sulfate	mg/L	14	250**	250	250	500	9.5	12	12	15	24	--	25	19	24	22	46
Total Dissolved Solids	mg/L	258	**500****	**500**	**500**	**500**	58	71	< 50	54	360	--	370	220	320	270	400
pH, Field	SU	4.8 - 9.2	**6.5 - 8.5****	**6.5 - 8.5**	**6.5 - 8.5**	**6.5 - 9.0**	6.7	6.9	**5.9**	**6.1**	7.2	7.1	7.2	7.4	7.5	7.3	7.3
Appendix IV																	
Antimony	ug/L	2	6	6.0	6.0	130	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Arsenic	ug/L	1	10	10	10	10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Barium	ug/L	35	2,000	2,000	2,000	820	< 5.0	5.4	5.5	6.5	17	--	16	8.4	9.4	9.7	14
Beryllium	ug/L	1	4	4.0	4.0	18	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium	ug/L	0.2	5	5.0	5.0	3.5	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Chromium	ug/L	2	**100**	**100**	**100**	**11**	< 1.0	< 1.0	1.2	< 1.0	**290**	1.8(1)	4.4	< 1.0	< 1.0	1.7	1.2
Cobalt	ug/L	15	NC	40	100	100	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	--	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0
Fluoride	ug/L	1,000	4,000	NC	NC	NC	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000	--	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Lead	ug/L	1	NC	4.0	4.0	39	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lithium	ug/L	10	NC	170	350	440	< 10	< 10	< 10	< 10	< 10	--	< 10	< 10	< 10	< 10	< 10
Mercury	ug/L	0.2	2	2.0	2.0	0.20#	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	--	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
Molybdenum	ug/L	5	NC	73	210	3,200	< 5.0	< 5.0	< 5.0	< 5.0	11	--	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Radium-226	pCi/L	NA	NC	NC	NC	NC	< 0.0696	0.167	< 0.0948	0.133	< 0.101	--	0.203	< 0.0882	0.160	< 0.0813	0.232
Radium-228	pCi/L	NA	NC	NC	NC	NC	< 0.306	< 0.333	< 0.381	< 0.384	< 0.357	--	< 0.567	< 0.384	< 0.441	< 0.342	< 0.518
Radium-226/228	pCi/L	1.93	5	NC	NC	NC	< 0.306	< 0.333	< 0.381	< 0.384	< 0.357	--	< 0.567	< 0.384	0.442	0.403	< 0.518
Selenium	ug/L	5	50	50	50	**5.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	--	< 1.0	< 1.0	1.9	3.8	**16**
Thallium	ug/L	2	2	2.0	2.0	3.7	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	--	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0

Notes:
ug/L - micrograms per liter.
mg/L - milligrams per liter.
SU - standard units; pH is a field parameter.
pCi/L - picocuries per liter.
MCL - Maximum Contaminant Level, EPA Drinking Water Standards and Health Advisories, April 2012.
NC - no criteria.
-- - not analyzed.
* - Michigan Part 201 Generic Drinking Water Cleanup Criteria, December 30, 2013.
** - Secondary Maximum Contaminant Level (SMCL), EPA Secondary Drinking Water Regulations (SDWR), April 2012.
^ - Michigan Part 201 Groundwater Surface Water Interface (GSI) Criteria. Hardness-dependent criteria calculated using site-specific hardness of 180 mg CaCO3/L as measured at surface water sample SW-01 collected on April 9, 2018 from the Pigeon River. Chromium GSI criterion based on hexavalent chromium per footnote {H}.
# - If detected above 0.20 ug/L, further evaluation of low-level mercury may be necessary to evaluate the GSI pathway per Michigan Part 201 and EGLE policy and procedure 09-014 dated June 20, 2012.
Indicates that the concentration in one or more wells exceeds the background level. If concentrations of all Appendix III and Appendix IV constituents are below the background level for two consecutive events, the unit may return to detection monitoring.
BOLD value indicates an exceedance of one or more of the listed criteria.
RED value indicates an exceedance of the MCL.
All metals were analyzed as total unless otherwise specified.
(1) - Due to anomalous chromium result and uncertainty that associated data quality objectives were met for the April 2019 analysis, a resample was collected June 21, 2019. The June 2019 result met data quality objectives and did not confirm the April 2019 result; therefore the June 2019 result is used for assessment monitoring in place of the April 2019 data.

Appendix E
Area Well Records

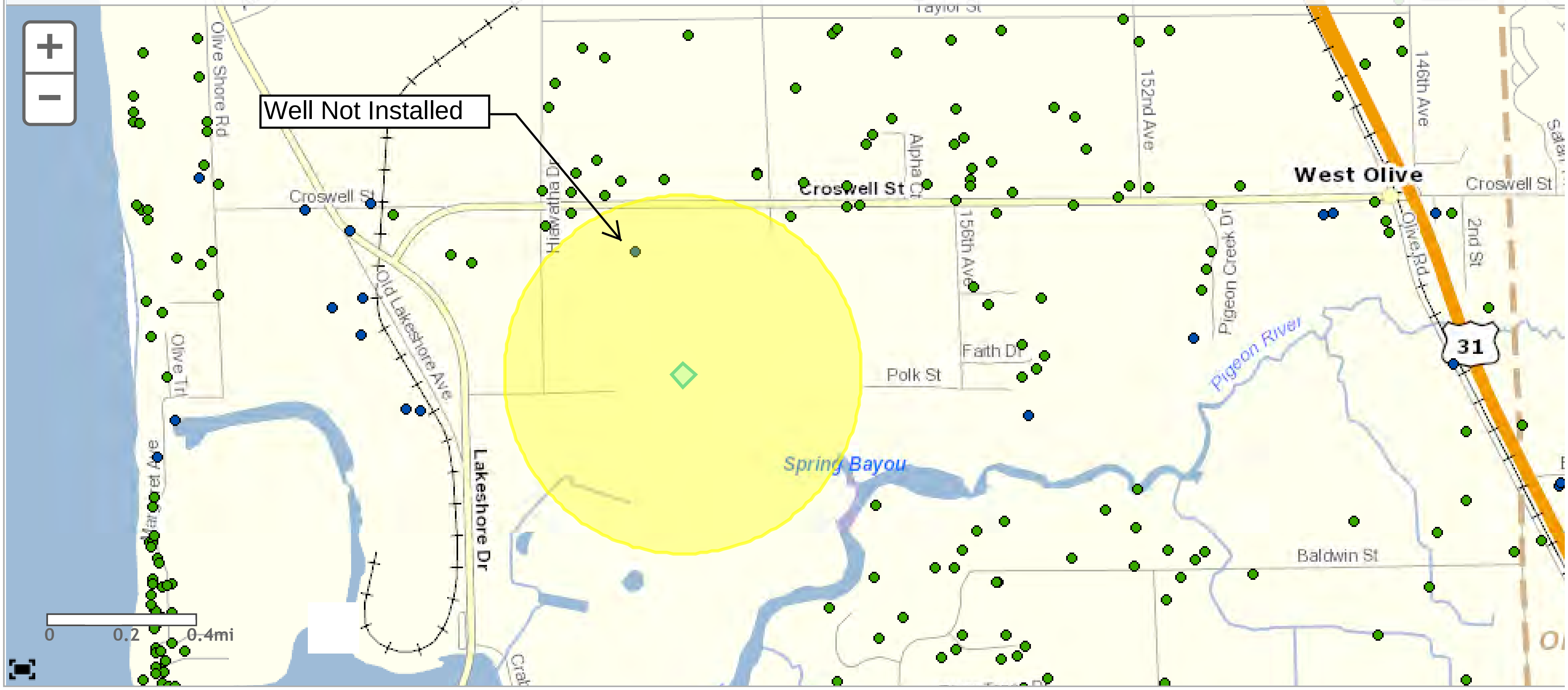
Michigan.gov Home DEQ Online Services Permits Programs Contact Feedback User's Guide

Department of Environmental Quality
GeoWebFace

MICHIGAN.GOV Michigan's Official Web Site

GeoWebFace Map GeoWebFace Results

Zoom In Zoom Out Pan Clear Zoom Extents Map Nav Info Identify



Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978.
Failure to comply is a misdemeanor.

Wellogic

Import ID:

Tax No: | Permit No: | County: Ottawa | Township: Port Sheldon

Well ID: 70000005503

Town/Range: 06N 16W | Section: 10 | Well Status: Active | WSSN: 2060770 | Source ID/Well No: 001

Elevation:

Latitude: 42.919174

Longitude: -86.188757

Method of Collection: QQQ - Centroid

Distance and Direction from Road Intersection:

Well Owner:

Well Address:

Owner Address:

Drilling Method: Rotary
Well Depth: 47.00 ft. **Well Use:** Type II public
Well Type: New **Date Completed:** 4/16/2002

Casing Type: **Height:**
Casing Joint:
Casing Fitting:

Diameter: 5.00 in. to 42.00 ft. depth

Borehole:

Static Water Level: Below Grade
Well Yield Test: **Yield Test Method:**

Screen Installed: No **Intake:**

Well Grouted: No

Wellhead Completion: Other

Nearest Source of Possible Contamination:

Type	Distance	Direction

Pump Installed: No
Pressure Tank Installed: No
Pressure Relief Valve Installed: No

Formation Description	Thickness	Depth to Bottom

Geology Remarks:

Drilling Machine Operator Name: RAYMER
Employment:

Contractor Type: Unknown **Reg No:**
Business Name:
Business Address:

Water Well Contractor's Certification

This well was drilled under my supervision and this report is true to the best of my knowledge and belief.

Signature of Registered Contractor **Date**

General Remarks:

Other Remarks:

Dry Ash Landfill Hydrogeological Monitoring Plan

JH Campbell Power Plant
West Olive, Michigan

October 2020

Prepared For:

Consumers Energy Company
1945 W. Parnall Road
Jackson, MI 49201

Prepared By:

TRC
1540 Eisenhower Place
Ann Arbor, Michigan 48108

Sarah B. Holmstrom, P.G.
Project Manager/Hydrogeologist

Graham Crockford, C.P.G.
Program Manager

Kristin Lowery, E.I.T.
Project Engineer

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1.0 Introduction

The JH Campbell (JHC) Dry Ash Landfill is a Type III solid waste disposal facility owned by Consumers Energy Company (Consumers Energy) located in West Olive, Michigan, which accepts coal ash from power plant operations (Figure 1). The Dry Ash Landfill was initially licensed over 20 years ago. The State of Michigan Waste Data System number is 395496.

TRC has prepared this Dry Ash Landfill Hydrogeologic Monitoring Plan (HMP) on behalf of Consumers Energy that serves as a revision to the Michigan Department of Environment, Great Lakes, and Energy (EGLE)[1]--approved HMP prepared for the Dry Ash Landfill in September 1996 (September 1996 HMP). In addition to the monitoring described in this HMP, groundwater monitoring is also currently performed at the Site in accordance with the Cells B-K monitoring described in the September 1996 HMP and an EGLE-approved Remedial Action Plan (RAP) and the Agreement for a Limited, Site-Specific, Criteria-Based Remedial Action LAND-WMD-2005-2, dated July 13, 2005. The original RAP, dated December 18, 2000, was revised on December 14, 2003, and revised again by a RAP Addendum dated January 31, 2008. On December 21, 2018, Consumers Energy and the EGLE executed Consent Agreement No. 115-01-2018. As outlined in Section 4.5 of the agreement, Consumers Energy is developing an updated, site-wide RAP to address groundwater across the entire solid waste disposal facility (including areas downgradient from the Dry Ash Landfill) by October 1, 2021 and will comply with criteria developed under Part 201 of the NREPA, as amended.

1.1 Background and Program Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) (CCR Rule) to regulate the solid waste management of CCRs at electrical generating facilities. The CCR Rule, which became effective on October 19, 2015, applies to the Consumers Energy Dry Ash Landfill (Figure 2) located at the JHC Power Plant Site (the Site). Consumers Energy began monitoring groundwater at the Dry Ash Landfill in accordance with the CCR Rule in 2015, with the construction of a groundwater monitoring system in 2015, followed by the collection of background groundwater samples, the initiation of detection monitoring, and subsequent data evaluation and reporting. As discussed in the 2020 Annual Groundwater Monitoring and Corrective Action Report, the Dry Ash Landfill is currently in assessment monitoring pursuant to the CCR Rule.

In addition to the CCR Rule, the Dry Ash Landfill has been regulated under Part 115 of the Natural Resources and Environmental Protection Act (NREPA) PA 451 of 1994, as amended (Part 115) and monitored in adherence to the facility's EGLE-approved *Hydrogeological Monitoring Plan (HMP) for JH Campbell Ash Storage Facility, Consumers Power Company, Solid Waste Disposal Area, Coal Ash, Type III* (September 1996) and the aforementioned RAP. Groundwater quality data for the Dry Ash Landfill has been collected since 1992, during the baseline monitoring period including prior to construction of the landfill. Quarterly groundwater data have been provided to the EGLE in the quarterly hydrogeologic monitoring reports since

[1] Effective Monday, April 22, 2019, the Michigan Department of Environmental Quality (MDEQ) became known as the Michigan Department of Environment, Great Lakes, and Energy.

ash placement began in early 1997.

After establishing the groundwater monitoring system and detection monitoring project pursuant to the requirements and schedule of §257.90 - §257.94, the State of Michigan enacted Public Act No. 640 of 2018 (PA 640) on December 28, 2018 to amend Part 115 of the NREPA. These amendments to Part 115 were developed to provide state of Michigan oversight of coal ash impoundments and landfills and to better align existing state solid waste management rules and statutes with the CCR Rule. This alignment would ensure compliance with the CCR standards through a state-approved permitting program that would be deemed to be "equivalent to" or "as protective as" through an administrative application that would be reviewed and authorized by U.S. EPA. Therefore, the basis for establishing a groundwater monitoring system and initiating detection and assessment monitoring will need to conform requirements for any licensed coal ash impoundment or landfill after December 28, 2018 with Part 115 amendments and the CCR Rule.

1.2 Purpose and Scope

The Dry Ash Landfill HMP is required for the construction permit application for proposed Cells 6 through 9 of the Dry Ash Landfill and a forthcoming operating license renewal in accordance with the provisions of the Michigan Part 115 Solid Waste Rules, as amended. The purpose of this HMP is to provide a means to comply with applicable monitoring requirements described in Part 115, as amended, and the self-implementing standards and schedules of the CCR Rules, until such a time as the USEPA recognizes Part 115, as amended, as an authorized permitting authority to regulate coal ash impoundments and landfills in Michigan. The monitoring program was developed based on the hydrogeologic characteristics of the site and surrounding area and the known and potential influence of the surface impoundment on the hydrogeologic system.

The methodologies outlined in this HMP are consistent with applicable regulations, general federal and state guidance, TRC's and Consumer Energy's Standard Operating Procedures (SOPs), and industry standards.

1.3 Requirements

As part of the construction permit application process, Consumers Energy is required to submit an HMP in compliance with Part 115 Rule 299.4905 to the EGLE. Revisions to Part 115 as amended by PA 640, in particular Section 11511a(3) and Section 11512(a)(1), require an approved HMP that complies with 299.4440 to 299.4445, if applicable, and 299.4905 to 299.4908 of the Part 115 Rules prior to issuing a solid waste operating license to a coal ash impoundment or landfill. A copy of the approved HMP will be placed in Consumers Energy's JH Campbell Plant Operating Record and used to monitor groundwater quality at the Dry Ash Landfill.

Consumers Energy will notify the Director of the EGLE ("Director" or their designee) of any plans to modify monitoring points or schedules described in this HMP. Such changes will be implemented upon approval by the Director and documented in the operating record.

1.4 Site Overview

The JH Campbell Plant is a coal fired power generation facility located in West Olive, Michigan, in Section 15, Township 06N, Range 16W, Port Sheldon Township, Ottawa County. The power plant site is on the eastern shore of Lake Michigan. The solid waste management area, which includes the Dry Ash Landfill, is bordered by the Pigeon River on the south, 156th Avenue on the east, and Croswell Street to the north with Lakeshore Drive bisecting the site from north to south. The power generating plant consists of three coal fired electric generating units located on the western side of the site and the CCR disposal area is on the east side of the site, east of Lakeshore Drive. Figure 1 is a site location map showing the facility and the surrounding area.

1.5 Geology/Hydrogeology

The Dry Ash Landfill is located north-northwest of the Pigeon River and/or Spring Bayou and northeast of Pigeon Lake. The subsurface materials encountered at the JH Campbell site generally consist of approximately 40 to 60 ft of poorly graded, fine-grained lacustrine sand, which makes up the uppermost aquifer encountered in the vicinity of the Landfill. The aquifer is underlain by a laterally extensive clay-rich till, which serves as the confining base of the aquifer and prevents vertical groundwater flow. Groundwater is typically encountered at depths ranging from around 7 to 35 ft bgs and generally flows to the south-southeast across the site, with a southwesterly groundwater flow component on the west edge of the site.

The geology and hydrogeology of the site and surrounding area is further detailed in the *Dry Ash Landfill Hydrogeological Report, JH Campbell Power Plant, West Olive, Michigan* (Hydrogeological Report) (TRC, July 2020).

2.0 Groundwater Monitoring Program

Rule 299.4905(1)(a) states that an HMP shall include a groundwater monitoring well system that is in compliance with the provisions of R 299.4906. The groundwater monitoring program presented in this section of the HMP has been designed specific to the Dry Ash Landfill. A description of the hydrogeologic characteristics of the site and surrounding area is provided in the Hydrogeological Report.

Several other monitoring wells are present at the facility and are used for routine monitoring throughout the site in accordance with the RAP, Pond A HMP and the CCR Rule and some wells are utilized in multiple programs (Figure 2). Data from the other site wells will be utilized as needed to supplement the groundwater flow interpretation and/or nature and extent evaluations, if needed.

2.1 Groundwater Monitoring Well Network

A groundwater monitoring system has been established for the Dry Ash Landfill in accordance with R 299.4906 and the CCR Rule §257.91, which consists of 17 monitoring wells (six background monitoring wells and 11 downgradient monitoring wells) that are screened in the uppermost aquifer. The monitoring well locations are shown on Figure 2. Monitoring well specifications and locations relative to groundwater flow direction (i.e. upgradient, downgradient, or side gradient) are included in Table 1.

MW-B1 through MW-B4 are located south of Cells 4 and 5 and future Cells 6 through 9. These monitoring wells were previously part of routine Part 115 monitoring programs and have not been previously monitored as part of the CCR Rule. Given the age of these wells and the need to establish a new baseline dataset in compliance with this HMP (using unfiltered samples and updating the list of constituents analyzed), Consumers Energy proposes to reinstall these monitoring wells prior to implementing this HMP. This will allow baseline sampling to commence subsequent to new well construction that will improve the well integrity and reliability of the groundwater data. Replacement wells will be installed at similar depths to the previous wells.

Monitoring wells JHC-MW-15017, JHC-MW-15018, and JHC-MW-15019 are located within the area of future Cells 6 and 7. These wells will be sampled to monitor conditions immediately downgradient of Cell 1 until Cells 6 and 7 are constructed, at which point, these wells will be decommissioned and removed from the monitoring program.

2.1.1 Static Water Level Monitoring

A subset of monitoring wells will be used for static water level monitoring as indicated on Table 1. These wells are located side-gradient of the Dry Ash Landfill and as such, are not representative of groundwater quality downgradient of the Dry Ash Landfill. Static water level measurements will be collected at these wells to facilitate evaluation of groundwater flow conditions.

2.2 Monitoring Well Construction

Table 1 provides a summary of monitoring well locations, construction, and elevation information. Soil boring logs and monitoring well construction details are provided in Appendix A. All monitoring wells completed on-site are clearly labeled and visible throughout the year. Protective covers are installed for each monitoring well.

2.3 Monitoring Parameters and Sampling Frequency

2.3.1 Detection Monitoring

Groundwater monitoring will be conducted quarterly for the parameters listed in Section 11511a(3)(c) – Detection Monitoring Constituents. Once a minimum of 8 quarterly monitoring events have been completed, Consumer's Energy will evaluate the data to determine if semi-annual groundwater sampling would be as equally representative of groundwater conditions as is quarterly sampling. If semi-annual sampling is deemed adequate, Consumers Energy will prepare a demonstration for the reduction in sampling frequency to the EGLE for approval. Table 2 provides a detailed summary of the monitoring parameters and frequency for the groundwater monitoring program. Per Section 11511a(3)(e) of the Part 115 amendment, groundwater samples collected for metals analysis will not be field filtered.

2.3.2 Assessment Monitoring

In addition to the HMP monitoring, groundwater monitoring will be conducted quarterly for the parameters listed in Section 11519b(2) – Assessment Monitoring Constituents for a period of two years subsequent to EGLE approval of the HMP, with the exception of radium, which will continue to be analyzed on a semiannual basis. After completion of two years of quarterly monitoring (i.e., 8 quarterly monitoring events), Consumers Energy will reduce the sampling frequency for non-detected constituents to semiannually. If data indicate that a reduction to semiannual monitoring is appropriate at a time sooner than two years or for constituents with limited detections, Consumers Energy will submit a request to EGLE for approval prior to making the change. Table 2 provides a detailed summary of the monitoring parameters and frequency for the groundwater monitoring program. Per Section 11511a(3)(e) of the Part 115 amendment, groundwater samples collected for metals analysis will not be field filtered. Monitoring of the groundwater to surface water interface (GSI) pathway will continue to be completed in accordance with the existing RAP until it is replaced with the forthcoming site-wide RAP.

2.4 Static Water Level Monitoring

Measurement of static groundwater level data will be collected from all monitoring wells listed on Table 1 during each sampling event, prior to sampling, using the methods described in Section 4.3.2. The monitoring well locations are depicted on Figure 2.

3.0 Leachate Monitoring Program

In 2011, the EGLE determined the Dry Ash Landfill no longer met the Part 115 definition of a “monitorable unit” due to indications that certain constituents existed in some monitoring wells above background concentrations and Consumers Energy was not able to obtain approval of an alternate source demonstration (ASD). Based on this determination, groundwater monitoring results are not the only consideration in determining compliance with regard to the landfill unit’s impact on groundwater. Rather, the landfill’s secondary leachate collection system is considered to be a leak detection system, in addition to the groundwater data.

Consumers Energy will remove liquids from the primary collection system (PCS) and secondary collection system (SCS) to minimize the head on the PCS and SCS liner systems. In addition, the volumes of liquids removed from the SCS will be calculated monthly.

The leachate collection system will be inspected regularly to assure proper operation of the system in accordance with Part 115 Rule 299.4432(5).

3.1 SCS Volume Removal Data

The quantity of liquids removed from the Dry Ash Landfill SCS will continue to be monitored for compliance with Part 115 Rule 299.4432(3)(b)(i).

SCS volume removal data will be utilized to calculate SCS flow rates for the Dry Ash Landfill in gallons per acre per day (gpad). The response flow rate (RFR) for the Dry Ash Landfill is 25 gpad in accordance with R 299.4437(1)(b). SCS flow rate data will be evaluated in accordance with the provisions of Rule 299.4437. The flow rate will be compared against the RFR of 25 gpad and transmitted to the EGLE as part of the quarterly hydrogeologic monitoring report.

Since 2011, Consumers Energy has completed multiple engineering improvements to enhance the leachate collection system. The SCS volume has not exceeded the RFR of 25 gpad at any of the cells (Cells 1 through 5) in the past 16 months. However, to ensure that the system continues to operate effectively, Consumers Energy will continue to optimize the system operation and perform monthly flow rate evaluations. In the event that the RFR is exceeded, Consumers Energy will complete the following response activities for each cell:

1. Notify the director in writing within 7 days of the RFR being exceeded.
2. Submit a preliminary written assessment of the situation within 14 days of the determination that the RFR has been exceeded. The preliminary assessment needs to include the amount of liquids removed, the likely sources of the liquids, the possible locations, size and cause of any leaks, and the short term actions taken and planned to address the problem.
3. Determine the extent practicable the location, size, and cause of any leak.
4. Determine whether waste receipt should cease or be curtailed.
5. Determine whether waste should be removed from the landfill cell for inspection, repairs, or controls.
6. Determine whether the entire landfill unit should be closed.
7. Determine any other short them or long term actions to mitigate or stop any leaks.

3.2 Leachate Disposal

Leachate recovered from the Dry Ash Landfill will be disposed of in accordance with Rule 299.4432(6), and in compliance with Part 31 of NREPA. Leachate is pumped into two lined leachate retention ponds for storage and disposed of under NPDES Permit No. MI0001422.

3.3 Leachate Analytical Testing Requirements

3.3.1 Sample Location

Primary collection system (PCS) and SCS leachate is collected in individual sumps for each active landfill cell. Liquid levels in the sumps are managed as described in Section F of this Construction Permit Application. Samples will be collected from each SCS sump on a quarterly basis and from each PCS sump annually. The approximate sample collection locations are shown on Figure 2.

Leachate samples will be collected from the sumps of the constructed cells as follows:

- ***PCS Sample Locations:*** PCS sumps C1P, C2P, C3P, C4P, and C5P will be monitored to evaluate leachate from the active landfill cells. Additional PCS sample locations will be included as future cells are constructed.
- ***SCS Sample Locations:*** SCS sumps C1S, C2S, C3S, C4S, and C5S will be monitored when sample volume is available to evaluate leachate from the active landfill cells. Additional SCS sample locations will be included as future cells are constructed.

3.3.2 Leachate Analytical Testing Requirements

Consumers Energy will perform analytical testing of SCS and PCS liquids from the Dry Ash Landfill. Table 3 provides a detailed summary of the monitoring parameters and frequency for the leachate monitoring program. After completion of two years of quarterly monitoring (i.e., 8 quarterly monitoring events), Consumers Energy will reduce the sampling frequency for non-detected leachate constituents to annually.

Leachate samples will not be field filtered, in accordance with Table 3. Reporting limits are consistent with the monitoring plan for groundwater and are detailed on Table 3.

4.0 Field Sampling Procedures

The following sections address the methods and procedures associated with the installation of any future monitoring wells and collection and handling of samples at the Site in conformance with R 299.4907 of the Part 115 Rules.

4.1 Monitoring Well Installation and Development Procedures

If required, field personnel will install and develop monitoring wells in accordance with the procedures detailed below.

4.1.1 Monitoring Well Installation Procedures

Soil borings for monitoring well installation will typically be constructed using hollow stem auger or direct push methods. At new or replacement monitoring well locations, soil samples will be collected during drilling activities in order to log local geology and verify depth to groundwater prior to well installation. Soil samples will be collected with split spoon or tube samplers at intervals appropriate to the local geology, typically ranging from continuous to 1 sample per 5-foot interval. The field personnel will log and document geology and drilling details on standard field forms similar to the logs provided in Appendix A.

Following drilling activities, soil borings will be converted into monitoring wells at the designated monitoring locations. Monitoring well casings and screens will arrive at the site in the original factory packaging and will remain in the packaging until the casing and screen materials are installed in the borehole. Permanent monitoring wells will typically be constructed of 2-inch Schedule 40 PVC flush-threaded riser pipe and equipped with a 5-foot, 0.01-inch slot screen.

After the screen and well casing are lowered into the borehole, the filter sand will be backfilled around the well screen and casing to a depth of approximately 2 feet above the top of the screen. Approximately 2 feet of bentonite chips will be used to seal the annular space above the sand pack. Additional bentonite chips or a bentonite slurry will be used to seal the remainder of the annular space above the sand pack, to approximately 1 foot below the ground surface. The slurry, if used, will be placed using a tremie from the bottom up. The remaining borehole annulus will be grouted with cement/bentonite grout to within one foot of land surface and finished with a concrete pad.

Monitoring wells will be protected with a locking flush-mount or aboveground steel protective cover, and vented caps. The aboveground protective covers will be cemented in place around the PVC riser to stick up from the ground surface approximately 2 to 3 feet. The flush-mount protective covers will be installed flush with the ground surface, with the PVC riser finished below ground. The protective covers will be locked and clearly labeled for identification purposes. Monitoring well construction details will be recorded at the time of installation on well construction diagrams similar to the ones included in Appendix A.

4.1.2 Monitoring Well Development

Monitoring wells will be developed after the grout and well seal material has cured. Curing time will typically be 24 hours following well installation, although for shallow wells, where grout and well seal material is placed above the water table, well development may be performed immediately following well installation.

The development will remove fine particles around the well screen and filter pack to improve hydraulic communication between the well and the surrounding aquifer. Development will be accomplished using a pump or bailer to surge and purge the well. Development will be complete when the purge water turbidity measurements are less than 10 Nephelometric Turbidity Units (NTUs) as a goal. However, for wells that are screened in silt- or clay-rich units, this may be impractical. Development of these wells will be complete when the purge water is relatively clear (visibly) and free from suspended solids, after approximately five well volumes have been evacuated, or when well goes dry. Development notes will be recorded on the well construction diagrams.

4.1.3 Well Identification

Each permanent well installed will be identified as follows: JHC-MW-XXXXX. The first two digits of the variable -XX will be filled in with the last two digits of the calendar year during which the well was installed and the last three digits of the variable XXX will be filled in with the number of the well.

4.2 Pre-Sample Procedures

The field personnel will obtain all necessary field sampling forms (examples provided in Appendix B) to complete the fieldwork. In addition, sample bottles, trip blanks, and deionized water will be obtained from the contract laboratory prior to sample collection. Potential contaminants from the sample bottles and rinse water will be minimized by obtaining these materials directly from the laboratory.

4.3 Groundwater Sampling Procedures

The following procedures will be used to collect groundwater monitoring data.

4.3.1 Monitoring Well Inspection

Prior to opening any groundwater monitoring well, field personnel will visually inspect the protective casing and the concrete collar for damage and wear. Visual observations of the integrity of the wells will be recorded in the field notes. Field personnel will notify Consumers Energy of any damage to the monitoring wells or protective casings. Field personnel will ensure that all wells are clearly and properly labeled and visible throughout the year.

4.3.2 Static Water Levels

After visual inspection of the monitoring well, the well will be unlocked and allowed to equilibrate with ambient air pressures prior to measuring the depths to water. Static water level measurements will be recorded using an electronic water level meter accurate to 0.01 foot, from each on-site well prior to purging and sampling. All water level measurements will be recorded within a 24-hour time period to minimize temporal bias of measured groundwater elevation changes for the monitoring well network.

Field personnel will measure water levels from an identified reference point on the well casing and record the measurement in the field notes. Depth-to-water measurements from the top-of-casing (TOC) will be subtracted from the TOC elevation to determine the potentiometric elevation. The static water level meter will be cleaned prior to and between each monitoring well according to the decontamination procedures described below.

4.3.3 Groundwater Sample Collection and Handling

Groundwater samples will be collected from the monitoring wells following Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (US EPA, 1996), as detailed in the Groundwater Sampling Standard Operating Procedures (SOP) (Appendix B). Low flow sampling will commence with the installation of either a peristaltic, stainless-steel 12-volt submersible impeller pump or bladder pump to a depth representing the middle of the saturated screen interval. An appropriate length of polyethylene tubing will be connected to the pump discharge prior to pump placement. The discharge line will be connected to a flow-cell and multi-meter to collect water quality indicator parameters (described below) during well purging to determine water quality stabilization.

The pump will be operated at a flow rate that ensures low volatilization and low well disturbance. Water quality indicator parameters and depth to water will be recorded at 3 to 5-minute intervals during the purging process and recorded on the sampling worksheet provided in Appendix B. Purging and sampling will proceed at a low pumping rate, expected to be between approximately 0.1 and 0.5 liters per minute or less, such that the water column in the well is not lowered more than 0.3 feet below the initial static depth to water measurement. The subject well will be considered ready to sample when three consecutive water quality measurements meet the stabilization criteria presented below.

Parameter	Stabilization Criteria
pH	3 readings within +/- 0.1 standard units (SU)
Specific Conductance	3 readings within +/- 3% millisiemens per centimeter (mS/cm)
Temperature	For Information Only
Turbidity	+/- 10% Nephelometric Turbidity Unit (NTU) variance between three consecutive readings and a turbidity less than 10 NTU[2]
Oxygen Reduction Potential (ORP)	3 readings within +/- 10 millivolts (mV)
Dissolved Oxygen (DO)	3 readings within +/- 0.3 milligrams per liter (mg/L)

[2] If sample cannot be stabilized at less than 10 NTUs, filtering may be necessary as detailed in Section 4.5.

If the well is dry, no attempt at sampling will be conducted, as the aquifer is not considered to have sufficient quantity at that location. Additionally, if the well is pumped dry during low-flow monitoring activity, the well will be left overnight to accumulate water, then a sample collected assuming the NTU criteria can be met or, if necessary, filter the sample as laid out in Section 4.5 below. Prior to use, all equipment will be calibrated in accordance with the manufactures' recommendations. Calibration information will be recorded in the field notes.

4.4 Leachate Sample Collection

If a primary collection system (PCS) or secondary collection system (SCS) leachate sample is required, a grab sample will be collected from the PCS or SCS sump. The sample will be screened with a water quality multi-meter and the pH, specific conductance, temperature, turbidity, ORP, and DO at the time of sample collection will be recorded in the field notes. The sample will be labeled, stored and transported to the laboratory using the same methodologies as outlined for the groundwater samples in Section 4.5.

4.5 Sample Preservation and Shipment

Samples will be collected immediately following stabilization of field parameters as set forth in in the preceding sections. Groundwater and leachate samples will be collected into the laboratory provided sample containers required for the analyses specified in the following section. The groundwater samples will be collected from the discharge tubing upstream of the water quality meter flow cell. Care will be taken to allow for a non-turbulent filling of laboratory containers. Routine samples will not be filtered in the field to provide a measure of total recoverable metals that will include both the dissolved and particulate fractions of metals as per Section 11511a(3)(e) of the Part 115 amendment.

If a more detailed understanding of the source of metals concentrations in groundwater is required for select monitoring wells, field filtered samples may be analyzed in addition to routine analysis. Field filtering may also be completed on highly turbid samples (greater than 10 NTU at stabilization). Field filtering will be completed using a 0.45-micron filter. If required, an attempt will be made to redevelop any monitoring wells that produce highly turbid prior to the subsequent sampling event. Where samples are filtered, a corresponding, unfiltered sample will also be collected.

The samples will be labeled, stored and transported to the laboratory according to the Chain-of-Custody Procedures SOP presented in Appendix C. Following collection, samples will be immediately labeled, logged on the chain-of-custody, and placed in a cooler with ice. Sample coolers transported to the laboratory via overnight or next day air freight will be sealed with packing tape and a signed chain-of-custody seal. Sample coolers transported to the laboratory directly must be secured to ensure sample integrity is maintained. The samples will be packaged and shipped according to U. S. Department of Transportation and EPA regulations. The documentation of actual sample storage and transport will be by the use of chain-of-custody procedures. A laboratory provided chain-of-custody record will contain the dates and times of collection, receipt, and completion of all the analyses on a particular set of samples. The laboratory will return a copy of the chain-of-custody with the analytical report.

4.6 Quality Assurance/Quality Control (QA/QC)

Quality assurance/quality control (QA/QC) samples will be collected to ensure sample containers are free of analytes of interest, assess the variability of the sampling and laboratory methods, and monitor the effectiveness of decontamination protocols. As such, QA/QC samples will be collected on a site wide basis per sampling event rather than on a unit by unit basis. The following QA/QC samples will be collected during each groundwater sampling event:

- Field duplicates will be collected at a frequency of one duplicate sample per 10 groundwater samples per event. The field duplicates will be collected at the same time and in the same manner as the original sample. The duplicates will be labeled as a blind sample and noted on the sampling form of the designated well.
- Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one MS/MSD sample per 20 groundwater samples per event. Duplicate and MS/MSD samples will be collected from different monitoring wells.
- Field blanks [3] will be collected at a frequency of one field blank per 20 groundwater samples with at least one field blank collected from the Dry Ash Landfill.
- Equipment blanks will be collected at a frequency of one equipment blank per 20 groundwater samples per event. The equipment blank will be collected by pouring distilled or deionized water over the decontaminated static water level meter or sample tubing and into the laboratory supplied containers.

The QA/QC samples will be submitted on a separate chain-of-custody to the laboratory for the routine analyses specified in Section 2. The laboratory should provide adequate documentation of laboratory reporting and QA/QC procedures.

4.7 Equipment Decontamination Procedures

All non-dedicated equipment will be decontaminated prior to use and between samples. Non-dedicated equipment will include a water level meter and low flow sampling pump (submersible) (if used). Each item will be cleaned using distilled or deionized water, and when necessary, a non-phosphate detergent wash followed by a distilled or deionized water rinse. When a peristaltic pump is used for low flow sampling, decontamination is not required, only replacement of the pump head tubing.

All dedicated equipment will be disposed of after each sampling point. Dedicated equipment will include polyethylene tubing and bladders if a bladder pump is used for low-flow sampling.

The flow-cell and water quality multi-meter (sonde) will be decontaminated at the completion of low-flow sampling. All sample collection will occur upstream of this device and therefore will not affect groundwater sample analytical results.

4.8 Investigation Derived Waste (IDW)

All waste created during monitoring well sampling will remain on site. All purge water from the

[3] Field blanks consist of analyte-free water exposed to the atmosphere during field sample collection. The water is containerized in an appropriate bottle with preservative for the analytical suite and shipped to the laboratory with the other field samples. The results are used to assess whether or not ambient/surrounding air conditions may have influenced analytical results.

monitoring wells will be discharged back onto the ground near the well it was purged from in a manner that ensures it does not directly enter a surface water or drain.

4.9 Field Documentation

All information pertinent to the field activities and sampling efforts will be recorded in a log or notebook following the documentation procedures presented in Section 5.4 of the SOP in Appendix B. Example field logs are provided in the attachments to Appendix B. At a minimum, entries in the sample logs will include the following:

- Property details and location
- Type of sample (for example, groundwater, surface water, waste)
- Number and volume of samples taken
- Sampling methodology
- Date and time of collection
- Sample identification number(s)
- Field observations including weather
- Any field measurements made (for example, pH, temperature, water depth and air monitoring data)
- Personnel present

Records shall contain sufficient information so that the sampling activity can be reconstructed without relying on the collector's memory. The sample logs will be preserved in electronic format.

5.0 Laboratory Analysis

All analyses will be performed within required hold times and analytical methods consistent with the data quality objectives of this HMP as presented in Tables 2 and 3. Laboratory Quality Assurance and Quality Control (QA/QC) procedures will be performed and documented in accordance with the Laboratory QA/QC Plan included in Appendix D. Additional QA/QC procedures, i.e., duplicate sample collection, field data forms, and chain-of-custody procedures, are described in Section 4 of this HMP.

6.0 Data Evaluation and Reporting

Consumers Energy will evaluate the groundwater data for each constituent included in the groundwater monitoring program using statistical methods that comply with R 299.4908 of the Part 115 Rules. The statistical evaluation will be conducted in accordance with the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance" USEPA, 2009 (Unified Guidance). The following sections describe the statistical data evaluation and reporting procedures.

6.1 Detection Monitoring Statistical Data Evaluation

Statistical data evaluation will be conducted for the detection monitoring constituents listed in Table 2 using the procedures in the *Groundwater Statistical Evaluation Plan* (Stats Plan) (TRC, October 2017, revised July 2020) included in Appendix E of this HMP.

In order to comply with the Part 115 amendments, background will be established for the Section 11511a(3) constituents not already included in the CCR Rule Appendix III (e.g., iron) throughout a minimum of four sampling events.

Background groundwater monitoring was conducted at the Dry Ash Landfill from December 2015 through August 2017 in accordance with the *JH Campbell Monitoring Program Sample and Analysis Plan* (SAP) (ARCADIS, 2016), pursuant to the CCR Rule, with the results from 2015 through 2017 documented in the *Annual Groundwater Monitoring Report for the JH Campbell Power Plant Dry Ash Landfill CCR Unit* (2017 Annual Report) (TRC, January 2018). Data collected to-date as part of the CCR Rule implementation will be used to the extent practical to inform this HMP and establish background groundwater conditions for the Dry Ash Landfill monitoring well system.

Per the CCR Rule and amended Part 115 Rules, if the detection monitoring program confirms a statistically significant increase (SSI) over background for one or more of the detection monitoring constituents, Consumers Energy will conduct assessment monitoring in compliance with §257.95 and R 299.4441 of the Part 115 Rules. Consumers Energy reported in the 2017 Annual Report that boron, calcium, chloride, sulfate, and total dissolved solids (TDS) were observed within groundwater at one or more downgradient monitoring well(s) with potential SSIs above background concentration levels. The Dry Ash Landfill is currently in assessment monitoring in accordance with the CCR Rule and has had no statistically significant levels exceeding the groundwater protection standards (GWPSs). Assessment monitoring statistical data evaluation is further discussed below.

6.2 Assessment Monitoring Statistical Data Evaluation

In April 2018, Consumers Energy initiated an Assessment Monitoring Program for the Dry Ash Landfill pursuant to Subpart 257.95 of the CCR Rule and consistent with R 299.4440 and R 299.4441 of Part 115, that included sampling and analyzing groundwater within the groundwater monitoring system for all constituents listed in Appendix IV of the CCR Rule and establishing groundwater protection standards (GWPSs) as described below.

Background will be established for the Section 11511a(c)(3) constituents and 11519b(2) constituents not already included in the CCR Rule (e.g., iron, copper, nickel, silver, vanadium, zinc) constituent lists after a minimum of four sampling events have been performed in compliance with this HMP.

In accordance with 40 CFR 257.95(h) and the Stats Plan, GWPSs were established for the Appendix IV constituents following the preliminary assessment monitoring event. The calculation of the GWPSs is documented in the *Groundwater Protection Standards* technical memorandum included in the 2018 *Annual Groundwater Monitoring Report for the JH Campbell Power Plant Dry Ash Landfill CCR Unit* (2018 Annual Report) (TRC, January 2019). GWPSs are used to assess groundwater quality downgradient from the Dry Ash Landfill by statistically comparing concentrations in the downgradient wells to the GWPSs for each Appendix IV constituent.

The Appendix IV GWPSs will be re-evaluated upon approval of this HMP to ensure compliance with Part 115. The lowest of the MCLs, RSLs, or applicable Part 201 RC will be the GWPSs unless the background concentration is greater than the MCL, RSL, or applicable Part 201 RC, in which case, the statistically-determined background value becomes the GWPS. For GWPSs that are established using background, tolerance limits are anticipated to be used to calculate the GWPS.

The *Unified Guidance* recommends that background data be updated every 4 to 8 measurements to account for any changes in background that may occur over time. It is anticipated that the background will be updated every two years, along with the resulting GWPS, consistent with the *Unified Guidance*

Consistent with the Unified Guidance, the preferred method for comparisons to a fixed standard are confidence limits. Confidence intervals will be established in a manner appropriate to the data set being evaluated, in accordance with the Stats Plan (Appendix E). An exceedance of the standard occurs when the 99 percent lower confidence level of the downgradient data exceeds the GWPS.

If Section 11519b(2) or 11511a(c)(3) constituents are detected at statistically significant levels exceeding the MCL or the GWPSs, Consumers Energy will take necessary next steps in accordance with Section 11519b(4) of the Part 115 amendments. In addition, Consumers Energy will continue implementing the monitoring program presented in this HMP.

6.3 Reporting

Analytical results and data reports as defined below will be submitted to the director no later than 30 days after the end of the calendar quarter in which the samples were obtained. Data reports will include the following:

- Statement of adherence to the approved HMP;
- Description of the sampling event;
- Tables of analytical results from the groundwater monitoring program;

- Statistical data evaluation;
- Groundwater contour maps with summary of groundwater flow direction and rates;
- Alternate source demonstration(s) (if applicable);
- Laboratory analytical results and chain of custody information;
- Field forms; and
- Signature of certified professional.

7.0 References

ARCADIS. May 18, 2016. Electric Generation Facilities RCRA CCR Detection Monitoring Program. JH Campbell Monitoring Program Sample and Analysis Plan, West Olive, Michigan. Prepared for Consumers Energy Company.

Consumers Power Company. September 1996. Hydrogeological Monitoring Plan for JH Campbell Ash Storage Facility, Consumers Power Company, Solid Waste Disposal Area, Coal Ash, Type III

TRC Environmental Corporation. October 2017, Revised July 2020. Groundwater Statistical Evaluation Plan – JH Campbell Power Plant, Pond A, West Olive, Michigan. Prepared for Consumers Energy Company.

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TRC Environmental Corporation. January 2018. Annual Groundwater Monitoring Report for the JH Campbell Power Plant Dry Ash Landfill CCR Unit, West Olive, Michigan (2017 Annual Report). Prepared for Consumers Energy Company.

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TRC Environmental Corporation. July 2020. Second Quarter 2020 Groundwater Monitoring Report, JH Campbell Solid Waste Disposal Area, West Olive, Michigan. Prepared for Consumers Energy Company.

TRC Environmental Corporation. July 2020. Dry Ash Landfill Hydrogeological Report, JH Campbell Power Plant, West Olive, Michigan. Prepared for Consumers Energy Company.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. Office of Conservation and Recovery. EPA 530/R-09-007.

USEPA. April 2015. 40 CFR Parts 257 and 261. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule. 80 Federal Register 74 (April 17, 2015), pp. 21301-21501 (80 FR 21301).

USEPA. July 2018. 40 CFR Part 257. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Amendments to the National Minimum Criteria (Phase One, Part One); Final Rule. 83 Federal Register 146 (July 30, 2018), pp. 36435-36456 (83 FR 36435).

Tables

Table 1
Monitoring Well Network Summary
JH Campbell – Dry Ash Landfill Hydrogeological Monitoring Program
West Olive, Michigan

Well Location	Well Location	Static Water Level Monitoring	Detection Monitoring Program	Assessment Monitoring Program	Northing	Easting	TOC Elevation (ft)	Date Installed	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)		
Background																
JHC-MW-15023	Upgradient	√	√	√	521927.21	12638205.16	619.98	10/1/2015	Sand	2" PVC, 10 Slot	14.0	to	24.0	603.0	to	593.0
JHC-MW-15024	Upgradient	√	√	√	522366.01	12637322.68	616.62	10/1/2015	Sand	2" PVC, 10 Slot	7.0	to	17.0	606.8	to	596.8
JHC-MW-15025	Upgradient	√	√	√	522702.98	12636668.15	617.17	10/1/2015	Sand	2" PVC, 10 Slot	7.0	to	17.0	607.1	to	597.1
JHC-MW-15026	Upgradient	√	√	√	522495.09	12635971.82	618.04	10/2/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	607.1	to	597.1
JHC-MW-15027	Upgradient	√	√	√	522394.86	12635097.51	617.30	10/2/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	604.8	to	594.8
JHC-MW-15028	Upgradient	√	√	√	521646.20	12634105.34	613.80	10/2/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	603.0	to	593.0
JHC-MW-15029	Side Gradient	√			520503.52	12633774.30	610.95	10/5/2015	Sand	2" PVC, 10 Slot	8.0	to	18.0	600.1	to	590.1
JHC-MW-15030	Side Gradient	√			519760.83	12633044.37	607.17	10/5/2015	Sand	2" PVC, 10 Slot	4.0	to	14.0	600.1	to	590.1
JHC-MW-15032	Side Gradient	√			520779.28	12638667.93	614.29	10/6/2015	Sand	2" PVC, 10 Slot	13.0	to	23.0	598.3	to	588.3
JHC-MW-15034	Side Gradient	√			521335.83	12638568.90	615.97	10/6/2015	Sand	2" PVC, 10 Slot	11.0	to	21.0	601.9	to	591.9
Landfill																
JHC-MW-15017(1)	Downgradient	√	√	√	521074.31	12635685.32	616.61	9/29/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	603.7	to	593.7
JHC-MW-15018(1)	Downgradient	√	√	√	521075.54	12635979.61	617.02	9/29/2015	Sand	2" PVC, 10 Slot	10.0	to	20.0	604.3	to	594.3
JHC-MW-15019(1)	Downgradient	√	√	√	521058.67	12636352.00	612.86	9/29/2015	Sand	2" PVC, 10 Slot	6.0	to	16.0	603.8	to	593.8
JHC-MW-15031	Downgradient	√	√	√	520118.00	12637801.51	635.87	10/6/2015	Sand	2" PVC, 10 Slot	33.0	to	43.0	599.9	to	589.9
JHC-MW-15035/MW-B5	Downgradient	√	√	√	520112.93	12637510.26	634.28	3/14/2001	Sand	2" PVC, 10 Slot	33.0	to	43.0	599.5	to	589.5
JHC-MW-15036/MW-B6	Downgradient	√	√	√	520099.80	12638094.34	618.34	3/13/2001	Sand	2" PVC, 10 Slot	20.0	to	30.0	597.9	to	587.9
JHC-MW-15037/MW-B7	Downgradient	√	√	√	520083.04	12638436.69	616.06	8/29/2001	Sand	2" PVC, 10 Slot	23.0	to	28.0	591.3	to	586.3
MW-B1(2)	Downgradient	√	√	√	520087.36	12635600.18	632.58	12/13/2007	Sand	2" PVC, 10 Slot	27.0	to	32.0	605.0	to	600.0
MW-B2(2)	Downgradient	√	√	√	520092.59	12636104.16	632.24	12/13/2007	Sand	2" PVC, 10 Slot	30.0	to	35.0	602.0	to	597.0
MW-B3(2)	Downgradient	√	√	√	520100.98	12636601.76	632.16	12/13/2007	Sand	2" PVC, 10 Slot	32.0	to	37.0	599.0	to	594.0
MW-B4(2)	Downgradient	√	√	√	520109.01	12637117.83	636.16	5/23/2011	Sand	2" PVC, 10 Slot	40.0	to	45.0	593.8	to	588.8

Notes:
Survey conducted by Nederveld, November 2015
Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).
TOC: Top of well casing.
ft BTOC: Feet below top of well casing.
ft BGS: Feet below ground surface.
(1) Monitoring well located within the future Cell 6 and 7 area. Well will be decommissioned during cell construction.
(2) Monitoring well to be replaced. Well location and construction data are approximate based on historical well specifications.

Table 2
Groundwater Monitoring Constituents and Analytical Program Summary
JH Campbell – Dry Ash Landfill HMP Monitoring Program
West Olive, Michigan

Part 115 Amendments - Public Act No. 640 of 2018								
Section 11511a(3)(c) - Detection Monitoring Constituents								
CONSTITUENT	MONITORED UNDER 40 CFR 257 SUBPART D	MONITORED UNDER 1996 HMP	ANALYTICAL METHOD	PRESERVATION[3]	HOLD TIME	REPORTING LIMIT (µg/L)	FILTER	FREQUENCY[4]
Boron	√	√	6010/6020	HNO_3, pH <2	180 days	50	no	Quarterly
Calcium	√		6010/6020	HNO_3, pH <2	180 days	1,000	no	Quarterly
Chloride	√		EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Fluoride[1]	√		EPA 300.0	None	28 days	1,000	no	Quarterly
Iron			6010/6020	HNO_3, pH <2	6 months	20	no	Quarterly
pH	√	√	Stabilized field measurement	NA	NA	0.1 standard units	no	Quarterly
Sulfate	√		EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Total Dissolved Solids	√		SM 2540C	None, <6ºC	7 days	50,000	no	Quarterly
Section 11519b(2) - Assessment Monitoring Constituents								
Antimony	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Arsenic	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Barium	√		6020	HNO_3, pH <2	180 days	5	no	Quarterly
Beryllium	√		6020	HNO_3, pH <2	180 days	1	no	Quarterly
Cadmium	√		6020	HNO_3, pH <2	180 days	0.2	no	Quarterly
Chromium, total	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Cobalt	√		6020	HNO_3, pH <2	180 days	6	no	Quarterly
Copper			6020	HNO_3, pH <2	6 months	1	no	Quarterly
Fluoride[1]	√		EPA 300.0	None, <6ºC	28 days	1,000	no	Quarterly
Lead	√		6020	HNO_3, pH <2	180 days	1	no	Quarterly
Lithium	√	√	6010/6020	HNO_3, pH <2	180 days	10	no	Quarterly
Mercury	√		7470	HNO_3, pH <2	28 days	0.2	no	Quarterly
Molybdenum	√	√	6020	HNO_3, pH <2	180 days	5	no	Quarterly
Nickel		√	6010/6020	HNO_3, pH <2	6 months	2	no	Quarterly
Selenium	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Silver			6020	HNO_3, pH <2	6 months	0.2	no	Quarterly
Thallium	√		6020	HNO_3, pH <2	180 days	2	no	Quarterly
Vanadium		√	6020	HNO_3, pH <2	6 months	2	no	Quarterly
Zinc			6020	HNO_3, pH <2	6 months	10	no	Quarterly
Radium 226 and 228 combined[2]	√		EPA 903.1/904.0	HNO_3, pH <2	None	1.00 picocurie per liter (pCi/L)	no	Semiannual

Notes:
HNO_3 – Nitric acid
NA – Not applicable
[1] Listed in both detection and assessment monitoring constituent lists
[2] Requires a larger sample volume (minimum 2 liter)
[3] All samples will be cooled to 4° C as part of sample preservation.
[4] Frequency reduction to semiannual will be requested after completion of two years (8 quarterly monitoring events) subseqent to the HMP approval date.

Table 3

Leachate Monitoring Constituents and Analytical Program Summary

JH Campbell – Dry Ash Landfill HMP Monitoring Program

West Olive, Michigan

Part 115 Amendments - Public Act No. 640 of 2018									
Section 11511a(3)(c) - Detection Monitoring Constituents									
CONSTITUENT	MONITORED IN SCS	MONITORED IN PCS	ANALYTICAL METHOD	PRESERVATION[1]	HOLD TIME	REPORTING LIMIT (µg/L)	FILTER	FREQUENCY	
								SCS	PCS
Boron	√	√	6010/6020	HNO_3, pH <2	180 days	50	no	Quarterly	Annually
Calcium	√	√	6010/6020	HNO_3, pH <2	180 days	1,000	no	Quarterly	Annually
Chloride	√	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly	Annually
Fluoride[2]	√	√	EPA 300.0	None	28 days	1,000	no	Quarterly	Annually
Iron	√	√	6010/6020	HNO_3, pH <2	6 months	20	no	Quarterly	Annually
pH	√	√	Stabilized field measurement	NA	NA	0.1 standard units	no	Quarterly	Annually
Sulfate	√	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly	Annually
Total Dissolved Solids	√	√	SM 2540C	None, <6ºC	7 days	50,000	no	Quarterly	Annually
Section 11519b(2) - Assessment Monitoring Constituents									
Antimony	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Arsenic	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Barium	√	√	6020	HNO_3, pH <2	180 days	5	no	Quarterly	Annually
Beryllium	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Cadmium	√	√	6020	HNO_3, pH <2	180 days	0.2	no	Quarterly	Annually
Chromium, total	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Cobalt	√	√	6020	HNO_3, pH <2	180 days	6	no	Quarterly	Annually
Copper	√	√	6020	HNO_3, pH <2	6 months	1	no	Quarterly	Annually
Fluoride[2]	√	√	EPA 300.0	None, <6ºC	28 days	1,000	no	Quarterly	Annually
Lead	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Lithium	√	√	6010/6020	HNO_3, pH <2	180 days	10	no	Quarterly	Annually
Mercury	√	√	7470	HNO_3, pH <2	28 days	0.2	no	Quarterly	Annually
Molybdenum	√	√	6020	HNO_3, pH <2	180 days	5	no	Quarterly	Annually
Nickel	√	√	6010/6020	HNO_3, pH <2	6 months	2	no	Quarterly	Annually
Selenium	√	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly	Annually
Silver	√	√	6020	HNO_3, pH <2	6 months	0.2	no	Quarterly	Annually
Thallium	√	√	6020	HNO_3, pH <2	180 days	2	no	Quarterly	Annually
Vanadium	√	√	6020	HNO_3, pH <2	6 months	2	no	Quarterly	Annually
Zinc	√	√	6020	HNO_3, pH <2	6 months	10	no	Quarterly	Annually
Radium 226 and 228 combined[3]	√	√	EPA 903.1/904.0	HNO_3, pH <2	None	1.00 picocurie per liter (pCi/L)	no	Annually	Annually

Notes:

HNO_3 – Nitric acid

NA – Not applicable

[1] *All samples will be cooled to 4 °C as part of sample preservation.*

[2] *Listed in both detection and assessment monitoring constituent lists*

[3] *Requires a larger sample volume (minimum 2 liter)*

Optional Additional Constituents									
Bicarbonate, carbonate, and total alkalinity	--	--	SM 2320B	None, <6ºC	14 days	10,000	no	Optional	Optional
Magnesium	--	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional	Optional
Sodium	--	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional	Optional
Potassium	--	--	6010/6020	HNO_3, pH <2	180 days	500	no	Optional	Optional

Notes:

HNO_3 – Nitric acid

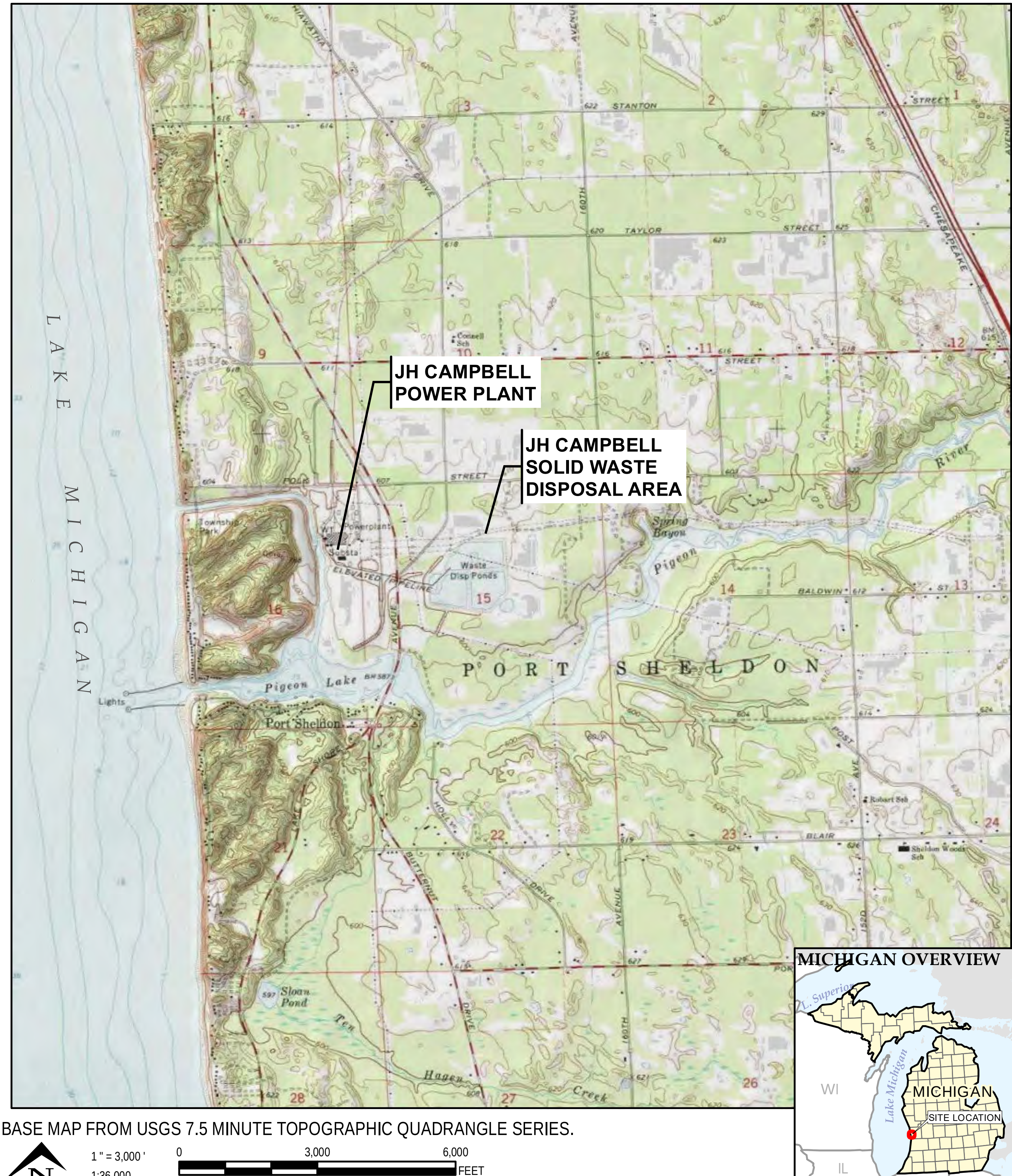
NA – Not applicable

[1] All samples will be cooled to 4 °C as part of sample preservation.

[2] Listed in both detection and assessment monitoring constituent lists

[3] Requires a larger sample volume (minimum 2 liter)

Figures



BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 3,000 '
1:36,000

0 3,000 6,000 FEET

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

TRC - GIS

PROJECT:

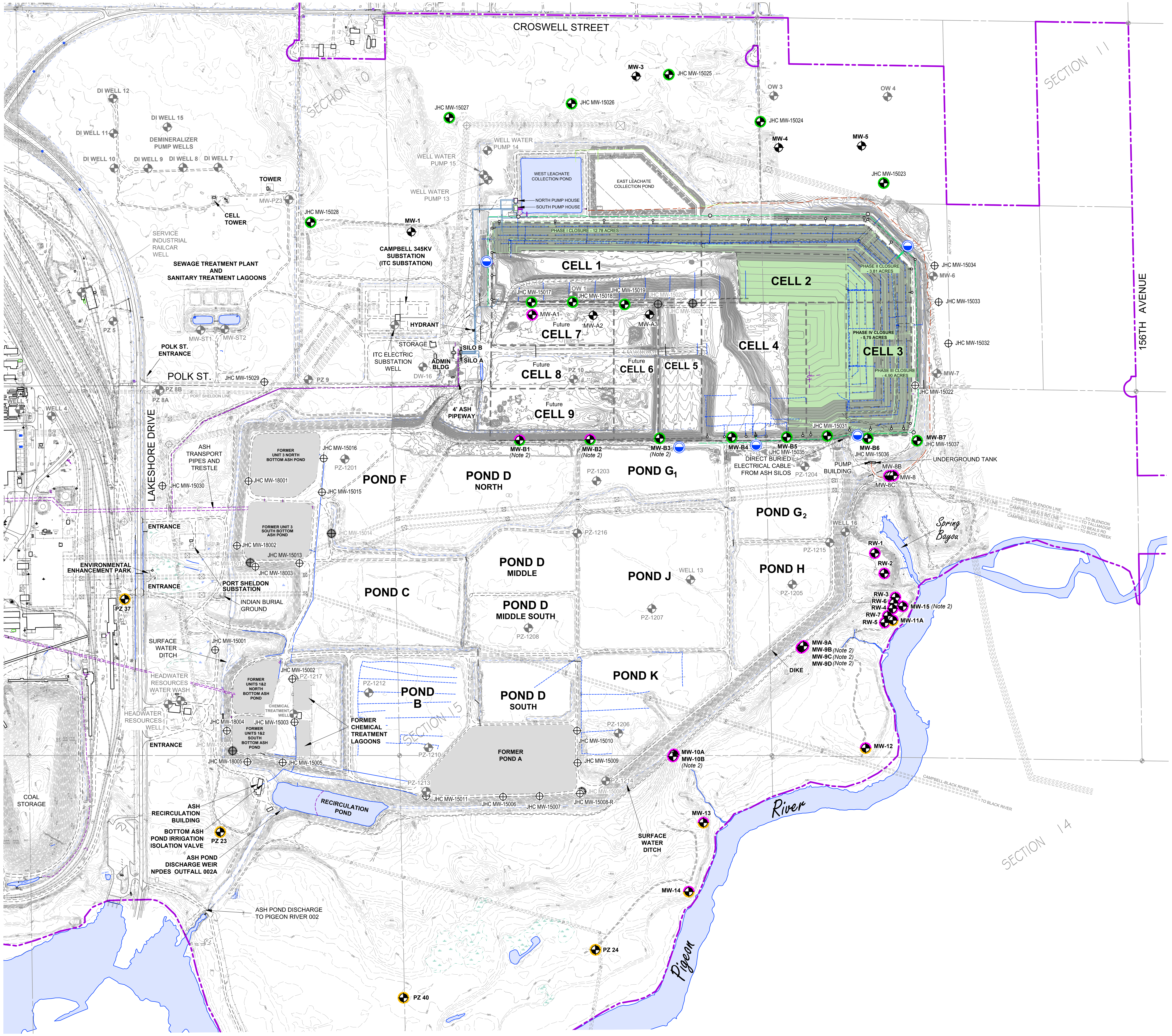
CONSUMERS ENERGY COMPANY
JH CAMPBELL POWER PLANT
WEST OLIVE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	S. MAJOR
CHECKED BY:	B. YELEN
APPROVED BY:	S. HOLMSTROM
DATE:	JANUARY 2020
PROJ. NO.:	322174
FILE:	322174-001-022.mxd

FIGURE 1



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SECTION LINE
- RAILROAD TRACKS
- CELL BOUNDARY
- FENCELINE
- DITCH
- UNPAVED ROAD OR DRIVE
- OVERHEAD POWER LINES
- ELECTRIC LINE
- SANITARY PIPE
- UTILITY
- LEACHATE PIPE
- ASH PIPE
- PIPELINE
- IRRIGATION PIPE
- WATER
- FACILITY COVER
- WETLAND
- POLE
- MW-1 MONITORING WELL
- MW-7 WELL
- JHC MW-15034 RCRA MONITORING PROGRAM WELL
- JHC MW-15004 DECOMMISSIONED RCRA MONITORING PROGRAM WELL
- MW-5 DRY ASH LANDFILL HMP MONITORING WELL
- PZ-23 CELLS B-K HMP WELL
- RW-1 RAP MONITORING WELL
- APPROXIMATE SUMP SAMPLING LOCATION

NOTES

1. BASEMAP DEVELOPED FROM CONSUMERS ENERGY, "CAMPBASE.DWG", DATED 02/10/2014 AND NEDERVELD "CAMPBELL PLANT MONITORING WELLS-CCR MONITORING" , DATED 11/25/2015. PROVIDED BY CONSUMERS ENERGY.
2. RAP SENTINEL WELL

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	SITE FEATURES MAP WITH TOPOGRAPHIC CONTOURS
DRAWN BY: D.STEHLE	PROJ. NO.: 367390.0001.01.03
CHECKED BY: K.LOWERY	FIGURE 2
APPROVED BY: S.HOLMSTROM	
DATE: AUGUST 2020	
TRC	1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 www.trccompanies.com
FILE NO.:	367390.0001.01.03.02A HMP.dwg

DRAWING NAME: J:_TRC\Consumers\JH Campbell\367390\0001\01\03_LF HMP\367390.0001.01.03.02A HMP.dwg --- PLOT DATE: October 02, 2020 - 10:26AM --- LAYOUT: FIG02 Site Features

Appendix A
Soil Boring Logs and Well Construction Diagrams

Date Start: 9/29/15
Date Finish: 9/29/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 12.0
Water Level Finish (ft. btoc.): 15.56

Northing: 521074.309
Easting: 12635685.32
Casing Elevation: 616.607

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 613.691

Descriptions By: A. Westhuis

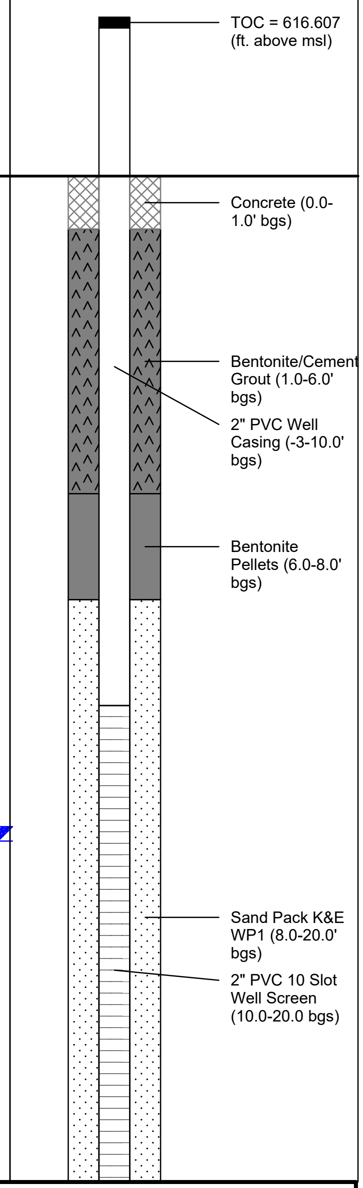
Well/Boring ID: **JHC MW-15017**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									
0								(0.0 - 0.3') Grass, Topsoil.		
								(0.3 - 10.0') SAND, fine to medium, subrounded; trace silt; poorly sorted; dry; yellowish brown (10YR 4/3).		
	610									
5		1	0.0-10.0'	4.0	NA					
	605									
10								(10.0 - 18.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10YR 6/3). NOTE: Wet at 12.0'.		
	600									
15		2	10.0-20.0'	7.0	NA					
								(18.0 - 20.0') SAND, medium, little fine, subrounded; trace silt; well sorted; wet; pale brown (10YR 6/3). NOTE: Little small pebbles, subrounded.		
	595									



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs.
Water level at development was 15.56' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 596.00 feet

Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** 15.56	**Northing:** 521074.309 **Easting:** 12635685.32 **Casing Elevation:** 616.607 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 613.691 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15017** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
20								End of boring at 20.0' bgs.		

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs.
Water level at development was 15.56' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 596.00 feet

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Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** 16.29	**Northing:** 521075.536 **Easting:** 12635979.61 **Casing Elevation:** 617.022 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 614.262 **Descriptions By:** A. Westhuis	**Well/Boring ID: JHC MW-15018** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									TOC Elevation = 617.022 (ft. above msl)
0								(0.0 - 0.3') Grass, Topsoil.		Concrete (0.0-1.0' bgs)
								(0.3 - 1.0') ASH and SAND, very fine to fine, well sorted; dry; light gray (10YR 7/2). NOTE: Fill material.		
	610							(1.0 - 10.0') SAND, fine, subrounded; well sorted; dry; brownish yellow (10YR 6/6).		Bentonite/Cement Grout (1.0-6.0' bgs)
5		1	0.0-10.0'	3.0	NA					2" PVC Well Casing (-3-10.0' bgs)
	605									Bentonite Pellets (6.0-8.0' bgs)
10								(10.0 - 17.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; very pale brown (10YR 7/3). NOTE: Wet at 12.0' bgs.	▼ (12.0)	
	600									Sand Pack K&E WP1 (8.0-20.0' bgs)
15		2	10.0-20.0'	7.0	NA					2" PVC 10 Slot Well Screen (10.0-20.0 bgs)
								(17.0 - 20.0') SAND, medium, little fine, subrounded; trace granules; subrounded; trace silt; well sorted; wet; very pale brown (10YR 7/4).		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
Water level at development was 16.29' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 600.45 feet

Date Start: 9/29/15 **Date Finish:** 9/29/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 12.0 **Water Level Finish (ft. btoc.):** 16.29	**Northing:** 521075.536 **Easting:** 12635979.61 **Casing Elevation:** 617.022 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 614.262 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15018** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** 60 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	595									
20								End of boring at 20.0' bgs.		

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
Water level at development was 16.29' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 600.45 feet

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Date Start: 9/29/15
Date Finish: 9/29/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 8.5
Water Level Finish (ft. btoc.): 12.78

Northing: 521058.673
Easting: 12636352
Casing Elevation: 612.857

Borehole Depth (ft. bgs.): 16.0
Surface Elevation: 609.812

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15019

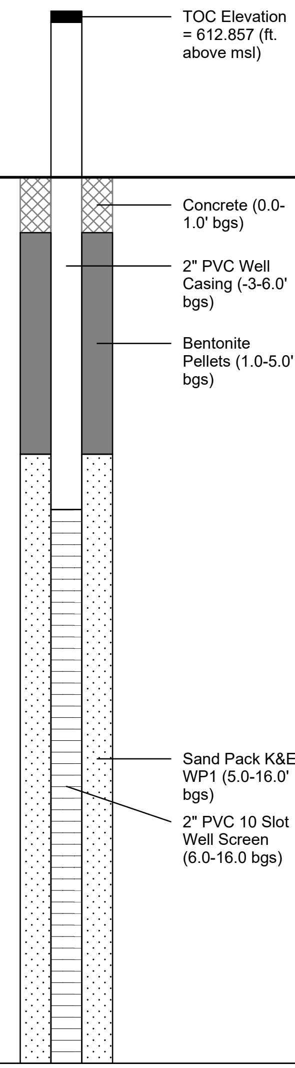
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: 60 F Cloudy, light rain

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	610							(0.0 - 0.3') Grass, Topsoil.	
								(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; dark yellowish brown (10YR 4/4).	
5	605	1	0.0-10.0'	4.0	NA				
								NOTE: Wet at 8.5' bgs.	
10	600							(10.0 - 12.0') SAND, fine, subrounded; little silt; well sorted; wet; brown (10YR 4/3).	
								(12.0 - 16.0') SAND, fine, subrounded; trace silt; well sorted; wet; brownish yellow (10YR 6/6).	
		2	10.0-16.0'	7.0	NA				
15	595								
								End of boring at 16.0' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 8.5' bgs during drilling.
Water level at development was 12.78' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.87 feet

Date Start: 9/30/15
Date Finish: 9/30/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.39

Northing: 520479.719
Easting: 12638430.24
Casing Elevation: 623.792

Borehole Depth (ft. bgs.): 33.0
Surface Elevation: 620.917

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15022**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
										TOC Elevation = 623.792 (ft. above msl)
0								(0.0 - 0.3') TOPSOIL; grass.		Concrete (0.0-1.0' bgs)
	620							(0.3 - 10.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry to moist; dark yellowish brown (10 YR 4/6).		
5		1	0-10'	5	NA					
	615									
10								(10.0 - 21.0') SAND, fine, subrounded; little very fine sand; trace granules, subrounded; trace silt; well sorted; moist to wet; yellowish brown (10 YR 5/6).		Bentonite/Cement Grout (1.0-19.0' bgs) 2" PVC Well Casing (-3.0-23.0' bgs)
	610									
15		2	10-20'	4	NA					
	605									

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 29.39' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 594.34 feet

Date Start: 9/30/15
Date Finish: 9/30/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air Knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 21.0
Water Level Finish (ft. btoc.): 29.39

Northing: 520479.719
Easting: 12638430.24
Casing Elevation: 623.792

Borehole Depth (ft. bgs.): 33.0
Surface Elevation: 620.917

Descriptions By: A. Westhuis

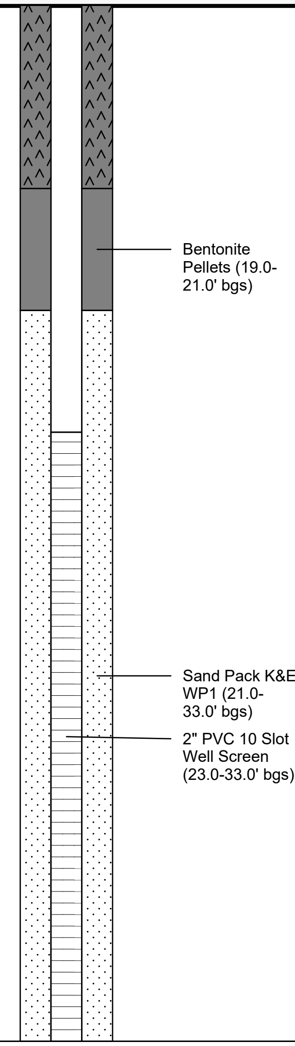
Well/Boring ID: JHC MW-15022

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
20	600	3	20-30'	5	NA			(21.0 - 29.0') SAND, fine to medium, subrounded; trace granules, subrounded; well sorted; wet; yellowish brown (10 YR 5/4).		
25	595									
30	590	4	30-33'	3	NA			(29.0 - 33.0') SAND, very fine to fine, subrounded; trace silt; well sorted; wet; yellowish brown (10 YR 5/4).		
35	585							End of boring at 33.0' bgs.		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 29.39' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 594.34 feet

Date Start: 10/1/15
Date Finish: 10/1/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: NA

Descriptions By: A. Westhuis

Well/Boring ID: **JHC-MW-15023**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	0							(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 10.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3). Note: Trace wood fragments from 7.0 to 10.0' bgs.		
5	-5	1	0-10'	10	NA					Grout (0.0-10.0' bgs) 2" PVC Well Casing (-3.0-14.0' bgs)
10	-10							(10.0 - 16.0') SAND, very fine to fine, subrounded; trace to little silt; well sorted; dry to moist; brownish yellow (10 YR 6/8).		Bentonite Pellets (10.0-12.0' bgs)
15	-15	2	10-20'	8	NA					

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
No odor or staining observed.

Date Start: 10/1/15 **Date Finish:** 10/1/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** NA **Water Level Finish (ft. btoc.):** NA	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth (ft. bgs.):** 25.0 **Surface Elevation:** NA **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC-MW-15023** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
								(16.0 - 17.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist; yellow (10 YR 7/6).		
								(17.0 - 18.0') SAND, fine, subrounded; trace silt; well sorted; moist; brownish yellow (10 YR 6/6).		Sand Pack K&E WP1 (12.0-25.0' bgs)
								(18.0 - 21.0') SAND, very fine; little fine sand, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).		2" PVC 10 Slot Well Screen (14.0-24.0' bgs)
20	-20									
		3	20-25'	4	NA			(21.0 - 25.0') SAND, medium; trace fine sand, subangular; trace granules, subangular; poorly sorted; wet; pale brown (10 YR 6/3).		
25	25							End of boring at 25.0' bgs.		
30	-30									
35	-35									

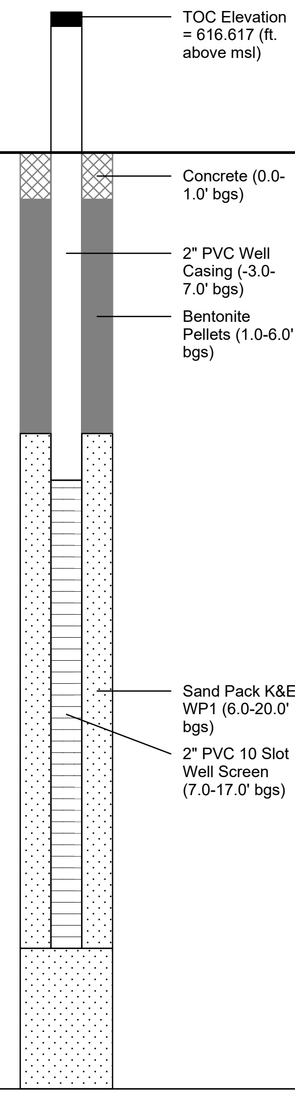
ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
No odor or staining observed.

Date Start: 10/1/15 **Date Finish:** 10/1/15 **Drilling Company:** Mateco Drilling **Driller's Name:** Dan Mourer **Drilling Method:** Air Knife/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 10.0 **Water Level Finish (ft. btoc.):** NA	**Northing:** 522366.013 **Easting:** 12637322.68 **Casing Elevation:** 616.617 **Borehole Depth (ft. bgs.):** 20.0 **Surface Elevation:** 613.787 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15024** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									
0								(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; brownish yellow (10 YR 6/6).		
	610									
5		1	0-10'	4	NA					
	605							NOTE: Wet at 10.0' bgs.		
10								(10.0 - 20.0') SAND, fine to medium, subrounded; trace to little very fine sand; trace silt; well sorted; wet; pale brown (10 YR 6/3).		
	600									
15		2	10-20'	9	NA					
	595									
20								End of boring at 20.0' bgs.		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface.

Air knife to 10.0' bgs.
Groundwater encountered at 10.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 602.24 feet above mean sea level.

Date Start: 10/1/15
Date Finish: 10/1/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 12.0
Water Level Finish (ft. btoc.): NA

Northing: 522702.978
Easting: 12636668.15
Casing Elevation: 617.167

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 614.137

Descriptions By: A. Westhuis

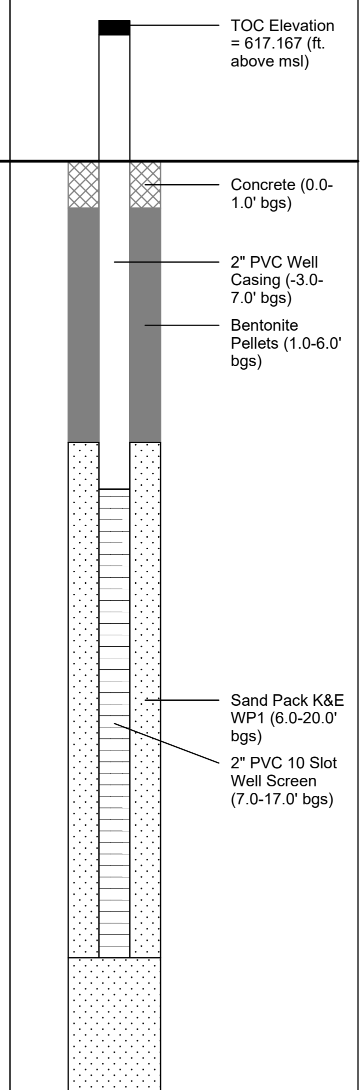
Well/Boring ID: **JHC MW-15025**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	615									
0								(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 5.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		
	610									
5		1	0-10'	10	NA			(5.0 - 12.0') SAND, fine, subrounded; trace silt; well sorted; dry; brownish yellow (10 YR 6/6). Note: Color change to brownish yellow (10YR 6/8) at 6.0' bgs.		
	605									
10										
								(12.0 - 15.0') SAND, fine, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).		
	600									
15		2	10-20'	8	NA			(15.0 - 16.0') SAND, fine to medium, subrounded; trace coarse sand, subrounded; trace granules, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).		
								(16.0 - 20.0') SAND, very fine to fine, subrounded; little silt; well sorted; wet; pale brown (10 YR 6/3).		
	595									
20								End of boring at 20.0' bgs.		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 603.36 feet above mean sea level.

Date Start: 10/2/15
Date Finish: 10/2/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 12.0
Water Level Finish (ft. btoc.): NA

Northing: 522495.091
Easting: 12635971.82
Casing Elevation: 618.042

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 615.087

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15026**

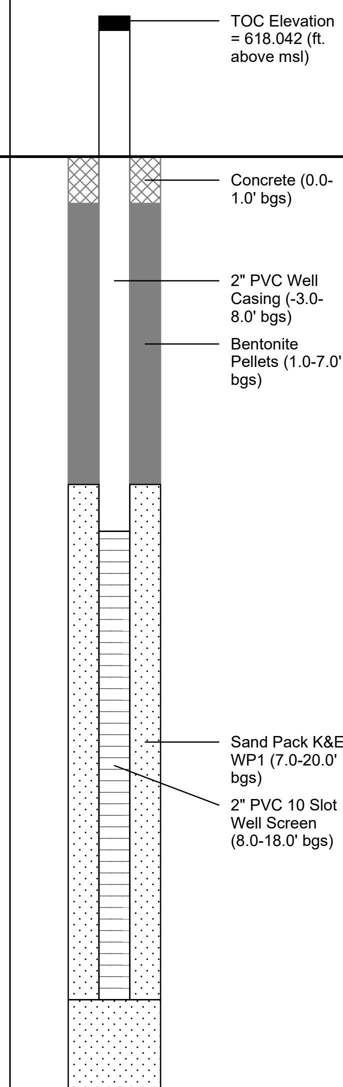
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 45F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	615							(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 3.0') SAND, fine, subrounded; trace medium sand, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
								(3.0 - 8.0') SAND, fine, subrounded; trace silt; well sorted; dry; brownish yellow (10 YR 6/6).	
5	610	1	0-10'	10	NA				
								(8.0 - 12.0') SAND, fine, subrounded; little very fine sand, subrounded; trace silt; well sorted; dry; pale brown (10 YR 6/3) to brownish yellow (10YR 6/6).	
10	605								
								(12.0 - 20.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).	
15	600	2	10-20'	6	NA				
20	595							End of boring at 20.0' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface.

Hand auger to 10.0' bgs.
Groundwater encountered at 12.0' bgs during drilling.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 602.32 feet above mean sea level.

Date Start: 10/2/15
Date Finish: 10/2/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 13.0
Water Level Finish (ft. btoc.): 15.85

Northing: 522394.86
Easting: 1235097.51
Casing Elevation: 617.302

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 614.767

Descriptions By: A. Westhuis

Well/Boring ID: **JHC MW-15027**

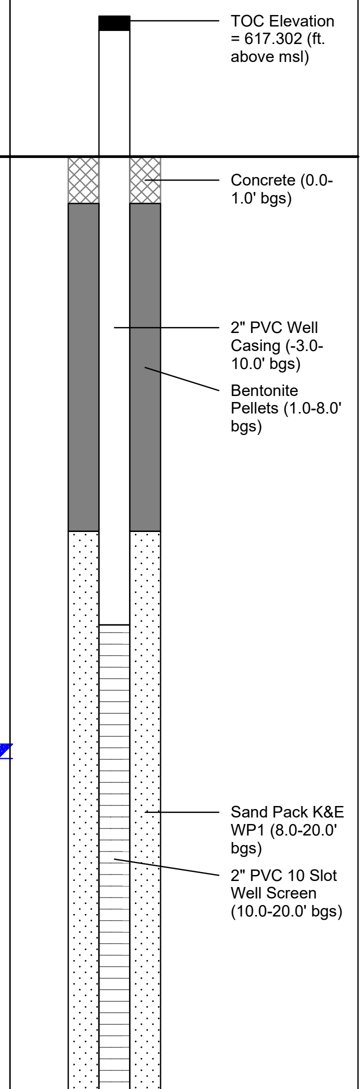
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 50F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	615								
0								(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 2.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; dark yellowish brown (10 YR 4/6).	
								(2.0 - 6.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
5	610	1	0-10'	10	NA				
								(6.0 - 16.0') SAND, fine, subrounded; trace silt; well sorted; dry; yellow (10YR 7/6).	
10	605								
								Note: Wet at 13.0' bgs.	▼
15	600	2	10-20'	8	NA				
								(16.0 - 20.0') SAND, fine; trace medium sand, subrounded; well sorted; wet; pale brown (10 YR 6/3).	
20	595							End of boring at 20.0' bgs.	

Well/Boring Construction



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs= below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 13.0' bgs during drilling.
Water level at development was 15.85' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 601.04 feet

Date Start: 10/2/15
Date Finish: 10/2/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 9.0
Water Level Finish (ft. btoc.): 14.38

Northing: 521646.198
Easting: 12634105.34
Casing Elevation: 613.8

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 611.025

Descriptions By: A. Westhuis

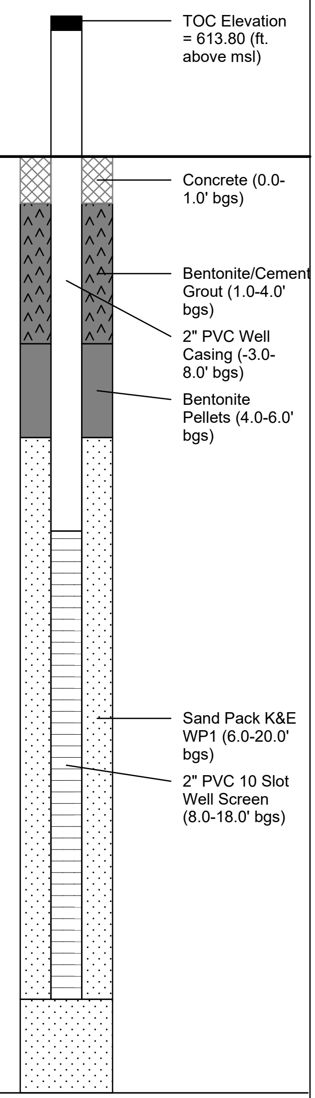
Well/Boring ID: JHC MW-15028

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
0	610							(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 5.0') SAND, very fine to fine, subrounded; trace silt; well sorted; dry; yellowish (10 YR 7/8).		
5	605	1	0-10'	10	NA			(5.0 - 9.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; pale brown (10 YR 6/3).		
10	600							(9.0 - 20.0') SAND, medium; trace to little very fine to fine sand, subrounded; trace silt; poorly sorted; moist to wet; pale brown (10 YR 6/3).		
15	595	2	10-20'	9	NA					
20	590							End of boring at 20.0' bgs.		



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Remarks: bgs= below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 9.0' bgs during drilling.
Water level at development was 14.38' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 599.00 feet

Date Start: 10/5/15
Date Finish: 10/5/15
Drilling Company: Mateco Drilling
Driller's Name: Dan Mourer
Drilling Method: Air knife/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 5.0
Water Level Finish (ft. btoc.): 7.99

Northing: 519760.827
Easting: 12633044.37
Casing Elevation: 607.167

Borehole Depth (ft. bgs.): 20.0
Surface Elevation: 604.047

Descriptions By: A. Westhuis

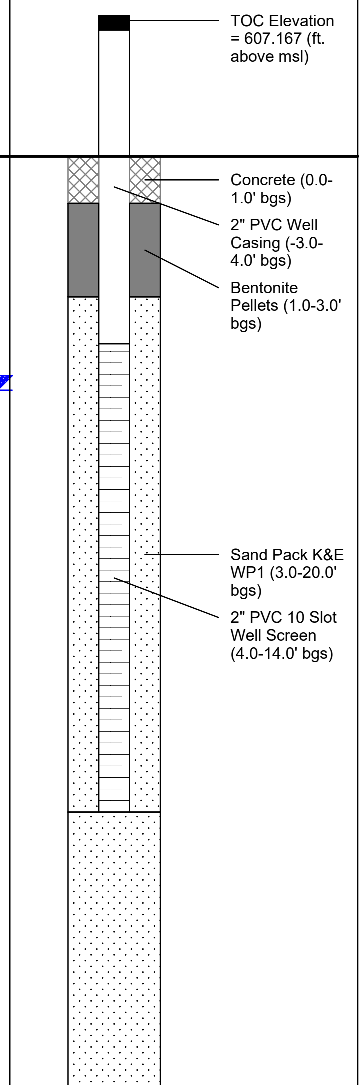
Well/Boring ID: **JHC MW-15030**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, Light Rain, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	605									
0								(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry to moist; dark brown (10 YR 3/3) to very pale brown (10YR 7/3).		
	600									
5		1	0-10'	3	NA			NOTE: Wet at 5.0' bgs.		
	595									
10								(10.0 - 20.0') SAND, fine, subrounded; little medium sand, subrounded; trace silt; well sorted; wet; very pale brown (10 YR 7/3) to light gray (10YR 7/2).		
	590									
15		2	10-20'	6	NA					
	585									
20								End of boring at 20.0' bgs.		



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Remarks: bgs = below ground surface
btoc = below top of casing

Air knife to 10.0' bgs.
Groundwater encountered at 5.0' bgs during drilling.
Water level at development was 7.99' btoc.
No odor or staining observed.
Groundwater elevation measured on December 3, 2015 was 599.65 feet

Date Start: 10/5/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): 43.20

Northing: 520118.003
Easting: 12637801.51
Casing Elevation: 635.872

Borehole Depth (ft. bgs.): 45.0
Surface Elevation: 632.937

Descriptions By: A. Westhuis

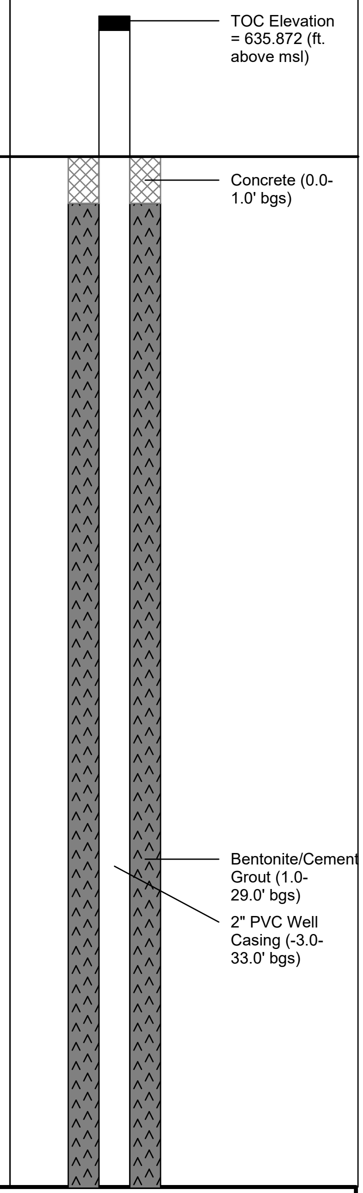
Well/Boring ID: **JHC MW-15031**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	635									
0								(0.0 - 0.3') TOPSOIL; grass.		
								(0.3 - 2.0') SAND, fine, subrounded; trace silt; well sorted; dry; dark grayish brown (10 YR 4/2).		
	630							(2.0 - 5.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).		
5		1	0-10'	10	NA			(5.0 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; pale brown (10 YR 6/3).		
	625									
10								(10.0 - 19.0') SAND, fine, subrounded; trace silt; well sorted; moist; brown (10 YR 5/3).		
	620									
15		2	10-20'	6	NA					
	615							(19.0 - 25.0') SAND, fine, subrounded; trace medium sand, subrounded; trace silt; well sorted; moist; yellowish brown (10 YR 5/4).		
20										



Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 36.0' bgs during drilling.
Water level at development was 43.20' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 592.53 feet

Date Start: 10/5/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): 43.20

Northing: 520118.003
Easting: 12637801.51
Casing Elevation: 635.872

Borehole Depth (ft. bgs.): 45.0
Surface Elevation: 632.937

Descriptions By: A. Westhuis

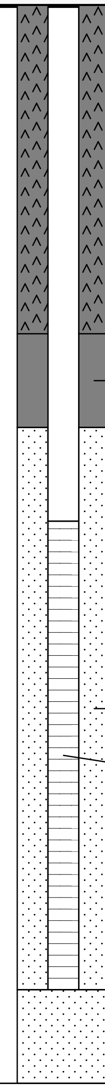
Well/Boring ID: **JHC MW-15031**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, 65F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	610									
25		3	20-30'	8	NA			(25.0 - 36.0') SAND, very fine to fine, subrounded; trace silt; well sorted; very pale brown (10 YR 7/3).		
	605									
30										Bentonite Pellets (29.0-31.0' bgs)
	600									
35		4	30-40'	8	NA					
								(36.0 - 45.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; pale brown (10 YR 6/3). NOTE: Wet at 36.0' bgs.		Sand Pack K&E WP1 (31.0-45.0' bgs)
	595									2" PVC 10 Slot Well Screen (33.0-43.0' bgs)
40										
	590	5	40-45'	5	NA					
45								End of boring at 45.0' bgs.		
	585									



Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 36.0' bgs during drilling.
Water level at development was 43.20' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 592.53 feet

Date Start: 10/6/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 16.0
Water Level Finish (ft. btoc.): 17.88

Northing: 520779.281
Easting: 12638667.93
Casing Elevation: 614.287

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: 611.322

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15032

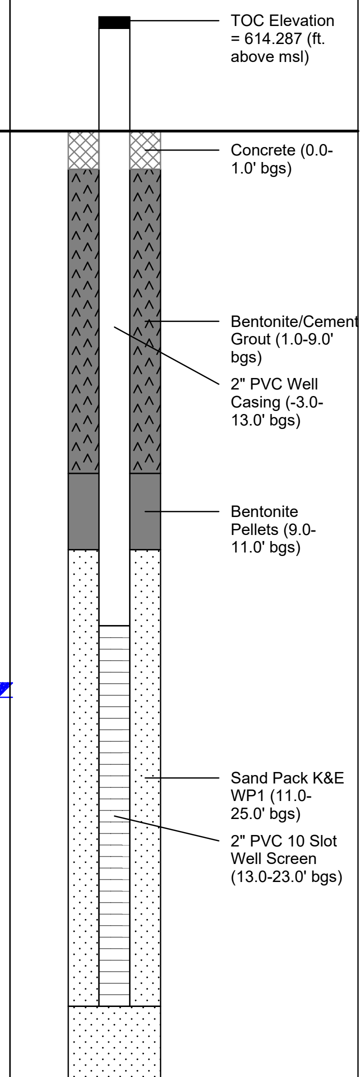
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Cloudy, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	615								
0	610	1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 2.5') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3).	
5	605							(2.5 - 11.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
10	600	2	10-20'	7	NA			(11.0 - 21.0') SAND, fine, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).	
15	595							NOTE: Wet at 16.0' bgs.	16.0
20	590	3	20-25'	5	NA			(21.0 - 25.0') SAND, fine to medium, subrounded; trace silt; well sorted; wet; pale brown (10 YR 6/3).	
25	585							End of boring at 25.0' bgs.	

Well/Boring Construction



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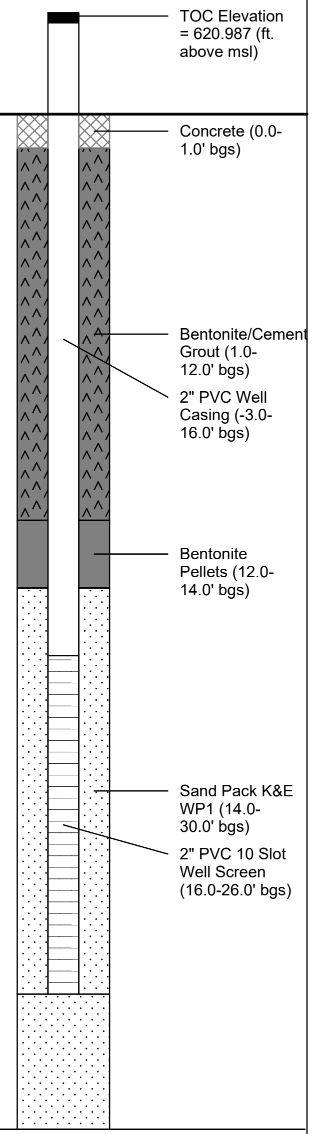
Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 16.0' bgs during drilling.
Water level at development was 17.88' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 595.41 feet

Date Start: 10/6/15 **Date Finish:** 10/6/15 **Drilling Company:** Mateco Drilling **Driller's Name:** John Pitsch **Drilling Method:** Hand Auger/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 19.0 **Water Level Finish (ft. btoc.):** 22.93	**Northing:** 521075.809 **Easting:** 12638598.12 **Casing Elevation:** 620.987 **Borehole Depth (ft. bgs.):** 30.0 **Surface Elevation:** 618.082 **Descriptions By:** A. Westhuis	**Well/Boring ID:** **JHC MW-15033** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** Cloudy, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	620								
0		1	0-10'	10	NA			(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 0.8') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3).	
	615							(0.8 - 2.0') SAND, fine, subrounded; trace silt; well sorted; dry; yellowish brown (10 YR 5/6).	
5	610							(2.0 - 10.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
10	605	2	10-20'	6	NA			(10.0 - 20.0') SAND, very fine to fine, subrounded; trace silt; well sorted; moist; yellowish brown (10 YR 5/4).	
15	600							NOTE: Wet at 19.0' bgs.	▼
20	595	3	20-30'	6	NA			(20.0 - 30.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; moist to wet; very pale brown (10 YR 6/3).	
25	590								
30								End of boring at 30.0' bgs.	

Well/Boring Construction



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Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater encountered at 19.0' bgs during drilling.
Water level at development was 22.93' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 598.05 feet

Date Start: 10/6/15
Date Finish: 10/6/15
Drilling Company: Mateco Drilling
Driller's Name: John Pitsch
Drilling Method: Hand Auger/Sonic
Sampling Method: Continuous
Rig Type: Sonic
Water Level Start (ft. bgs.): 13.0
Water Level Finish (ft. btoc.): 16.87

Northing: 521335.834
Easting: 12638568.9
Casing Elevation: 615.972

Borehole Depth (ft. bgs.): 25.0
Surface Elevation: 612.902

Descriptions By: A. Westhuis

Well/Boring ID: JHC MW-15034

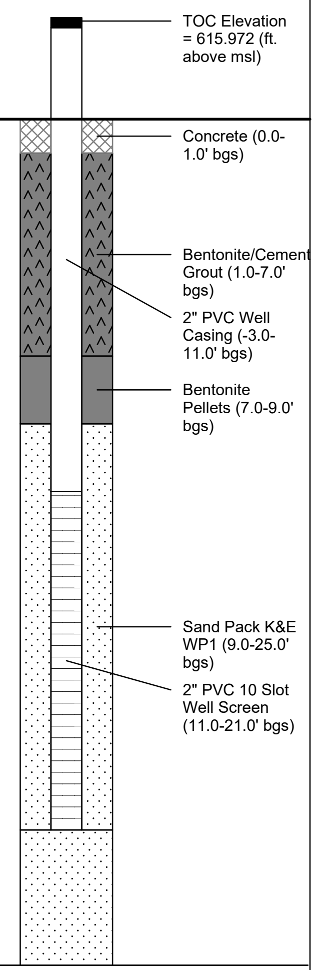
Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: Sunny, 60F.

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	615								
0								(0.0 - 0.3') TOPSOIL; grass.	
								(0.3 - 0.8') SAND, fine, subrounded; trace silt; well sorted; dry; brown (10 YR 4/3).	
	610							(0.8 - 1.5') SAND, fine, subrounded; trace silt; well sorted; dry; yellowish brown (10 YR 5/6).	
5		1	0-10'	10	NA			(1.5 - 13.0') SAND, fine, subrounded; trace silt; well sorted; dry; very pale brown (10 YR 7/3).	
	605								
10									
	600							(13.0 - 25.0') SAND, fine; little medium sand, subrounded; trace silt; well sorted; moist to wet; pale brown (10 YR 6/3).	
15		2	10-20'	5	NA				
	595								
20									
	590	3	20-25'	5	NA				
25								End of boring at 25.0' bgs.	
	585								
30									

Well/Boring Construction



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Remarks: bgs = below ground surface
btoc = below top of casing

Hand auger to 10.0' bgs.
Groundwater not encountered during drilling.
Water level at development was 16.87' btoc.
No odor or staining observed.
Groundwater elevation measured on December 2, 2015 was 599.07 feet

Date Start: 3/14/01
Date Finish: 3/14/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): 36.0
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 634.89

Borehole Depth (ft. bgs.): 43.5
Surface Elevation: NA

Descriptions By: Rebecca J. Koepke

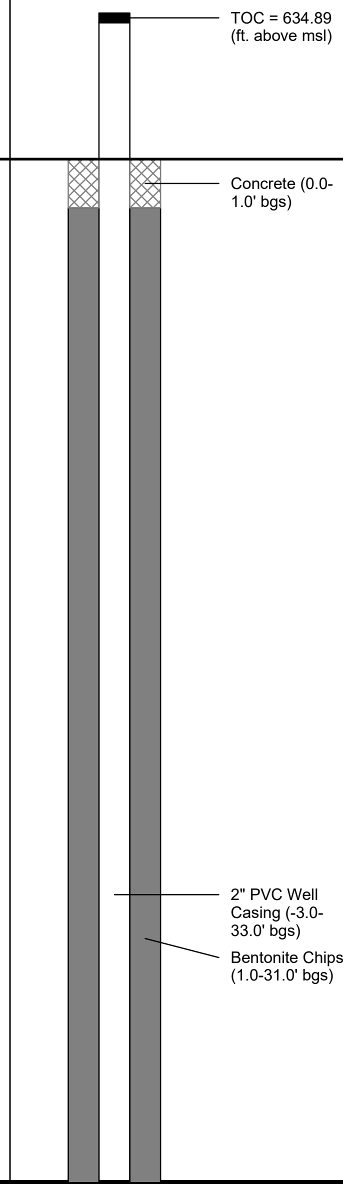
Well/Boring ID: **JHC MW-15035**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	625									
0								(0.0 - 0.5') SANDY ORGANIC SOIl, very dark brown, very fine to fine, loose, moist.		
								(0.5 - 30.5') SAND, brownish yellow (10YR 6/8), poorly graded, fine, trace silt, round, loose, slightly moist.		
	620									
5		1	5.0-7.0'	0.9	NA					
	615									
10		2	10.0-12.0'	1.6	NA					
	610									
15		3	15.0-17.0'	1.6	NA					
	605									
20								NOTE: Brownish yellow (10YR 6/6)		



ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Groundwater encountered at 36.0' bgs during drilling.
No odor or staining observed.

Project: DE000722.0003.00006 Template: ARCADIS_Analytical Boring-Well 2013_New Logo
Data File: MW-15035.dat Date: 2/4/2016 Created/Edited by: Natural Resource Technology, Inc./A. Westhuis

Date Start: 3/14/01 **Date Finish:** 3/14/01 **Drilling Company:** EDC, Inc. **Driller's Name:** Sean Smith **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** Hollow Stem Auger **Water Level Start (ft. bgs.):** 36.0 **Water Level Finish (ft. btoc.):** NA	**Northing:** NA **Easting:** NA **Casing Elevation:** 634.89 **Borehole Depth (ft. bgs.):** 43.5 **Surface Elevation:** NA **Descriptions By:** Rebecca J. Koepke	**Well/Boring ID:** **JHC MW-15035** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
		4	20.0-22.0'	1.8	NA					
	600									
25		5	25.0-27.0'	1.8	NA					
	595									
30		6	30.0-32.0'	1.3	NA			NOTE: Yellow (10YR 7/6) NOTE: Very pale brown (10YR 7/4)		
	590									
35		7	35.0-37.0'	1.8	NA			NOTE: Wet at 36.0' bgs		Sand Pack Flat Rock #30 (31.0-43.5' bgs) 2" PVC 10 Slot Well Screen (33.0-43.0 bgs)
	585									
40										
	580							End of boring at 43.5' bgs.		
45										

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

Groundwater encountered at 36.0' bgs during drilling.
No odor or staining observed.

Date Start: 3/13/01 **Date Finish:** 3/13/01 **Drilling Company:** EDC, Inc. **Driller's Name:** Sean Smith **Drilling Method:** Hollow Stem Auger **Sampling Method:** Split Spoon **Rig Type:** Hollow Stem Auger **Water Level Start (ft. bgs.):** NA **Water Level Finish (ft. btoc.):** NA	**Northing:** NA **Easting:** NA **Casing Elevation:** 615.90 **Borehole Depth (ft. bgs.):** 30.5 **Surface Elevation:** NA **Descriptions By:** Rebecca J. Koepke	**Well/Boring ID: JHC MW-15036** **Client:** Consumers Energy **Location:** JH Campbell Facility 1700 Crosswell Street Site A West Olive, MI 49460 **Weather Conditions:** NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	625									TOC = 615.90 (ft. above msl)
0								(0.0 - 0.5') SANDY ORGANIC SOIl, very dark brown, very fine to fine, loose, moist.		Concrete (0.0-1.0' bgs)
								(0.5 - 30.5') SAND, very pale brown (10YR 7/4), poorly graded, fine, trace silt, round, loose, slightly moist.		
5	620	1	5.0-7.0'	0.9	NA					
10	615	2	10.0-12.0'	1.6	NA			NOTE: Very fine.		2" PVC Well Casing (-3.0-20.0' bgs) Bentonite Chips (1.0-18.0' bgs)
15	610	3	15.0-17.0'	1.6	NA			NOTE: Very pale brown (10YR 8/3), fine.		
20	605	4	20.0-22.0'	1.8	NA			NOTE: Fine to medium, moist.		
25	600	5	25.0-27.0'	1.8	NA					Sand Pack Flat Rock #30 (18.0-30.5' bgs) 2" PVC 10 Slot Well Screen (20.0-30.0 bgs)
30	595									
								End of boring at 30.5' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

No odor or staining observed.

Date Start: 8/29/01
Date Finish: 8/29/01
Drilling Company: EDC, Inc.
Driller's Name: Sean Smith
Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Rig Type: Hollow Stem Auger
Water Level Start (ft. bgs.): NA
Water Level Finish (ft. btoc.): NA

Northing: NA
Easting: NA
Casing Elevation: 613.42

Borehole Depth (ft. bgs.): 28.5
Surface Elevation: NA

Descriptions By: Rebecca J. Koepke

Well/Boring ID: **JHC MW-15037**

Client: Consumers Energy

Location: JH Campbell Facility
1700 Crosswell Street Site A
West Olive, MI 49460

Weather Conditions: NA

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)	Well/Boring Construction
	625									TOC = 613.42 (ft. above msl)
0		1	0.0-2.0'	1.5	NA			(0.0 - 1.0') SAND, semi compact, dark, organic, clayey, fine, moist.		Concrete (0.0-1.0' bgs)
								(1.0 - 2.0') SAND, loose, tan, fine, trace silt, moist.		
		2	2.0-4.0'	1.96	NA			(2.0 - 3.0') SAND, medium compact, light brown, fine, trace clay, moist.		
								(3.0 - 28.5') SAND, loose, tan, fine, trace silt, moist.		
5	620	3	4.0-6.0'	1.5	NA					
		4	6.0-8.0'	1.4	NA					
10	615	5	8.0-10.0'	1.0	NA					
		6	10.0-12.0'	1.2	NA					Bentonite Grout (1.0-20.0' bgs); 2" PVC Well Casing (-3.0-26.0' bgs)
		7	12.0-14.0'	1.5	NA					
15	610	8	14.0-16.0'	1.2	NA					
		9	16.0-18.0'	NA	NA					
20	605	10	18.0-20.0'	1.0	NA					
		11	20.0-22.0'	1.6	NA					Bentonite Pellets (20.0-21.0' bgs)
		12	22.0-24.0'	1.5	NA			NOTE: Wet at 22.0' bgs, grades to light brown.	▼	
25	600	13	24.0-26.0'	1.5	NA					Sand Pack (21.0-28.5' bgs)
		14	26.0-28.0'	1.8	NA					2" PVC 10 Slot Well Screen (23.0-28.0' bgs)
30	595							End of boring at 28.5' bgs.		

ARCADIS Design & Consultancy for natural and built assets

Remarks: bgs = below ground surface
btoc = below top of casing

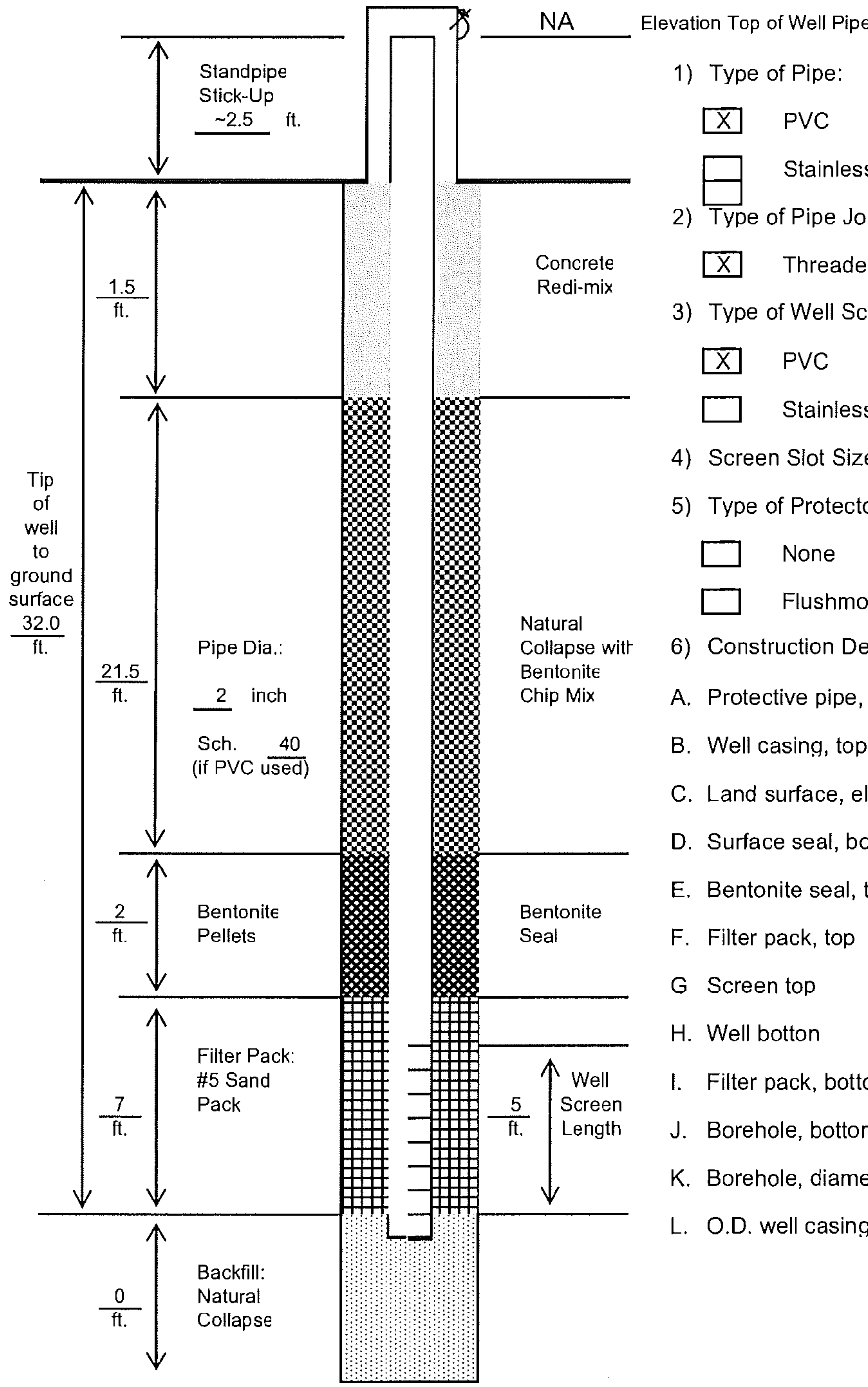
Groundwater encountered at 22.0' bgs during drilling.
No odor or staining observed.

WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation STS PROJECT NO. 200706041

WELL NO.: **MW-B1** DATE INSTALLED: 12/13/07 DRILLERS: Shepler DRILL RIG: Hollow Stem Auger

NORTHING: 804.80 EASTING: 3996.22



1) Type of Pipe:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

2) Type of Pipe Joint:

- [X] Threaded
- [ ] Other

3) Type of Well Screen:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

- [ ] None
- [X] Steel Pipe with Lock
- [ ] Flushmount

6) Construction Details

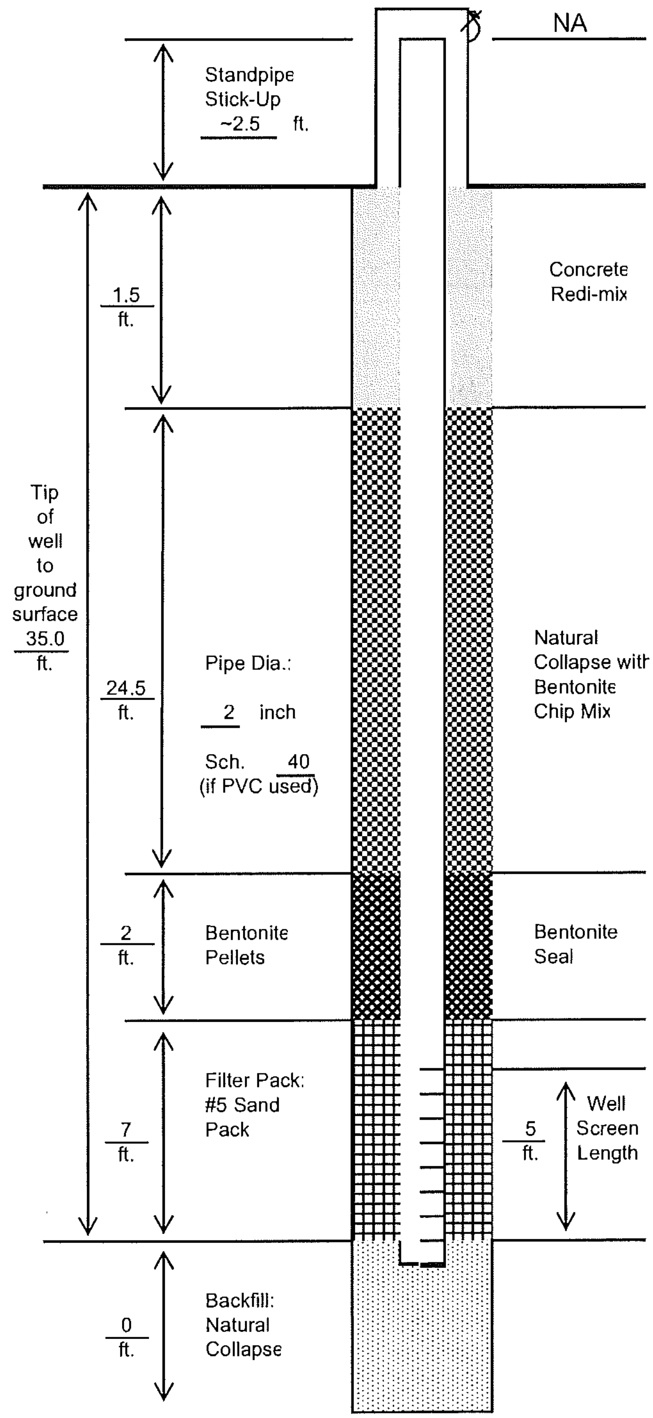
A. Protective pipe, top elevation		NA	ft. MSL
B. Well casing, top elevation		NA	ft. MSL
C. Land surface, elevation		NA	ft. MSL
D. Surface seal, bottom	____ ft. MSL or	1.50	ft. BGS
E. Bentonite seal, top	____ ft. MSL or	23.00	ft. BGS
F. Filter pack, top	____ ft. MSL or	25.00	ft. BGS
G Screen top	____ ft. MSL or	27.00	ft. BGS
H. Well botton	____ ft. MSL or	32.00	ft. BGS
I. Filter pack, bottom	____ ft. MSL or	32.00	ft. BGS
J. Borehole, bottom	____ ft. MSL or	32.00	ft. BGS
K. Borehole, diameter	8.0	inches	
L. O.D. well casing	2.00	inches	

WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation   STS PROJECT NO. 200706041

WELL NO.: **MW-B2**   DATE INSTALLED: 12/13/07   DRILLERS: Shepler   DRILL RIG: Hollow Stem Auger

NORTHING: 802.20   EASTING: 4500.00



1) Type of Pipe:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

2) Type of Pipe Joint:

- [X] Threaded
- [ ] Other

3) Type of Well Screen:

- [X] PVC
- [ ] Galvanized
- [ ] Stainless
- [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

- [ ] None
- [X] Steel Pipe with Lock
- [ ] Flushmount

6) Construction Details

A. Protective pipe, top elevation	NA ft. MSL			
B. Well casing, top elevation	NA ft. MSL			
C. Land surface, elevation	NA ft. MSL			
D. Surface seal, bottom	ft. MSL or	1.50 ft. BGS		
E. Bentonite seal, top	ft. MSL or	26.00 ft. BGS		
F. Filter pack, top	ft. MSL or	28.00 ft. BGS		
G Screen top	ft. MSL or	30.00 ft. BGS		
H. Well botton	ft. MSL or	35.00 ft. BGS		
I. Filter pack, bottom	ft. MSL or	35.00 ft. BGS		
J. Borehole, bottom	ft. MSL or	35.00 ft. BGS		
K. Borehole, diameter	8.0 inches			
L. O.D. well casing	2.00 inches			

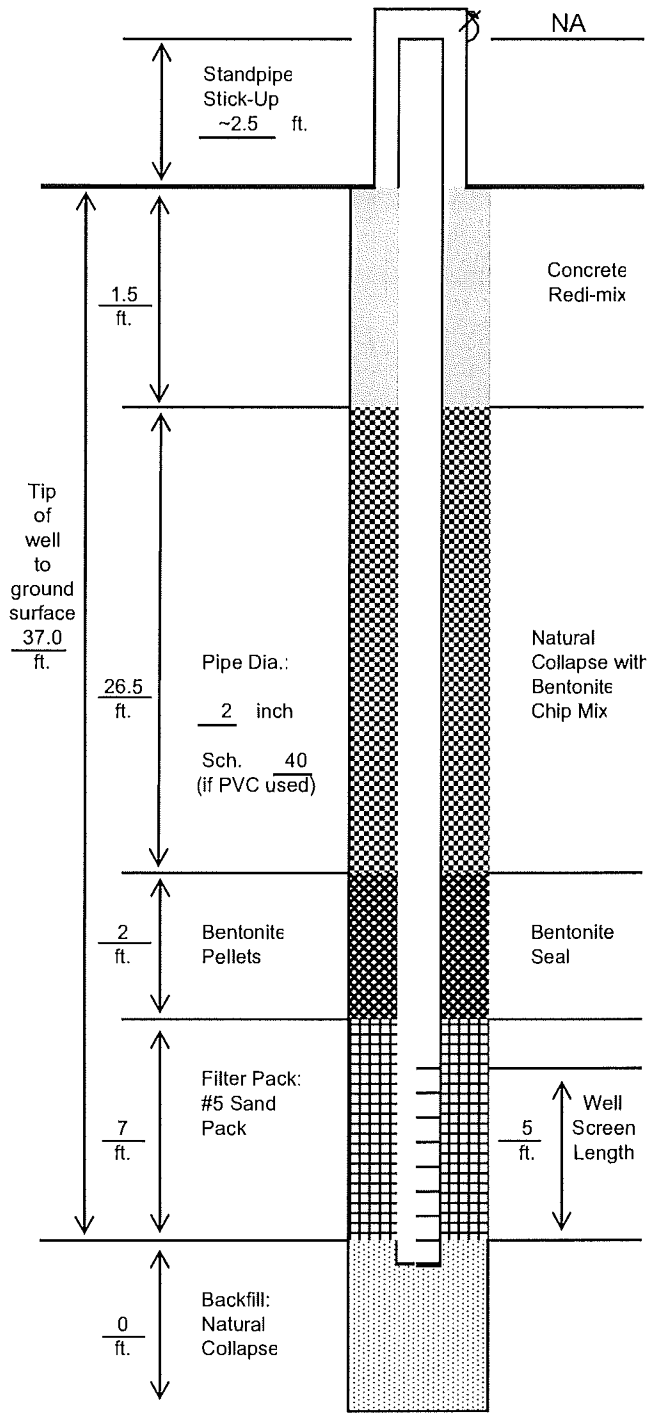
STS

WELL INSTALLATION DIAGRAM

PROJECT: Consumers Energy - JH Campbell - Well Installation STS PROJECT NO. 200706041

WELL NO.: **MW-B3** DATE INSTALLED: 12/13/07 DRILLERS: Shepler DRILL RIG: Hollow Stem Auger

NORTHING: 802.55 EASTING: 4997.50



NA Elevation Top of Well Pipe

1) Type of Pipe:

[X] PVC [ ] Galvanized

[ ] Stainless [ ] Other

2) Type of Pipe Joint:

[X] Threaded [ ] Other

3) Type of Well Screen:

[X] PVC [ ] Galvanized

[ ] Stainless [ ] Other

4) Screen Slot Size? 10

5) Type of Protector Pipe:

[ ] None [X] Steel Pipe with Lock

[ ] Flushmount

6) Construction Details

A. Protective pipe, top elevation		NA	ft. MSL
B. Well casing, top elevation		NA	ft. MSL
C. Land surface, elevation		NA	ft. MSL
D. Surface seal, bottom	ft. MSL or	1.50	ft. BGS
E. Bentonite seal, top	ft. MSL or	28.00	ft. BGS
F. Filter pack, top	ft. MSL or	30.00	ft. BGS
G Screen top	ft. MSL or	32.00	ft. BGS
H. Well botton	ft. MSL or	37.00	ft. BGS
I. Filter pack, bottom	ft. MSL or	37.00	ft. BGS
J. Borehole, bottom	ft. MSL or	37.00	ft. BGS
K. Borehole, diameter		8.0	inches
L. O.D. well casing		2.00	inches

WATER WELL DRILLING AND PUMP INSTALLATION
WELLOGIC FIELD WORK SHEET

Well B-4

Well owner: ____
Permit number: ____
Drill rig operator: Randy Shepler
Job number: 1100454
Date: 03/26/2007

Well depth: 45 ft.

Well type: ✓ new
___ dry hole
___ replacement

Well use: ___ household
___ public (well label & WSSN needed)
___ other Monitoring Well

Drilling method: ___ mud rotary
___ cable tool
___ other 4¼ Auger

Date completed: 03/26/07

CASING type: ✓ pvc
___ steel galvanized
___ steel black
___ other ____

Diameter: 2 in. to 45 ft. depth
___ in. to ___ ft. depth

Casing joint: ___ solvent welded
___ welded
___ threaded and coupled
___ other Flush Joint

Height: 3 ft. above grade

Casing fittings: ___ centralizer
___ drive shoe
___ shale packer
___ other ____

BOREHOLE diameter: 8 in. to 45 ft. depth
___ in. to ___ ft. depth

STATIC WATER LEVEL: N/A ft. below / above grade

WELLHEAD COMPLETION:
___ 12" above grade
___ pitless adapter
___ well house
___ other Exp. CAP.

NEAREST SOURCE OF CONTAMINATION:
Type ____ ft. ___ direction ____
Type ____ ft. ___ direction ____

SCREEN: installed ✓ yes ___ no

Well intake: ___ bedrock well
___ unscreened drift well

Filter pack: ✓ yes ___ no

Filter pack from: 38 ft. to 45 ft.

Filter type (brand): KtE #1

Screen material: ✓ pvc slotted
___ s.s. wirewrapped
___ other ____

Screen diameter: 2 in. ___ telescoped ✓ pipe size

Screen length: 5 ft. Slot: 10

Set between: 40 ft. and 45 ft.

Blank: ___ ft. above / below / other

Screen fittings: ___ k packer
___ bremer check
___ other Attached

GROUTING method: ___ pipe outside casing
___ driven dry granular
✓ other Chips

Number of bags: 1

Additives: None.

Grout material: ___ high solids bentonite
___ neat cement & bentonite
___ neat cement
___ other bentonite chips

Grouting depth: 4 ft. to 8 ft.

DEPTH TO WATER WHILE PUMPING:

___ ft. after ___ hrs. at ___ gpm

Yield test method: ___ air ___ bailer ___ test pump
___ other ____

PUMP installed: ___ yes ___ no

Pump installation only ___ yes ___ no

Manufacturer ______

Model no ______ hp. ______

Drop pipe diameter: ______ in Length ______ ft

Pump capacity: ______ gpm

Drawdown seal ___ yes ___ no

Pump type ___ submersible
___ other ______

PRESSURE TANK installed: ___ yes ___ no

Tank buried: ___ yes ___ no

Tank type: ___ bladder/diaphragm
___ other ______

Manufacturer ______

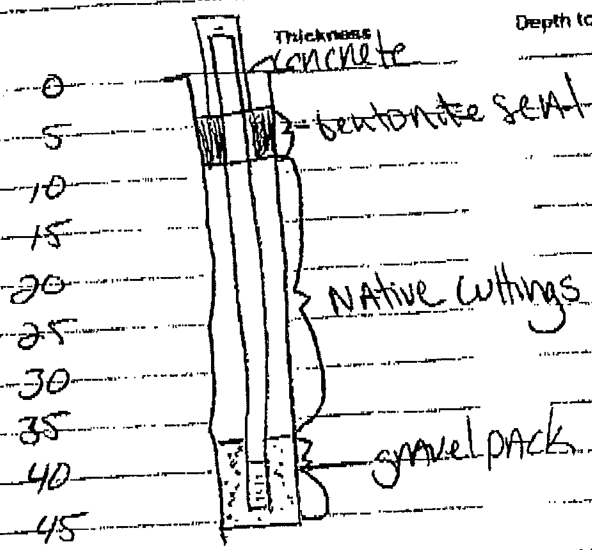
Model no. ______

Total tank capacity: ______ gallons

GEOLOGY
Formation Description

Thickness

Depth to Bottom:



General remarks:
N 803.015
E 5500.253
Ground 631.895

Top of Casing 634.48

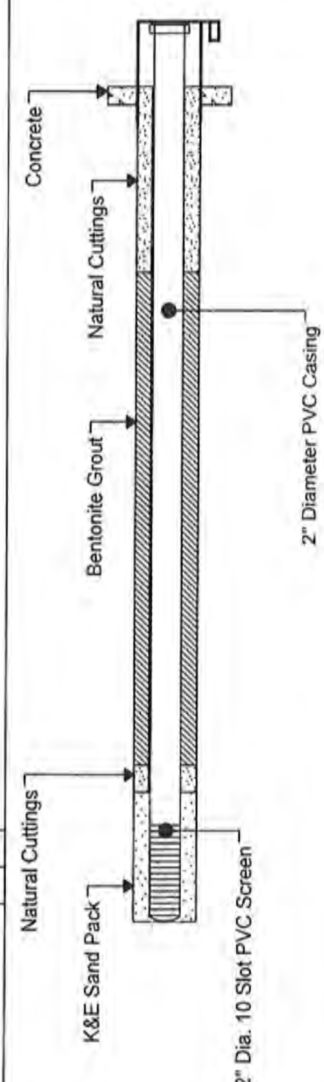
Engineering & Environmental Solutions, LLC

200 North Franklin Street
Suite 202
Zeeland, Michigan 49464

Project Name: Consumers Energy Company	**Log of Borehole: MW-B4R**
Project Number: 005-11-001	Start Date: 5-23-2011
Site Location: J.H. Campbell	End Date: 5-23-2011
Drilling Method: 4.25" OD HSA	Driller: EDAC
Sampling Method: 2' Split Spoon	Crew Chief: Rick
Ground Elevation (feet): 633.80	Depth to Water (ft BGS during drilling): 36
Top of Casing Elevation (feet): 636.16	Easting: 5514
Logged By: Kurt Van Appledorn	Northing: 802

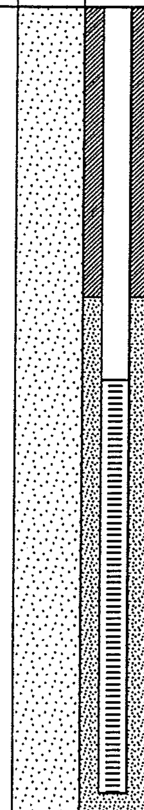
Comments: Original MW-B4 was abandoned in place by backfilling with bentonite grout

SUBSURFACE PROFILE				SAMPLE				
Depth (feet BGS)	Symbol	Description	Depth/Elev.	Sample Length (feet)	Recovery (feet)	Blow Counts	PID (ppb)	Well Completion Details
0		Ground Surface	633.8 0.0					
40		Brown (7.5YR/5/3) fine SAND, trace medium sand, wet.		2	1.3	2 2 4 6		
				2	1.0	7 14 18 23		
45		End of Boring	588.8 45.0					



Sheet: 1 of 1

Sample: Number and Type	Sample: Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	PID/FID	Soil Properties: Compressive Strength	Soil Properties: Moisture Content	Soil Properties: Liquid Limit	Soil Properties: Plasticity Index	Soil Properties: P 200	RQD/ Comments
MW-B5 (5)	21	5/6 8/6	26											
			28											
MW-B5 (6)	15	2/3 6/6	30	yellow (10YR 7/6)										
			32											
			34		SP									
MW-B5 (7)	22	2/4 6/7	36	very pale brown (10YR 7/4) wet at approximately 36 feet below ground surface										
			38											
			40											
			42											
			44	*End of Boring at 43.5 feet below ground surface*										
			46											
			48											
			50											
			52											
			54											
			56											
			58											
			60											
			62											



Appendix B
Groundwater Sampling SOP

Title: **Groundwater Sampling**	Procedure Number: **ECR 009**
	Revision Number: **3**
	Effective Date: **January 2020**

Authorization Signatures

Technical Reviewer	Date	Environmental Sector Quality Director	Date
Darby Litz	1/1/20	Elizabeth Denly	1/1/20

TABLE OF CONTENTS

Page No.

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
    - Passive diffusion bags (PDBs)
    - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
    - Funnel (Fill kit)
    - PVC cable ties
    - Tool to cut cable ties
    - PVC discharge tubes
    - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [µm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Drawdown	The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.
FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.
Flow-Through Cell	The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.
Flush Mount	The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a "curb box" which is an "at-grade" enclosure designed to protect the well riser.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.

Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.
Well Riser	Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.
Well Screen	Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field. Special care should be taken when sampling for PFAS. Please refer to Attachment D for details.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with ECR SOP 006, *Well Development.* The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

    (1) After purging the well with the peristaltic pump, collect all fractions except VOCs from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
    (2) Turn the pump off.
    (3) Change into clean gloves.
    (4) Disconnect the tubing coming out of the well from the inlet side of the pump and immediately put a finger over the end of this tubing to prevent water from draining out of the tubing.
    (5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
    (6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

Sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, if possible.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on <u>all</u> wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to ECR SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to ECR SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see ECR SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in ECR SOP 004 *Water Level and Product Measurements.*

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = πr^2 h (cf) **Equation 1**

where:

π = pi (3.14)

r = radius of well in feet (ft)

h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]

cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:

h = height of water column (feet)

f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25' to 30') and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper

disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110- or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

<u>Dedicated systems:</u> Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

<u>Non-dedicated systems:</u> Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\,(mL\,/\,min) = \frac{volume\ collected\ (mL)}{1\,minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

<u>Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH):</u> Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the

meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 Field Blanks

Field blanks consists of analyte free water exposed to the atmosphere during field sample collection. The water is containerized in an appropriate bottle and preservative for the analytical suite and shipped to the laboratory with the other field samples. The results are used to assess whether or ambient/surrounding air conditions may have influenced analytical results.

4.5 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.6 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample

- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

Interstate Technology Regulatory Council (ITRC). March 2006. *Technology Overview of Passive Sampler Technologies.*

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

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USEPA. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. EPA/542-S-02-001. USEPA Office of Solid Waste and Emergency Response.

USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling.* SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples.
http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2014	NOT APPLICABLE
1	JULY 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFCS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.
2	NOVEMBER 2016	ADDED ADDITIONAL INFORMATION REGARDING PFAS.
3	JANUARY 2020	TRC RE-BRANDING; ADDED FIELD BLANKS TO SECTION 4

Attachment A:

Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

Jurisdiction	Information Source	Applicable Stabilization Criteria
USEPA Region 1	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; U.S. Environmental Protection Agency Region 1, January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf (for low flow PDF) http://www.epa.gov/region1/lab/qa/qualsys.html (for EPA's Quality System Documents)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% if >5 NTUs; if three Turbidity values are <5 NTU, consider the values as stabilized Dissolved Oxygen: ±10% if >0.5 mg/L, if three Dissolved Oxygen values are <0.5 mg/L, consider the values as stabilized Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 2	Groundwater Sampling Procedure: Low Stress (Low Flow) Purging and Sampling, SOP # SST-7, Revision No. 1, November 2010.	Same as above
USEPA Region 4	USEPA Region 4 SOPs: http://www.epa.gov/region4/sesd/fbqstp/index.html See Chemical Parameter Stabilization Criteria (section 3.2.1.1.2 of Groundwater Sampling SOP, revision 3/6/2013: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf	pH: ±0.1 unit Specific Conductance: ±5% Temperature: Not used Turbidity: "Stabilized" (no criteria specified) if >10 NTUs ; if three Turbidity values are <10 NTUs, consider the values as stabilized Dissolved Oxygen (optional parameter): ±0.2 mg/L or ±10% of saturation, whichever is greater Oxidation/Reduction Potential: Not used
USEPA Region 5	Ground Water Forum Issue Paper (May 2002, Yeskis and Zavala) http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf A minimum set of parameters would include pH, conductivity, and turbidity or DO. Puls and Barcelona, 1996 (pH, specific conductance, ORP, turbidity) Wilde et al., 1998 (pH, turbidity, DO)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: Not used Turbidity: ±10% if >10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 9	See USEPA Region 1 (above)	
USEPA Region 10	See USEPA Region 5 (above)	
Alabama	Alabama Environmental Investigation and Remediation Guidance (section C.3.1) http://www.adem.state.al.us/MoreInfo/pubs/AEIRGInvestigation.pdf	pH: ±0.1 unit Specific Conductance: ±10% Temperature: "Constant" (no criteria specified) Turbidity: Stabilized (no criteria specified), or <10 NTUs Dissolved Oxygen: No criteria specified Oxidation/Reduction Potential: No criteria specified

Jurisdiction	Information Source	Applicable Stabilization Criteria
Indiana	Indiana Department of Environmental Management The Micro-Purge Sampling Option http://www.in.gov/idem/files/remediation_tech_guidance_micro-purge.pdf The parameters normally measured for stability (listed in increasing order of sensitivity) are pH, temperature, specific conductivity, oxidation-reduction potential, DO and turbidity. At least one of the last three listed must be used.	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% Dissolved Oxygen: ±10% Oxidation/Reduction Potential: ±10 millivolts (document says microvolts, but that may be an error)
Michigan	MDEQ Part 201 Op Memo 2, Attachment 5 http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_2_Attachment5_249853_7.pdf	No specific values to determine stabilization are listed, but the Op Memo lists several other groundwater sampling guidance documents. If a valid reference exists, then it can be used to justify a sampling approach and stabilization parameters.
New Jersey	New Jersey Department of Environmental Protection http://www.state.nj.us/dep/srp/guidance/fspm/	pH: ± 0.1 unit Specific Conductance: ± 3% Temperature: ± 3% Dissolved Oxygen: ± 10% Turbidity: ± 10% for values greater than 1 NTU ORP/Eh: ± 10 millivolts
Ohio	Ohio EPA SOPs: http://www.epa.state.oh.us/portals/30/rules/FSOPs.pdf See Purging Stabilization Criteria (SOP 2.2.4, dated January 2, 2007, review in progress)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: No criteria specified Turbidity: Below 10 NTUs ideal; ±10% if greater than 10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
This table was last updated in July 2014.		

Attachment B:

Example Groundwater Field Data Records

TRC

Groundwater Field Data Record

Project:	Project No.:	Date/Time:	Sheet ___ of ___
TRC Personnel:		Well ID:	

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Sampling Equipment: ____________

Flow-thru Cell Volume: ____________

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) ______ ft.

Riser Stick-up (from ground) ______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch

Other: ______

WELL MATERIAL

☐ PVC ☐ SS

Other: ______

Well Depth ______ ft. ☐ top of riser ☐ top of casing ☐ ______ ☐ measured ☐ historical

Water Depth ______ ft.

Well Volume ______

LNAPL/DNAPL Depth = ______

NAPL Thickness = ______

Depth of pump intake: ______

Static water level after pump put into well: ______

Initial purge Rate/ Water Level (100-400 ml/min): ______

Adjusted purge Rates/time/WL(record changes) ______

Flow rate at time of sampling: ______

Total volume of water purged: ______

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

Time									
Temp. (°C)									
Conduct. (µmhos/cm)									
DO (mg/L)									
pH (su)									
ORP (millivolts)									
Turbidity (NTU)									
Flow (ml/min)									
Depth To Water (ft)									
Cumulative Purge Vol. (gal or L)									

Time							
Temp. (°C)							
Conduct. (µmhos/cm)							
DO (mg/L)							
pH (Std. Units)							
Eh/ORP (millivolts)							
Turbidity (NTU)							
Flow (ml/min)							
Depth To Water (ft)							
Cumulative Purge Vol. (gal or L)							

Stabilization Criteria*
(3 consecutive readings)
- Temperature: ± 3 %
- Conduct. (µmhos/cm): ± 3 %
- DO (mg/L): ± 10 % (for values >0.5 mg/L)
- pH (Std. Units): ± 0.1 SU
- ORP (millivolts): ± 10 mV
- Turbidity (NTU): +/- 10 % (for values >5.0 NTUs)
- Drawdown: < 0.3 ft (can be greater as long as water level stabilizes above well screen)

	Purge	Sample
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bladder Pump	☐	☐
Bailer	☐	☐
Other: ______	☐	☐

Comments: ______

Analytical Parameter	Filtered (Y/N)	Preservation	# Bottles	Size/Type Bottles	Time Collected	QC	Sample #

* Consult the applicable regulatory guidance for the specific criteria.

Signed: ____________

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PAGE ______ OF ______

TRC

WATER SAMPLE LOG

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:				WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6"	☐ OTHER ______		
WELL MATERIAL:	☐ PVC	☐ SS	☐ IRON	☐ GALVANIZED STEEL	☐ OTHER ______		
SAMPLE TYPE:	☑ GW	☐ WW	☐ SW	☐ DI	☐ LEACHATE	☐ OTHER ______	

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:
PURGE METHOD:	☐ PUMP ______ ☐ BAILER ______		PH: ______ SU	CONDUCTIVITY: ______ umhos/cm	
			ORP: ______ mV	DO: ______ mg/L	
DEPTH TO WATER: ______ T/ PVC	FLOW-THRU CELL VOLUME		TURBIDITY: ______ NTU		
DEPTH TO BOTTOM: ______ T/ PVC			☐ NONE ☐ SLIGHT	☐ MODERATE ☐ VERY	
PUMP INTAKE DEPTH: ______ T/ PVC	______ LITERS		TEMPERATURE: ______ °C	OTHER: ______	
WELL VOLUME: ______ ☐ LITERS	☐ GALLONS		COLOR: ______	ODOR: ______	
VOLUME REMOVED: ______ ☐ LITERS	☐ GALLONS		FILTRATE (0.45 um) ☐ YES	☐ NO	
COLOR: ______	ODOR: ______		FILTRATE COLOR: ______	FILTRATE ODOR: ______	
TURBIDITY			QC SAMPLE: ☐ MS/MSD	☐ DUP: ______	
☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY			COMMENTS:		
DISPOSAL METHOD: ☐ GROUND ☐ DRUM ☐ OTHER					

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or </= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED — PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - ______

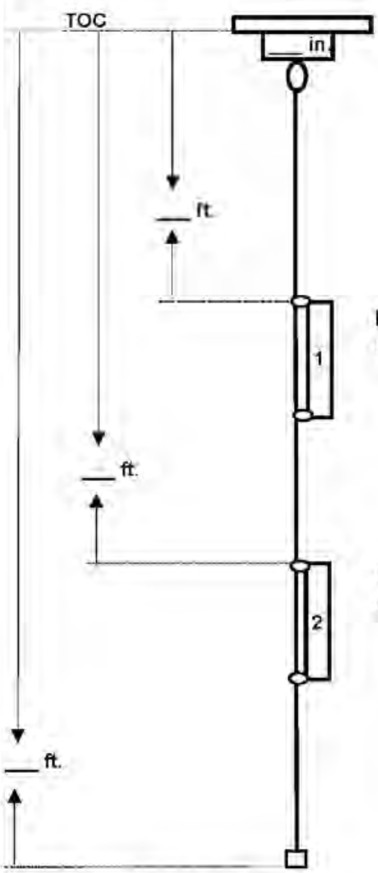
NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD: ______	DATE SHIPPED: ______	AIRBILL NUMBER: ______
COC NUMBER: ______	SIGNATURE: ______	DATE SIGNED: ______

REVISED 06/2011

Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)	Project Name/No:	Well ID:

Installation of PDBs:	**Sampling of PDBs:**
TRC Personnel: ______	TRC Personnel: ______
Date: ______	Date: ______
Time: ______	DTW (ft): ______
DTW (ft): ______	



PDB #1
Length: ___ in.

Sample ID: ______
Sample Time: ______
Evidence of algae, iron or other coatings?: ______

PDB #2
Length: ___ in.

Sample ID: ______
Sample Time: ______
Evidence of algae, iron or other coatings?: ______

Measured well depth during tether installation: ___ ft.

Field Notes:

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Attachment C: SOP Fact Sheet

GROUNDWATER SAMPLING

PURPOSE AND OBJECTIVE

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling. All three approaches are summarized in this document.

WHAT TO BRING

- Site-specific HASP and field book
- Project-specific work plan
- Figure or site map showing well locations and table showing well construction details
- Field data sheets from previous sampling event
- Well wrenches, ratchet set, and turkey baster to remove standing water from flushmount manholes
- Bolt cutters, padlocks and keys
- Water level meter of sufficient length
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing (Teflon®, Teflon®–lined polyethylene, or HDPE, type dependent upon project objectives)
- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, ORP, and DO)
- Turbidity meter
- Equipment decontamination supplies (refer to ECR SOP 010, *Equipment Decontamination*)
- Appropriate PPE
- Field book
- Sample bottleware, labeled cooler, ice, temperature blank and blank COC forms; may also need field blank bottles and reagent-grade water
- Zip-loc® plastic bags
- Groundwater field data records
- Graduated cylinder and stop-watch
- Rope for tying off pump at desired intake
- Indelible marking pens
- Bubble wrap
- 5-gallon bucket(s)

<u>**As Needed:**</u>

- Calibrated PID or FID for well mouth readings
- Oil/water interface probe of sufficient length
- Drums for purge water, grease pen and adhesive drum labels; appropriate crescent or socket wrench
- Filtration equipment, if required (0.45 micron filters, or as otherwise required for the project)
- Other non-routine PPE such as Tyvek coveralls or respirators
- Traffic cones
- Field calibration sheets and calibration solutions

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the most recent version.
- Review the project-specific work plan with the Project Manager and/or the field team leader. Discuss the following:
  - Communication procedures;
  - Sampling order and designation;
  - Collection and sample method;
  - Analytical parameters, holding times and turn-around times;
  - Laboratory (contact/shipping info, COC, billing references);
  - Purge water management (Drums? Discharge to ground?);
  - QC sample collection; and
  - Decontamination procedures.
- Verify that monitoring wells will be accessible and/or coordinate to have a site contact available to assist.
- Make sure that monitoring well sample designations and QC sample designations/frequency are understood.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure or mobilization to site, test equipment and make sure it is in proper working order. Have rental equipment supplier contact information available for use in field.
- Review sample bottle order for accuracy and completeness and damaged bottles.
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

ON-SITE

GROUNDWATER SAMPLING

- Review the HASP with all field personnel, sign acknowledgement form and conduct Health & Safety tailgate meeting. Check in security, site contact, or designated person per project-specific work plan or Project Manager.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.
- Open wells to allow equilibration and collect full round of water level gauging before sampling is started (unless otherwise noted in project-specific work plan). Record the following:
  - Well mouth PID/FID reading (if necessary);
  - Depth to product and water;
  - Total well depth (not required if free product is measured unless otherwise noted in project-specific work plan); and
  - Condition of wells (i.e., lid broken, pad cracked, rusted lock) and collect photographs if site allows camera use.

SAMPLING PROCEDURES: PRE-PURGE

- Decontaminate pump.
- Take water level measurements prior to pump installation.
- Connect sampling tubing to pump outlet and lower to sample depth; **ALWAYS USE ROPE TO SECURE PUMP TO SURFACE.**
- The pump intake depth(s) for each well should be specified in the project-specific work plan (either specific depth or mid-point of saturated well screen).
- For wells with screened or open borehole intervals greater than 10 feet in length, sampling of multiple intervals may be required.
- If samples are to be collected from multiple depths from an individual well, always collect a sample from the shallowest depth first and leave enough extra tubing coiled at the surface so the pump can be lowered to the next interval; always try to cover excess tubing present at the surface to prevent the air temperature from influencing the measurements and exposure to contaminants on the ground;
- Be careful not to let the pump hit the bottom of the well.
- If using Teflon®-lined tubing, be sure that the lining does not bunch up around the connection. This will restrict water flow and make the pump work harder than it has to.
- Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

SAMPLING PROCEDURES: MULTIPLE-VOLUME PURGING

- The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization.
- The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters.
- Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. Once this information is known, the well volume can be calculated using the following equation:

  Well Volume (V) = $\pi r2$ h
- For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed.
- For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.
- If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume.
- In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection.
- If, after 3 well volumes have been removed, the field parameters have not stabilized, additional well volumes (up to a total of 5 well volumes), should be removed.
- If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging.

SAMPLING PROCEDURES: LOW-FLOW PURGING

- The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample.
- When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval to help prevent disturbance of any sediment at the bottom of the well.

GROUNDWATER SAMPLING

- To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.
- The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings.
- Attempts should be made to avoid pumping a well dry.

Field Parameter Stabilization During Purging

- Generally, an adequate purge with respect to the groundwater chemistry is achieved when stability for at least three consecutive measurements is achieved. See stability requirements in Appendix A of this SOP.

POST-PURGE GROUNDWATER SAMPLE COLLECTION

- New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.
- If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.
- If using bottom-filling bailers, slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling). Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.
- Collect groundwater samples in the following order:
  - VOCs;
  - SVOCs;
  - Other organic parameters;
  - Unfiltered inorganic constituents; and
  - Filtered inorganic constituents.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Preserve the non-VOC samples in pre-preserved vials supplied by the laboratory or if the sample containers are not pre-preserved, preserve the non-VOC samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed. See procedures listed in Section 2.3.4 of this SOP. Clearly note "filtered" on the sample label and the COC.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment between uses.

PASSIVE SAMPLING

- There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers. Be aware of sample holding times, and arrange for samples to be in the laboratory's possession accordingly.
- Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.
- New passive samplers are attached via PVC cable ties to a tether (pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well.
- The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers).
- Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.
- Detach the passive sampler from the tether.
- Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

GROUNDWATER SAMPLING

- Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. The VOA vials must be filled within the first several minutes of passive sampler retrieval.
- A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.
- Dispose of the passive sampler after use.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.

DOs AND DO NOTs OF GROUNDWATER PURGING AND SAMPLING

DOs:

- DO have the following items when going into the field: site-specific work plan; site-Specific HASP; appropriate PPE (steel-toed boots, safety glasses, etc.) as required by the Site-Specific HASP; field book and a water-proof ball-point pen; business cards; nitrile gloves; well keys; copies of well installation forms and field data forms from previous sampling event.
- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled. There is little time between taking parameters.
- DO look at the water quality parameters from the previous round of sampling. If there is a large deviation from the previous round's measurements, make sure the meters are properly calibrated and the parameter units are the same. Otherwise, consult the Project Manager or field team leader.
- DO fill sample bottles slowly to make sure that they are not overfilled and that preservative does not become diluted. If collecting filtered samples, fill all non-filtered first, then fill filtered samples - if water is very silty, more than one filter might be required to fill sample bottles.
- DO record the time that purging begins and ends. "Purge Stop" and sample start time are the same.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them. It is also recommended to call when sampling is winding down for the day to make sure that the project-specific work plan has been fully implemented and there are no additional tasks to complete. Provide shipping tracking numbers to the Project Manager and laboratory contact.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO record sample locations and parameters in the field book and the Groundwater Field Data Records as you purge.
- DO check on the purging setup frequently to make sure proper equipment function is maintained.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if this is an issue.
- DO NOT allow the pump or sampling equipment to hit the bottom of the well - If the pump hits the bottom of the well, it can stir up mud. Remember, the goal of low-flow sampling is to collect non-turbid samples.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT leave air bubbles in VOA vials.
- DO NOT pour any extracted water back down into the well.
- DO NOT lean over wells with pens, keys, cell phones, tools, etc. in your pocket.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

Attachment D: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing. • Passive diffusion bags (PDBs) should not be used due to the presence of LDPE material in PDBs. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use LDPE or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil. • Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. • Do not use Post-It Notes during sample handling or mobilization/demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
	• Personnel involved with sample collection and handling should wear nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up to sample a well.
1.6.1	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
2.2.5	Tubing used to purge and sample groundwater for PFAS must not be LDPE or Teflon®. HDPE and silicone are acceptable.
2.3 and 2.3.3	LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable.
2.4	Due to LDPE material in PDBs, PDBs cannot be used for PFAS sampling.
2.5 (e)	Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable.
2.5 (f)	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable.
4.3	Due to low reporting limit requirements for PFAS, trip blanks for PFAS analysis should be included in sample coolers if PFAS are being analyzed for in the associated groundwater samples.

Notes:

[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

Appendix C
Chain-of-Custody Procedures SOP

Title: **Chain-of-Custody Procedures**		Procedure Number: **ECR 002**	
		Revision Number: **1**	
		Effective Date: **January 2020**	
Authorization Signatures			
Technical Review	Date	Environmental Sector Quality Director	Date
James Peronto	1/1/20	Elizabeth Denly	1/1/20

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FIGURES

ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in proper Chain-of-Custody practices.

This SOP was prepared to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. Sample custody procedures are an important part of the field investigation program in order to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law or other evidentiary venue. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration (i.e., representative of the identified sample media).

1.2 Summary of Method

Evidence of the sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be properly documented.

A sample or evidence file is considered to be in a person's custody if the item is:

- In a person's possession
- In the view of the person after being in a person's possession
- Secured and preserved so that no one can tamper with it after having been in a person’s possession
- In a secured area, restricted to authorized personnel

The Field Team Leader or designee is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The Field Team Leader or designee is also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

1.3 Equipment

The following list is an example of items that may be utilized when implementing sample custody procedures in the field. Project-specific conditions or requirements may warrant the use of additional items or deletion of items from this list. Many of these items may be provided by the selected analytical laboratory for a given project.

- Chain-of-Custody forms
- Sample labels
- Sample tags
- Custody seals
- Computer
- Indelible/waterproof ink
- Printer

2.0 PROCEDURES

Sample custody and transfer procedures are summarized below. These procedures are intended to ensure that the samples will arrive at the laboratory with the Chain-of-Custody intact. The Chain-of-Custody procedures are initiated in the field immediately following sample collection. The procedures consist of four main components: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the Chain-of-Custody (COC) form, (3) reviewing the COC form for accuracy and (4) preparing the samples for shipment and transfer of custody.

2.1 Specific Chain-of-Custody Procedures

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container. Individual sample containers may be pre-labeled or labeled in the field at the time of collection. Sufficient sample information should be cross-referenced in the field documentation for tracking purposes.

Sample labels typically contain the following information:

- Unique sample identification
- Sample location and/or depth/description number, if different from above
- Sample matrix
- Type of analysis to be performed
- Type of chemical preservation used
- Grab or composite designation
- Filtered or unfiltered
- Sampling date and time
- Sampler's affiliation and initials
- Site and/or client name

An example of a sample label is provided in Figure 1.

2.1.2 Custody Seals

Custody seals may be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. Custody seals are attached to the cover seal of the cooler and can be covered with clear plastic tape after being signed and dated by field personnel. An example of a custody seal is shown in Figure 1. The use of custody seals will be determined on a project-specific basis by the Project Manager.

2.1.3 Chain-of-Custody Form

For all analyses, COC forms must be completed for each sample set submitted. COC forms are initiated by the samplers in the field and maintained until samples are analyzed by the laboratory. If multiple laboratories are being used, a separate set of COC forms must be completed for each laboratory receiving samples to ensure proper transfer of custody from the time of sample collection to analysis. These forms serve as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms typically contain the following pertinent information:

- Project/site name and/or project number
- Carrier name, if applicable
- Air bill numbers(s), if known and applicable
- Laboratory name and address
- Sample identifications
- Sample matrix (e.g., soil, water)
- Type of sample (i.e., grab or composite)
- Date/time sample collected
- Size, type, and number of containers
- Preservative used
- Required analysis or method
- Turnaround time
- Names of individuals responsible for custody of samples
- Date shipped or otherwise transferred

Figure 2 provides an example COC form. It should be noted that this is an example format only. Laboratories typically provide their own laboratory-specific COC form. Other COC formats may be used as long as all of the applicable information is included. COC forms will be initiated in the field.

All entries on the COC form must be legible and must be made in blue or black permanent ink. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error. The original entry should still be legible even though crossed out.

2.1.4 Transfer of Custody

Samples will be accompanied by a properly completed COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time of transfer on the COC form.

All samples will be shipped directly to the laboratories by a TRC employee, an overnight commercial carrier, or a laboratory-supplied courier service.

In the case of sample shipment by an overnight commercial carrier, a properly prepared air bill, including the project number (Figure 3), will serve as an extension of the COC form while the samples are in transit. The COC forms will be sealed inside the sample cooler within a clear plastic bag and the custody seals, if used, will be completed on the outside of the cooler prior to shipment. Commercial carriers are not required to sign off on the custody forms since the forms are sealed inside the cooler prior to shipment so any custody seal remains intact. The original COC form will accompany the samples at all times. A copy of all COC forms submitted to the laboratory will be retained by the sampler along with field records/logbooks documenting sample collection and will be placed in the project files.

If at the completion of sampling the samples are not shipped directly from the field or point of collection to the analytical laboratory, the samples will be temporarily stored in an iced cooler at a secure location (e.g., locked vehicle, residence, office) or in a locked refrigerator at the TRC office. Access to the secure location and transfer of the sample containers for laboratory delivery shall only be provided by a TRC employee and such sample transfer shall be recorded on the COC form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Following sample collection, all samples will be brought to a location for batching and paperwork checks. At this location, labels and logbook information are cross-checked to ensure there is no error in sample identification or sample collection time and that all samples are accounted for. The sample information is transferred to the COC form. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled for transport.

The Field Team Leader has the responsibility of maintaining the COC and air bill documentation. Individual responsibilities may be delegated to other field staff, as appropriate. Quality control procedures will place emphasis on ensuring that appropriate samples were collected and submitted to the laboratory for the correct analyses. The COC forms will also be reviewed by the Field Team Leader or designee to ensure that all required information is clearly presented.

Many laboratories will provide a sample receipt confirmation via electronic mail upon request. COC forms should be cross-checked with laboratory sample receipt confirmations, if applicable, to ensure that all samples were received and logged-in correctly by the laboratory.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Not applicable.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all COC forms completed during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

It is good practice to scan all completed COC forms at the conclusion of field activities and store the resulting electronic PDF files in the project directory.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001. December 1987.

U.S. Environmental Protection Agency (EPA) Office of Enforcement and Compliance Monitoring – National Enforcement Investigations Center (NEIC) requirements (NEIC, 1986)

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	MARCH 2013	NOT APPLICABLE
1	JANUARY 2020	TRC RE-BRANDING AND SOP RE-NUMBERING

Figure 1 Example Sample Label and Custody Seal

Sample Label

CLIENT/SOURCE	☐ GRAB ☐ COMPOSITE OTHER
SITE NAME	DATE
SAMPLE #	TIME
ANALYSIS	PRESERVATIVE
	COLL. BY

Custody Seal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL

Date

Signature

Figure 2 Example Chain-of-Custody Form

Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Chain-of-Custody Record

Page ____ of ____

Project Name ____________
Project No.: ____________
Sampling Date(s): ____________
Laboratory Name: ____________
Laboratory Location: ____________
Sampler Name(s): ____________

Shipping Carrier ❑ FED EX ❑ COURIER
Date Shipped ____________
Airbill No. ____________

MCP Work Only: Have the appropriate number of field samples been collected for this program?
❑ YES ❑ NO

Turnaround Time (Circle One)
15 Day 10 Day 5 Day 3 Day Other: ________

ANALYSIS AND PRESERVATIVE

SAMPLE ID	DATE/TIME SAMPLED	COMPOSITE OR GRAB	MATRIX	VOLUME / CONTAINER TYPES	NUMBER OF CONTAINERS							
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								
	/			/								

COMMENTS

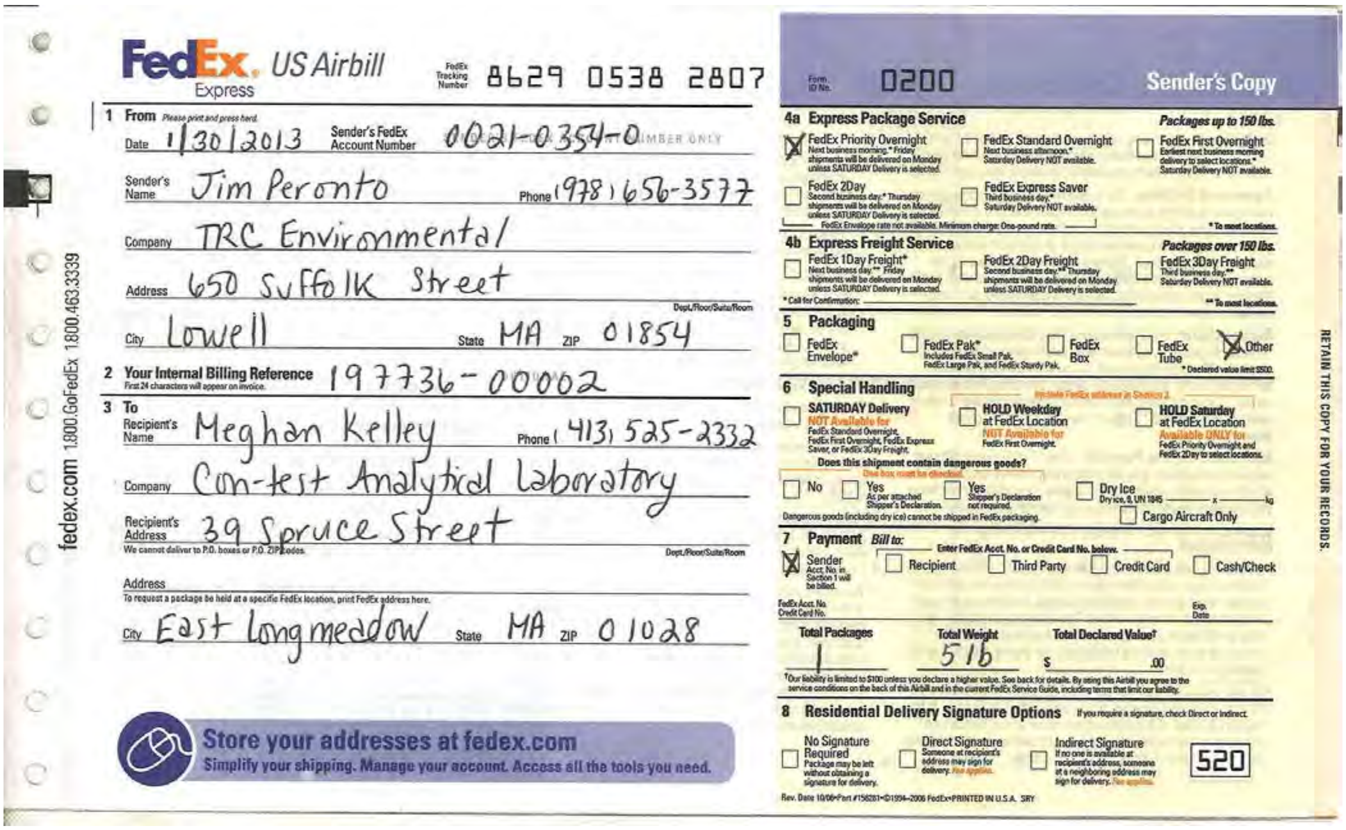
Send results to: ____________
Cooler temperature: ____________

Relinquished By:(Signature)	/ Date/Time	Received By:(Signature)	/ Date/Time
Relinquished By:(Signature)	/ Date/Time	Received By:(Signature)	/ Date/Time

№ 0020

WHITE – LABORATORY YELLOW – LABORATORY COPY PINK – OFFICE COPY GOLD – FIELD COPY

Figure 3 Example Federal Express Air Bill


FedEx Express US Airbill
FedEx Tracking Number 8629 0538 2807
Form ID No. 0200
Sender's Copy

1 From
Date 1/30/2013
Sender's FedEx Account Number 0021-0354-0
Sender's Name Jim Peronto
Phone (978) 656-3577
Company TRC Environmental
Address 650 Suffolk Street
City Lowell State MA ZIP 01854

2 Your Internal Billing Reference 197736-00002

3 To
Recipient's Name Meghan Kelley
Phone (413) 525-2332
Company Con-test Analytical Laboratory
Recipient's Address 39 Spruce Street
We cannot deliver to P.O. boxes or P.O. ZIP codes.
Address
To request a package be held at a specific FedEx location, print FedEx address here.
City East Longmeadow State MA ZIP 01028

Store your addresses at fedex.com
Simplify your shipping. Manage your account. Access all the tools you need.

4a Express Package Service — Packages up to 150 lbs.
[X] FedEx Priority Overnight
[ ] FedEx Standard Overnight
[ ] FedEx First Overnight
[ ] FedEx 2Day
[ ] FedEx Express Saver

4b Express Freight Service — Packages over 150 lbs.
[ ] FedEx 1Day Freight
[ ] FedEx 2Day Freight
[ ] FedEx 3Day Freight

5 Packaging
[ ] FedEx Envelope
[ ] FedEx Pak
[ ] FedEx Box
[ ] FedEx Tube
[X] Other

6 Special Handling
[ ] SATURDAY Delivery
[ ] HOLD Weekday at FedEx Location
[ ] HOLD Saturday at FedEx Location
Does this shipment contain dangerous goods?
[ ] No [ ] Yes As per attached Shipper's Declaration [ ] Yes Shipper's Declaration not required [ ] Dry Ice
[ ] Cargo Aircraft Only

7 Payment Bill to:
[X] Sender [ ] Recipient [ ] Third Party [ ] Credit Card [ ] Cash/Check
Total Packages 1
Total Weight 5 lb
Total Declared Value $ .00

8 Residential Delivery Signature Options
[ ] No Signature Required
[ ] Direct Signature
[ ] Indirect Signature
520

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Attachment A: SOP Fact Sheet

CHAIN-OF-CUSTODY PROCEDURES

PURPOSE AND OBJECTIVE

Chain-of-Custody procedures have been developed to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Sample custody procedures are an important part of the field investigation program to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

WHAT TO BRING

- Chain-of-Custody (COC) forms
- Sample Labels
- Custody Seals (if required)
- Indelible/waterproof ink

ON-SITE

- Complete all sample labels with indelible/waterproof ink.
- At a minimum, sample labels should include: site name; unique sample identification; sample date and time.
- COC forms must be completed for each sample set and must be initiated in the field by the sampler.
- COC forms must be completed in blue or black permanent ink.
- At a minimum, the COC forms should include: site name; sample identification; sample matrix; type of preservative; type of analysis; sampling date; and sampler's name.
- Once sampling activity is completed and the COC form is filled out, place samples in sample coolers.
- Package samples to prevent breakage and/or leakage.
- The COC forms will be reviewed by the Field Team Leader or designee prior to relinquishing the samples.
- The original COC form must accompany samples to the laboratory.
- When samples are transferred from one person to another, both the relinquisher and the person receiving the samples should sign, date and record the date of transfer on the COC form.
- If samples are not sent directly to laboratory, samples need to remain on ice and be stored in a secure location.

Appendix D
Laboratory QA/QC Plans

The testing protocol at the Trail Street Laboratory includes the following elements as general QA/QC requirements that have to be met for each analytical method before results data are validated and reported. Any exceptions to these requirements are noted in the case narrative, and the affected results are flagged accordingly.

Metals by EPA 6020B

QC Element	Control Limits (%)
Calibration Verification	90-110
LCS	80-120
LRB	< RL
Duplicate RPD	0-20
MS Recovery	75-125
MS/MSD RPD	0-20

Mercury by EPA 7470A

QC Element	Control Limits (%)
Calibration Verification	90-110
LCS	85-115
LRB	< RL
Duplicate RPD	0-20
MS Recovery	80-120
MS/MSD RPD	0-20

Inorganic Anions by EPA 300.0

QC Element	Control Limits (%)
Calibration Verification	90-110
LCS	90-110
LRB	< RL
Duplicate RPD	0-20
MS Recovery	80-120
MS/MSD RPD	0-20

Total Dissolved Solid (TDS) by SM 2540C

QC Element	Control Limits (%)
LCS	ERA Certificate of Analysis
LRB	< RL
Duplicate RPD	0-5 of average
MS Recovery	N/A
MS/MSD RPD	N/A

The analysis for each test method is performed based on the following SOPs:

- Metals; CHEM-2.5.10 (Rev 5) - Metals Analysis by Inductively Coupled Plasma - Mass Spectrometry
- Mercury; CHEM-2.5.03 (Rev 4) - Mercury Analysis in Water Samples by Cold Vapor AAS
- Anions; CHEM-2.5.40 (Rev 5) - Anions Analysis by Ion Chromatography
- TDS; CHEM-2.5.55 (Rev 0) - Filterable (TDS) Residue

TITLE: MERCURY ANALYSIS IN WATER SAMPLES BY COLD VAPOR AAS

Written or Revised by ____________ Date 06/18/2020
Level I or Above

Technical Review/Approval by ____________ Date 06/18/20
Level III (not author)

Administrative Approval by ____________ Date 06/18/20
Department Head

TITLE: MERCURY ANALYSIS IN WATER SAMPLES BY COLD VAPOR AAS

1.0 SCOPE

1.1 This procedure is used as the digestion method of aqueous samples for mercury and the analysis by cold vapor atomic absorption spectroscopy (CVAAS). Mobility-procedure extracts, aqueous wastes, surface and groundwater, brackish waters, industrial and domestic wastewaters are all considered applicable matrices for analysis by this SAP.

1.2 This SAP follows the guidelines of EPA Method 7470A.

1.3 A typical Method Detection Limit (MDL) for mercury with this procedure is 0.05µg/L. The practical quantitation level (PQL) or minimum level (ML) is 0.10µg/L.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 EPA SW-846, Test Methods for Evaluation Solid Waste, Physical/Chemical Methods, Method 7470A, Mercury in Liquid Waste.

2.2 EPA Method 245.1, Determination of Mercury in Water by Cold Vapor Atomic Absorption Spectrometry.

2.3 Chemistry Standard Operating Procedures, as applicable.

2.4 Laboratory Services Quality Assurance Procedures, as applicable.

2.5 Manufacturer's Instruction Manual for Hot Block and Nippon Mercury Analyzer.

3.0 DEFINITIONS

3.1 Sample Batch – A group of samples which behave similarly with respect to the sampling or the testing procedures being employed, and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch.

3.2 Laboratory Control Sample (LCS) – A known matrix spiked with compound(s) representative of the target analytes. The control sample should be carried through the complete sample preparation and analytical procedure. This is used to document laboratory performance.

3.3 Laboratory Reagent Blank (LRB) or Method Blank (MB) – An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in

sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process. For a method blank to be acceptable for use with the accompanying samples, the concentration in the blank of any analyte of concern should not be higher than the highest of either:
(1) 2.2 x MDL (method detection limit), or
(2) Five percent of the regulatory limit for that analyte, or
(3) Ten percent of the measured concentration in the sample.

3.4 Matrix Duplicate (DUP) – An intra-laboratory split sample undergoing all preparation and analysis steps as the parent sample and which is used to document the precision of the method. The precision (or repeatability) is expressed as % RPD (Relative Percent Difference).

3.5 Matrix Spike (MS) – An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

3.6 Matrix Spike Duplicates (MSD) – Intra-laboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

3.7 Method Detection Limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

3.8 ERA – An optional secondary standard, similar or in addition to the ICV (Initial Calibration Verification), purchased from Environmental Resources Associates and provided with a certificate of analysis and acceptance criteria limits by the vendor, per each lot. When a specific ICV standard is not used, the ERA serves as the following:

- Quality Control Sample or QCS, referred in EPA Method 245.1
- Initial Calibration Verification or ICV, referred in SW-846 methods

4.0 SUMMARY OF METHOD

4.1 A known portion of a water sample is transferred to a digestion vessel, digested in a mixture of Sulfuric and Nitric Acid, and oxidized at 95°C in a hot block for 2 hours with potassium permanganate/potassium persulfate.

4.2 After the preparation is complete, the Mercury in the digested sample is reduced with stannous chloride to elemental mercury and measured by conventional cold vapor atomic absorption spectrometry (CVAAS).

4.2 The typical range for mercury with this standard analytical procedure (SAP) is 0.1-10 µg/L.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Hot Block – A heating device capable of maintaining a temperature of 95°C.

5.1.2 Digestion polypropylene vessels, 50mL.

5.1.3 Automatic Eppendorf pipettes with adjustable volumes, 10-100 µL (yellow tips); and 100 - 1,000 µL (blue tips).

5.1.4 CVAAS Mercury Analyzers – Nippon Instruments Corporation, Model RA-3 equipped with an auto sampler, SC-3, reagent dispenser, RD-3, and computerized software control, RA3Win, version 1.1.7. Nippon Instruments Corporation, Model RA-3A equipped with an auto sampler, SC-3, reagent dispenser, RD-3, and computerized software control, RA3000AWin, version 1.1.6.

5.2 REAGENTS

5.2.1 Reagent Water – All reagent water shall be analyte free reagent water. All references to water in this procedure refer to reagent water unless otherwise specified.

5.2.2 Potassium permanganate, $KMnO_4$, 5% solution (w/v) – Dissolve 100 g of potassium permanganate in 2 liters of reagent water.

5.2.3 Sulfuric acid, H_2SO_4, concentrated – Redistilled or Trace Metal grade of low mercury content.

5.2.4 Nitric acid, HNO_3, concentrated – Redistilled or Trace Metal grade of low mercury content.

5.2.5 Potassium persulfate, 5% solution (w/v) – Dissolve 100 g of potassium persulfate in 2 liters of reagent water.

5.2.6 Sodium Chloride-Hydroxylamine Sulfate solution – Dissolve 60 g of sodium chloride and 60 g of hydroxylamine sulfate in reagent water and dilute to 500mL. Hydroxylamine hydrochloride may be used in place of hydroxylamine sulfate, preparation of Hydroxylamine hydrochloride remains the same.

5.2.7 Stannous Chloride, 20% w/v – Dissolve 10 g of stannous chloride in 15 ml of concentrated HCl; add 35 ml of reagent water.

5.2.8 Mercury Stock Solution, 1000 ppm – Purchased commercially from manufacturers like High Purity Standards, Inorganic Ventures , or SPEX Industries.

5.2.9 Mercury Working Standards – Add 100µL of the 1,000ppm Hg Stock (5.2.8), 1mL HCl and 1ml of HNO_3 to a 100mL Class A volumetric flask. Bring to volume with reagent water to make a 1 ppm Hg solution. Add 10 mL of the 1 ppm Hg working standard, 1mL HCl and 1ml HNO_3 to a 100mL Class A volumetric flask. Bring to volume with reagent water to make a 0.1 ppm Hg solution. These working standards are prepared fresh, each day when mercury is analyzed.

5.2.10 Solution volumes stated may be adjusted to fit sample load, but solution concentrations must remain as stated.

5.3 CALIBRATION REQUIREMENTS

5.3.1 Dispense 1.5 ml of H_2SO_4 and 0.75 mL of HNO_3 in preparation vessel containing 30 ml of reagent water. For first standard of 0.2 ppb, add 60 µL of 0.1 ppm working standard (Section 5.2.9). Follow the steps in 9.4 – 9.9 to finish digestion of standards along with samples.

5.3.2 To prepare the next set of standards, follow Steps in 5.3.1 using additions of 150 µL, 300 µL, 600 µL of 0.1 ppm working standard, and 150 µL, 300 µL of 1.0 ppm working standard to produce standards of 0.5, 1.0, 2.0, 5.0, and 10 ppb, respectively. A calibration blank is prepared along with the standards in a similar manner, except for the addition of the working standard. Follow steps 9.4 – 9.9 to finish digestion of standards along with samples.

5.3.3 The calibration curve described above would consist of a minimum of 5 standard levels (0, 0.2, 0.5, 1.0, 2.0, and 10.0 µg/L) and must achieve a minimum correlation coefficient of 0.995 in order to be considered valid. The 5.0 ppb standard is used as a mid-point continuing calibration verification standard.

5.3.4 The mid points of the calibration curve cannot be dropped. If a low point is dropped the reporting limit must be increased to the level of the lowest standard included in the curve. If a high point is dropped samples must be diluted within the concentration range of highest point. When permissible changes (as described above) to the calibration curve are necessary, the date and initials of the person making the adjustment, and the reason for the adjustment are to be documented. The change must be approved by the Technical Director (or delegate) before the curve is used to generate results for analytical samples.

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 The preparation of the samples is recorded in a laboratory notebook, along with the lot numbers and/or solution numbers of all reagents and standards used during digestion. A digestion worksheet (or form similar in intent) can be used as well for this purpose and must have the initials and date of the person completing the preparation on every page. An example of the digestion worksheet is found on the Company network, at "K:\CHEM\Mercury\Mercury".

5.4.2 Raw data hardcopy printouts.

5.4.3 After the analysis has been completed the results are summarized onto an Excel Reporting Form, which also includes the QA/QC summary for the analytical run, and traceability information for the calibration standards.

5.4.4 When the information in section 5.4.2 is entered directly in LIMS, the Excel Reporting Form is considered optional and its completion is left at the analyst's discretion.

5.5 PERSONNEL REQUIREMENTS

5.5.1 All tests and data reporting shall be performed by certified persons of Level I or above, in the appropriate discipline. The project report shall be issued and reviewed by a certified person of Level II or above, in the appropriate discipline. The project report if so, indicated on the work request (or form similar in intent), may require approval from a certified person of Level III, in the appropriate discipline.

5.5.2 For projects where reporting under the 2009 TNI Standard has been requested, all tests and data reporting shall be performed by analysts with a completed initial, or an on-going Demonstration of Capability (IDOC/DOC), as applicable.

5.6 ENVIRONMENTAL CONDITIONS

5.6.1 Digestion and the addition of reagents must take place in a fume hood.

5.6.2 Samples must be prepared and analyzed within 28 days of sample collection date, in accordance with CHEM-1.2.02 – Sample Preservation, Hold Time and Containers.

6.0 PRECAUTIONS

6.1 Observe normal safety practices as specified in the latest online revision of the Accident Prevention Manual and the Consumers Energy Chemical Hygiene Plan.

6.2 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Every effort should be made to minimize the generation of excess waste in the preparation of standards and reagents related to this procedure.

6.3 For guidance on proper disposal of unused samples, stock chemicals and reagents refer to SOP CHEM-1.2.08 Handling and Disposal of Lab Testing Waste.

7.0 LIMITATIONS AND ACTIONS

7.1 Sulfide is a possible interference with mercury determination and is eliminated by the addition of potassium permanganate. Concentrations as high as 20 mg/Kg of sulfide, as sodium sulfide, do not interfere with the recovery of added inorganic mercury.

7.2 Copper has also been known to interfere; however, copper at concentrations as high as 10 mg/Kg has had no effect on recovery of mercury from spiked samples.

7.3 Samples high in chlorides require additional permanganate to eliminate the production of free chlorine from chloride, which interferes with the analysis wavelength of 253.7 nm. Free chlorine is removed by the addition of excess hydroxylamine sulfate.

7.4 Organic compounds which have broadband UV absorbance at/near 253.7 are interferences. When a sample is known to be a solvent, glycol, or thin oil, and is to be analyzed by this method, verify the matrix effect by employing a matrix spike for the suspect sample, in addition to the regular sample aliquot.

7.5 This digestion procedure is not intended for sample preparation and digestion for low-level mercury (below 0.1 ppb).

7.6 Certain volatile organic materials that absorb at the 253.7 nm wavelength may cause interference. A preliminary run at the instrument, without reagents should determine if this type of interference is present.

8.0 ACCEPTANCE CRITERIA

8.1 The frequency of the quality control items, their acceptance criteria and associated corrective action for this method SAP is listed in the table below:

Quality Control Items, Frequency and Corrective Action

QC Item	Frequency	Acceptance Criteria	Corrective Action
ICV	After initial instrument calibration.	90-110% (EPA 7470A) 95-105%(EPA 245.1)	Reanalyze to confirm. If confirmed, reprep and reanalyze batch.
ICB	Immediately following ICV	<2.2 x MDL or <10% of analyte in samples	Reanalyze to confirm. If confirmed, reprep and reanalyze batch.
ERA	Once per analysis.	As the range provided on the certificate of analysis	Reanalyze to confirm. If confirmed, reprep and reanalyze batch. Replace calibration standard(s) if necessary.
LCS	Every batch of 20 samples.	85-115%	Reanalyze to confirm. If confirmed, reprep and reanalyze batch.
LRB	Every batch of 20 samples.	<2.2 x MDL or <10% of analyte in samples	Reanalyze to confirm. If confirmed, reprep and reanalyze batch.
CCV	Before and after each batch. Every 10 samples.	90-110%	All samples following the last acceptable CCV must be reanalyzed after the problem has been identified and corrected.
CCB	Before and after each batch. Every 10 samples.	<2.2 x MDL or <10% of analyte in samples	All samples following the last acceptable CCB must be reanalyzed after the problem has been identified and corrected.
DUP	Every batch of 20 samples.	RPD 0-20%	Reanalyze to confirm. If confirmed, reprep and reanalyze batch.
MS	Every 20 samples. (EPA 7470A) Every 10 samples. (EPA 245.1)	80-120% (EPA 7470A) 70-130% (EPA 245.1)	(EPA 7470A) Reanalyze to confirm. If confirmed, reprep and reanalyze batch. (EPA 245.1) If LCS and CCV's are within limits data is still acceptable. The issue is judged to be matrix related not system related. Otherwise follow instructions for EPA 7470A.
MSD	Same as MS.	Same as MS with RPD 0-20%	Same as MS.

8.2 Method detection limit (MDL) - A mercury MDL must be established using an LRB solution fortified at a concentration of two to three times the estimated detection limit. Refer to the most current EPA Method to determine the MDL, referenced in 40 CFR Part 136. When an MDL is not established, all results are to be evaluated for reporting at the quantitation level, as defined in the applicable TNI standard, typically at the lowest standard level included in the calibration curve.

9.0 PROCEDURE

9.1 Transfer 30 mL sample, or an aliquot diluted to 30 mL with reagent water, by pouring from the sample bottle or by using a pipette, to a 50mL digestion vessel.

NOTE: Reduced or increased volumes or semi-automated versions of this method that use the same reagents and molar ratios are acceptable.

CAUTION: All reagent additions should take place in a fume hood.

9.2 Add 1.5 mL H_2SO_4, conc., and swirl to mix.

9.3 Add 0.75 mL HNO_3, conc., and swirl to mix.

9.4 Add 4.5 mL $KMnO_4$ solution to all samples, in the hood. Swirl to mix and wait 15 minutes before the next step to ensure that the purple color persists. Add additional portions of potassium permanganate solution, if necessary, until the purple color persists for at least 15 minutes (record the volume of excess potassium permanganate on the digestion worksheet).

9.5 Add 2.4 mL potassium persulfate and swirl to mix.

9.6 Cap loosely and heat for 2 hours in a hot block at 95°C ± 3°C.

9.6.1 A capped digestion vial, containing about 30mL of reagent water, is randomly placed in a different location within the hot block with each batch during digestion. This capped blank uses a calibrated temperature measuring device to monitor the internal sample temperature. To prevent the sample from boiling, take caution to not exceed internal temperature of 100°C. The vertical columns of the hot block are labeled with ‘A’– ‘F’ and the horizontal rows are labeled with ‘1’–‘9’. The position used (ex. C10), time, and temperature at the beginning and end of digestion is recorded on the digestion worksheet. The temperature of the hot block is set to 112°C to allow for the internal temperature to be 95°C ± 3°C.

9.7 Remove the vessels and cool.

9.8 Cautionary note: although the strength of the oxidizing agent is verified in section 9.4 above, it’s best when samples have a purple hue after removal from the hot block and before addition of sodium chloride-hydroxylamine sulfate, or hydroxylamine hydrochloride. When a sample does not maintain a purple hue, it could be an indication of an incomplete oxidation. The sample should be considered suspect for matrix effect; re-digestion starting with Section 9.1 might be needed. A diluted aliquot and/or increased potassium permanganate should be considered if the sample is to be re-digested. Record all dilutions, re-digestions, and excess solution added on the digestion worksheet.

9.9 Add 1.8 mL sodium chloride-hydroxylamine sulfate, or hydroxylamine hydrochloride, to reduce excess permanganate. Additional sodium chloride-hydroxylamine sulfate, or hydroxylamine hydrochloride, solution may be required if additional permanganate solution was added (record the volume of any excess solution added).

9.10 Samples are now ready for analysis.

9.11 Standards and Quality Assurance.

9.11.1 Prepare the following, alongside the samples, using Sections 9.1 through 9.9:

- Laboratory Reagent Blank, one per batch of 20 samples.
- Laboratory Control Sample using reagents and mercury standard for a final concentration of 2 µg/L, ppb (or other designated concentration), one per batch of 20 samples.
- Duplicate sample, one per batch of 20 samples if reporting method 7470A or one for every 10 samples if reporting method 245.1.
- Matrix spike and a matrix spike duplicate using the mercury standard for a final added concentration of 2 µg/L, ppb (or other designated concentration). The MS/MSD should be analyzed at a frequency of one per batch of 20 samples if reporting method 7470A, or one for every 10 samples if reporting method 245.1.

  NOTE: The MS/MSD is prepared following the steps in 9.1 through 9.9 above. The sample volume used for MS/MSD shall be equal to the volume used for the parent sample. If only a limited sample volume is available, the duplicate analysis above is optional, and the repeatability is to be evaluated by calculating the % RPD for the MS/MSD pair.

9.12 Calibration and use of Nippon Instruments Reducing Vaporization Mercury Analyzer MERCURY/RA-3.

TITLE: MERCURY ANALYSIS IN WATER SAMPLES BY COLD VAPOR AAS

9.12.1 Turn on power switches. It will take approximately 20 minutes for instrument to warm up.

9.12.2 Prepare the Stannous Chloride (5.2.7) in designated bottle located in holder on the instrument. Prepare 3% v/v HCl (97 mL reagent water and 3 mL HCL) in the designated bottle located in holder on the instrument. Fill Rinse bottle with fresh reagent water. Attach appropriate pump tubing to each bottle.

9.12.3 Once the instrument has warmed up, the main screen will appear on RA-3, use touch screen to select <SC/RD >.

9.12.4 Use arrow button to highlight "1. Measurement Preparation" and press the Enter button. Make sure tubing is in place, press Start/Stop button. Reagents will be injected.

9.12.5 When the injections have finished, press the ESC button to return to the main screen.

- Note: Program/Instrument will not start if not on main screen.

9.12.6 Open RA3Win program on computer.

9.12.7 Enter appropriate Calibration concentrations, starting with blanks and ending with highest concentration, and volume amounts in the STD tab.

9.12.8 Pipette 5 mL of each standard into a clean, dry sample tube and place in the corresponding positions indicated in the program. Check boxes for all standard positions in use, click green Start button in upper left of program.

9.12.9 Once Calibration Curve is acceptable, enter sample information under SMP tab. Pipette 5 mL of each sample into a clean, dry sample tube and place in the corresponding positions indicated in the program. Check boxes for all positions in use, click green start to begin run.

9.12.10 At the end of the run, save the run using a specific name (Ex. AB20-0117), print the calibration and raw data, then select <SC/RD> on the touch screen of RA-3.

9.12.11 Use arrow button to highlight "2. Finishing Measurement". Press Enter. Follow instructions on screen to rinse and drain reagents from pump tubing.

- Note: There are multiple steps to draining and rinsing pump tubing.

9.12.12 Turn off power switches on rear of RA-3 and SC-3.

9.13 Calibration and use of Nippon Instruments Reducing Vaporization Mercury Analyzer MERCURY/RA-3A.

9.13.1 Turn on power switches on rear of RA-3 and SC-3. It will take approximately 20 minutes for instrument to warm up.

9.13.2 Prepare the Stannous Chloride (5.2.7) in designated bottle located in holder on the instrument. Prepare 3% v/v HCl (97 mL reagent water and 3 mL HCL) in the designated bottle located in holder on the instrument. Fill Rinse bottle with fresh reagent water. Attach appropriate pump tubing to each bottle.

9.13.3 Once the instrument has warmed up, the main screen will appear on RA-3A. Open RA3000AWin program on computer. Click the ‘Run’ tab at the top left of the program. Scroll down to ‘Reagent Operation’ and click on ‘Reagent Filling’. Follow the steps to introducing the reagents prior to analyzing samples.

9.13.4 Follow Section 9.12.7 – 9.12.9 within this procedure to analyze samples.

9.13.5 At the end of the run, save the run using a specific name (Ex. AB20-0117), print the calibration and raw data, then select the ‘Run’ tab at the top left of the program. Scroll down to ‘Reagent Operation’ and click on ‘Reagent Discharge’. Follow the steps to discharge all reagents from the tubing.

9.13.6 Turn off power switches on rear of RA-3 and SC-3.

10.0 CALCULATIONS

10.1 MDL - Calculate the MDL as follows:

$$MDL = t \times S$$

where,
t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t= 3.14 for seven replicates]
S = standard deviation of the replicate analyses

10.2 Percent Recovery – Calculate percent recovery using the following equation:

$$R = \frac{C_s - C}{s} \times 100$$

TITLE: MERCURY ANALYSIS IN WATER SAMPLES BY COLD VAPOR AAS

where,
R = percent recovery
C_s = fortified sample concentration
C = sample background concentration
s = concentration equivalent of analyte added to sample

10.3 Relative Percent Difference - Calculate RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\frac{C_1 + C_2}{2}} \times 100$$

where,
RPD = relative percent difference,
C_1 = first analyte concentration,
C_2 = second analyte concentration.

11.0 DATA REPORTING

11.1 Create an analysis batch in LIMS.

11.2 Generate a .csv file and place it in the parser folder for Mercury, to be transferred electronically into LIMS. Data can also be manually entered into LIMS.

11.3 Print the instrument raw data for the analysis run and forward it along with the sample preparation and QA/QC summary to the person responsible for data review & validation.

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

Written or Revised by ______________ Date 06/18/2020
Level I or Above

Technical Review / Approval by ______________ Date 06/18/20
Level III (not author)

Administrative Approval by ______________ Date 06/18/20
Department Head

1.0 SCOPE

1.1 Inductively coupled plasma-mass spectrometry[1-2] (ICP-MS) is applicable to the determination of sub-µg/L concentrations of a large number of elements in water samples and in soil, solids, and waste extracts or digests. When dissolved constituents are required, samples are filtered through 0.45 µm membrane filters and acid-preserved prior to analysis. No digestion is needed prior to analysis for dissolved elements in water samples; however, it is recommended that dissolved solids be lower than 0.2% (w/v), in order to reduce potential interferences. Acid digestion prior to filtration and analysis is performed for groundwater, aqueous samples, industrial wastes, soils, sludges, sediments, and other solid wastes for which total (acid-leachable) elements are needed. This SAP (Standard Analytical Procedure) follows the guidelines of both, EPA Method 200.8 and SW-846 Method 6020B.

1.2 The elements that can be determined using this SAP are listed below. Typical MDL and reporting limits are listed in Table 1 (Attachment A).

Metal	Symbol	CAS No	Metal	Symbol	CAS No
Aluminum	Al	7429-90-5	Magnesium	Mg	7439-95-4
Antimony	Sb	7440-36-0	Manganese	Mn	7439-96-5
Arsenic	As	7440-38-2	Molybdenum	Mo	7439-95-4
Barium	Ba	7440-39-3	Nickel	Ni	7440-02-0
Beryllium	Be	7440-41-7	Potassium	K	7440-09-7
Boron	B	7440-42-8	Selenium	Se	7782-49-2
Cadmium	Cd	7440-43-9	Silver	Ag	7440-22-4
Calcium	Ca	7440-70-2	Sodium	Na	7440-23-5
Chromium	Cr	7440-47-3	Strontium	Sr	7440-24-6
Cobalt	Co	7440-48-4	Tin	Sn	7440-31-5
Copper	Cu	7440-50-8	Titanium	Ti	7440-32-6
Iron	Fe	7439-89-6	Thallium	Tl	7440-28-0
Lead	Pb	7439-92-1	Vanadium	V	7440-62-2
Lithium	Li	7439-93-2	Zinc	Zn	7440-66-6

1.3 If this procedure is used to determine any analyte not listed in the table above, it is the responsibility of the analyst to demonstrate the accuracy and precision of the method in the samples to be analyzed. The analyst is always required to monitor potential sources of interferences and take appropriate action to ensure data of known quality.

1.4 Users of the method data should state the data-quality objectives prior to analysis. Users of the method must document and have on file the required initial demonstration performance data described in Section 11.2 prior to using the method for analysis.

1.5 With the exception of silver, where this method is approved for the determination of certain metal and metalloid contaminants in drinking water, samples may be analyzed directly by pneumatic nebulization without acid digestion if the samples have been properly preserved with acid and have turbidity of <1 NTU at the time of analysis. This total recoverable determination procedure is referred to as "direct analysis".

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 Laboratory Services Quality Assurance Procedures, as applicable.

2.2 Chemistry Department Standard Operating Procedures, as applicable.

2.3 Applicable Metals Sample Preparation Procedure(s).

2.4 Horlick, G., et al., *Spectrochim. Acta 40B,* 1555 (1985).

2.5 Gray, A. L., *Spectrochim. Acta 40B,* 1525 (1985); 41B, 151 (1986).

2.6 Tan, S. H., and Horlick, G., *Appl. Spectrosc. 40,* 445 (1986).

2.7 Vaughn, M. A., and Horlick, G., *Appl. Spectrosc. 40*, 434 (1986).

2.8 Holden, N. E., "Table of the Isotopes," in Lide, D. R., Ed., *CRC Handbook of Chemistry and Physics,* 74th Ed., CRC press, Boca Raton, FL, 1993.

2.9 Hinners, T. A., Heithmar, E., Rissmann, E., and Smith, D., *Winter Conference on Plasma Spectrochemistry,* Abstract THP18; p. 237, San Diego, CA (1994).

2.10 Lichte, F. E., et al., *Anal. Chem. 59,* 1150 (1987).

2.11 Evans, E. H., and Ebdon, L., *J. Anal. At. Spectrom. 4,* 299 (1989).

2.12 Beauchemin, D., et al., *Spectrochim. Acta 42B,* 467 (1987).

2.13 Houk, R. S., *Anal. Chem. 58,* 97A (1986).

2.14 Thompson, J. J., and Houk, R. S., *Appl. Spectrosc. 41,* 801 (1987).

2.15 SW-846, Method 6020A, Revision 1, February 2007.

2.16 EPA Method 200.8, Revision 5.5, 1998.

3.0 DEFINITIONS

3.1 Accuracy – The closeness of agreement between an observed value and an accepted

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

reference value. When applied to a set of observed values, accuracy will be a combination of a random component and of a common systematic error (or bias) component.

3.2 Batch – A group of samples which behave similarly with respect to the sampling or the testing procedures being employed and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch.

3.3 Bias – The deviation due to matrix effects of the measured value (x_s - x_u) from a known spiked amount. Bias can be assessed by comparing a measured value to an accepted reference value in a sample of known concentration or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike). Thus, the bias (B) due to matrix effects based on a matrix spike is calculated as:

$$B = (x_s - x_u) - K$$

Where: x_s = measured value for spiked sample
x_u = measured value for unspiked sample
K = known value of the spike in the sample

Using the following equation yields the percent recovery (%R):

$$\%R = 100\,(x_s - x_u)/K$$

3.4 Blank – See Equipment Rinsate, Field Blank, Laboratory Reagent Blank and Method Blank.

3.5 Calibration Blank – A volume of reagent water acidified with the same acid matrix as in the calibration standards. The calibration blank is a zero standard and is used to calibrate the ICP instrument.

3.6 Calibration Curve or Standard Curve – A plot of concentrations of known analyte standards versus the instrument response to the analyte.

3.7 Calibration Standard – A solution used to calibrate the instrument response with respect to the analyte concentration. Calibration standards are prepared by successively diluting a stock standard solution to produce working standards which cover the working range of the instrument. Standards should be prepared at the frequency specified in the appropriate section, using the same type of acid or solvent and at the same concentration as the samples to be analyzed, following sample preparation.

3.8 Continuing Calibration Verification (CCV) – A mid-point standard prepared from the same stock solution as the calibration standards, used to check the performance of the instrument and verify that the instrument is properly calibrated on a continuing basis. It is also referred to as the Instrument Check Standard. The CCV standard should be prepared so as to contain metal concentrations equal, or nearly equivalent to the midpoint concentration of the calibration curve.

3.9 Control Sample – A QC sample introduced into a process to monitor the performance of the system.

3.10 Dissolved Analyte – The concentration of analyte in an aqueous sample that will pass through a 0.45 µm membrane filter assembly prior to sample acidification.

3.11 Duplicate (Dup) – See Matrix Duplicate, Field Duplicate and Matrix Spike Duplicate.

3.12 Equipment Blank – See Equipment Rinsate.

3.13 Equipment Rinsate – A sample of analyte-free media which has been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. This blank is useful in documenting adequate decontamination of sampling equipment.

3.14 Field Blank – An aliquot of reagent water or other blank matrix that is placed in a sample container in the laboratory or in the field, and treated as a sample in all respects, including shipment to the sampling site, exposure to the sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the field blank is to determine if method analytes or other interferences are present in the field environment.

3.15 Field Duplicates – Independent samples which are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate containers, and analyzed independently. These duplicates are useful in documenting the precision of the sampling process.

3.16 Initial Calibration Verification (ICV) – A standard made from a stock solution obtained from a source different than the one used for the calibration standards, used to verify the validity of the calibration curve. The ICV standard should be prepared so as to contain metals concentrations that are near, but not equal to the midpoint concentration level of the calibration curve.

3.17 Instrument Detection Limit (IDL) – The concentration equivalent to the analyte signal which is equal to three times the standard deviation of a series of 7-10 replicate measurements of the calibration blank signal at the selected analytical masses. The smallest concentration detectable on a specific instrument.

3.18 Internal Standard (IS) – Pure analytes added to a sample, extract, or standard solution in known amounts and used to measure the relative responses of other method analytes that are components of the same sample or solution. The internal standard must be an analyte that is not a sample component.

3.19 Laboratory Control Sample (LCS) – A known matrix, solid or liquid, spiked with compound(s) representative of the target analytes. This is used to document laboratory performance. The LCS is analyzed exactly like a sample, carried through all steps of the sample preparation, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements. If the matrix used is aqueous, the LCS is equivalent to the Laboratory Fortified Blank (LFB) described below.

3.20 Laboratory Fortified Blank (LFB) – An aliquot of LRB to which known quantities of the method analytes are added in the laboratory. The LFB is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

3.21 Laboratory Reagent Blank (LRB) or Method Blank or Preparation Blank – An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process. Based on the needs of the project, the concentration in the blank of any analyte of concern should not be higher than either of:

- The method detection limit times 2.2
- Half of the lower limit of quantitation (LLOQ)
- Ten percent of the measured concentration in the sample.

3.22 Linear Dynamic Range (LDR) – The concentration range over which the instrument response to an analyte is linear. The Upper Linear Dynamic Range limit is defined as the concentration where the measured value is within 10% of the actual prepared value of the linear range verification (LRV) standard. An LRV standard is analyzed at the beginning of every analytical run. If a linear verification standard is not employed, all sample results above the highest calibration standard are to be diluted in the working range of the analyzer. Typical analytes included in the LRV standard and their expected concentrations are listed in Table 1 (Attachment A).

3.23 Lower Limit of Quantitation (LLOQ) – A low concentration level determined through the analysis of at least 7 replicate samples spiked at the LLOQ and processed through all preparation and analysis steps of the method. The mean recovery and relative standard deviation of these samples provide an initial statement of precision and accuracy at the LLOQ. The mean recovery should be within 35% of the true value and the RSD should be < 20%.

3.24 Lower Limit of Quantitation (LLOQ) Check Standard – A low concentration level standard (at LLOQ) used to check the performance of the instrument at the LLOQ level. It is also referred to as the low level read-back standard or verification, or blank spike (BS) standard. Typical analytes and their expected concentration at the LLOQ are listed in Table 1 (Attachment A).

3.25 Matrix – The component or substrate (i.e., surface water, drinking water, soil) which contains the analyte of interest.

3.26 Matrix Duplicate (Dup) – An intra-laboratory split sample which is used to document the precision of a method in a given sample matrix.

3.27 Matrix Spike (MS) – An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

3.28 Matrix Spike Duplicates (MSD) – Intra-laboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.

3.29 Method Detection Limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

NOTE: The MDL is to be performed by following the EPA guidelines approved at CFR 40 Part 1136.

3.30 Precision – The agreement among a set of replicate measurements without assumption of knowledge of the true value. Precision is estimated by means of duplicate/replicate analyses. These samples should contain concentrations of analyte above the MDL and may involve the use of matrix spikes. The most commonly used estimates of precision are the relative standard deviation (RSD) or the coefficient of variation (CV), and the relative percent difference (RPD) when only two samples are available.

$$RSD = CV = 100\frac{S}{\overline{x}}$$

Where x = the arithmetic mean of the x_i measurements, and S = variance.

$$RPD = 100\left[(x_1 - x_2)/\{(x_1 + x_2)/2\}\right]$$

3.31 Quality Assurance – An orderly assemblage of detailed procedures designed to produce data of sufficient quality to meet the data quality objectives for a specific data collection activity.

3.32 Quality Control Sample (QCS) – A solution of method analytes of known concentrations which is used to fortify an aliquot of Reagent Water and acidified to the same acid type and concentration as present in calibration standards and analytical samples. The QCS is obtained from a source external to the laboratory and different from the source of calibration standards. It is the equivalent of the ICV standard.

3.33 Reagent Blank – See Method Blank, Laboratory Reagent Blank.

3.34 Reagent Grade – Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents which conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

3.35 Reagent Water – Water that has been generated by any method which would achieve the performance specifications for ASTM Type 1 water (ASTM 1193D).

3.36 Reference Material – A material containing known quantities of target analytes in solution or in a homogeneous matrix. It is used to document the bias of the analytical process.

3.37 Rinse Blank – A solution consisting of 2% Nitric Acid in reagent grade water, used to flush the instrument for a predetermined amount of time, between each measurement of standards and/or samples, during the instrument's "wash" cycle. The purpose of the wash is to ensure that all traces of the analytes from the previous measurement are rinsed out before moving to the next measurement.

3.38 SOP – Standard Operating Procedure, a written document that details the process for an operation, analysis, or action, with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks. Used mainly for administrative procedures.

3.39 SAP – Standard Analytical Procedure, a written document that details the process for an operation, analysis, or action, with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks. Used mainly for analytical procedures.

3.40 Split Samples – Aliquots of sample taken from the same container and analyzed independently. In cases where aliquots of samples are impossible to obtain, field duplicate samples should be taken for the matrix duplicate analysis. These are usually taken after mixing or composting and are used to document intra- or inter-laboratory precision.

3.41 Standard Addition – The practice of adding a known amount of an analyte to a sample immediately prior to analysis. It is typically used to evaluate interferences.

3.42 Stock Standard Solution – A concentrated solution containing one or more method analytes, purchased from a reputable commercial source, and accompanied by a Certificate of Analysis which provides NIST traceability information.

3.43 Total Recoverable Analyte – The concentration of analyte determined by analysis of the solution extract of a solid sample or an unfiltered aqueous sample following digestion with hot mineral acid(s) as specified in the sample preparation methods.

3.44 Tuning Solution – A solution which is used to determine acceptable instrument performance prior to calibration and sample analyses, based on the specifications of the method and/or manufacturer.

4.0 SUMMARY OF METHOD

4.1 An aliquot of a well-mixed, homogeneous aqueous or solid sample is accurately weighed or measured for sample processing. For total recoverable (“acid-leachable”) analysis of a solid or an aqueous sample containing undissolved material, analytes are first solubilized through the use of appropriate sample digestion procedures (EPA SW-846, Method 3005 – Method 3052, SM 3030E). For the determination of dissolved analytes in a filtered aqueous sample aliquot, or for the “direct analysis” total recoverable determination of analytes in drinking water where sample turbidity is <1 NTU, the sample is made ready for analysis by the appropriate addition of nitric acid, Internal Standard, and dilution to a predetermined volume. The samples should be mixed well before analysis.

4.2 During analysis, sample material in solution is introduced by pneumatic nebulization into radio-frequency plasma where energy transfer processes cause desolvation, atomization and ionization. The ions are extracted from the plasma through a differentially pumped vacuum interface and separated on the basis of their mass-to-charge ratio by a quadrupole mass spectrometer having a minimum resolution capability of 0.90 amu peak width at 10% peak height. The ions transmitted through the quadrupole are detected by an electron multiplier or Faraday detector and the ion information processed by a data handling system. Interferences relating to the technique (Section 7.1) must be recognized and corrected. Such corrections must include compensation for isobaric elemental interferences and interferences from polyatomic ions derived from the plasma gas reagents or sample matrix. Instrumental drift as well as suppressions or enhancements of instrument response caused by the sample matrix must be corrected for by the use of internal standards.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Inductively coupled plasma-mass spectrometers manufactured by Perkin Elmer; **Elan DRC II Standard Mode and NexION** ICP-MS models**.**

5.1.1.1 The Elan is a freestanding mobile bench-mounted ICP mass spectrometer designed for routine trace element analysis. The vacuum system utilizes a 360 L/sec and a 50 L/sec side-mounted turbomolecular pump (only one turbo-pump for Elan DRC II), backed by two conventional roughing pumps. All required electronics, turbomolecular, and roughing pumps are located within the bench housing, which is fitted with doors on all four sides to provide easy access for maintenance and service.

5.1.1.2 A compact, fully automated free-running RF generator powers the ICP at 40 MHz, which provides highly efficient power coupling to the plasma with rapid and responsive electronic autotuning. The operating power and autotuning of the generator is under full computer control and provides an operating range of 600 to1600 watts.

5.1.1.3 A unique PlasmaLok® interface eliminates secondary discharges and stabilizes ion energies, ensuring that optimum performance is maintained across a wide range of samples types and operating conditions.

5.1.1.4 The sample introduction system consists of a cross flow nebulizer with, a quartz chamber inert to most mineral acids and organic solvents, and a fully-demountable torch assembly on a quick-change bayonet mount, with 1.2 mm Injector Tube.

5.1.1.5 The AutoLens ion optics system enables on-the-fly computer controlled lens optimization to generate maximum analyte ion signal with minimum interference.

5.1.1.6 The quadrupole of the ICP-MS systems, driven by a high-frequency 2.5 MHz power supply, was carefully designed to produce a perfect hyperbolic field for optimum resolving power and ion transmission efficiency, producing an abundance sensitivity of greater than 10^6 that helps minimize spectral interferences. The combination of the thermally stabilized quadrupole power supply and the state-of-the-art binary, gold-metallized ceramic roads offers exceptional mass calibration stability.

5.1.1.7 A dual-stage discrete dynode electron multiplier provides detection over a full eight orders of magnitude of dynamic range.

5.1.1.8 The instruments are controlled by the Elan and NexION software. The software, in conjunction with the System Controller, continuously monitors over 70 test points of the instrument to ensure that if a failure should occur, the system will alert the operator or, if necessary, shut the instrument down safely.

5.1.2 S-10 Auto-samplers.

5.1.3 PolyScience, Model 6105PE Cooling Units.

5.1.4 Argon gas supply: 160 L Dewar of high purity liquid Argon.

5.1.5 Digital bottle top dispenser capable of dispensing volumes of 0.2 mL in 0.01 mL increments.

5.1.6 Automatic pipette with disposable 2.50 mL combitips capable of dispensing volumes from 100 to 500 µL.

5.1.7 Automatic pipettors with adjustable volumes, 10-100 µL (yellow tips); 100-1,000 µL (blue tips).

5.1.8 Polypropylene vessels, 50 mL.

5.1.9 Volumetric flasks of various volumes, 10 mL to 1 L.

5.2 REAGENTS

5.2.1 Nitric Acid (HNO_3), concentrated, Trace Metal Grade. Acids used in the preparation of standards and for sample processing must be of high purity. Trace metal grade (also known as re-distilled) acids are recommended because of the high sensitivity of ICP-MS. Nitric acid at 2% (v/v) or less in the solution to be analyzed is required for the ICP-MS, in order to minimize damage to the interface.

5.2.2 Hydrochloric Acid (HCl), concentrated, Trace Metal Grade. Several polyatomic ion interferences result when HCl is used. However, its use is recommended to maintain stability in solutions containing high concentrations of antimony and silver. When used, corrections for the chloride polyatomic ion interference must be applied to all data. At the same time, the standards used for calibration and/or calibration verification should contain the same percentage of HCl as the samples to be analyzed.

5.2.3 Reagent Water (Deionized Water). All references to reagent water in the method refer to ASTM Type I water (ASTM D1193), unless otherwise specified.

5.2.4 Internal Standard Stock Solutions:

- Lithium 6, 1,000 µg/mL stock solution
- Scandium, 1,000 µg/mL stock solution

- Germanium, 1,000 µg/mL stock solution
- Rhodium, 1,000 µg/mL stock solution
- Indium, 1,000 µg/mL stock solution
- Rhenium, 1,000 µg/mL stock solution

5.2.5 Internal Standard Working Solution (IS-WS) – From the above stock solutions, 2.0 mL of each is transferred to a 1000 mL polyethylene container, along with 20 mL of concentrated HNO_3 and brought to a final volume with 970 mL of reagent water. The concentration in the flask will be 2.0 mg/L. This represents the internal standards working solution from which 0.5 mL (for a 50 mL final volume) will be added to all calibration standards and blanks. This will provide a 20 µg/L internal standard concentration in all calibration standards, similar to the concentration of internal standards in analytical samples. The appropriate volume of the IS-WS is to be added to samples during sample preparation or dilution, in order to have the same concentration of internal standard present in samples to be analyzed.

5.2.6 SPEX Industries (S) (or like) – Multielement standard solution containing 100 µg/mL each of Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Ti, Tl, V, Zn. This solution is used for the preparation of the initial calibration verification (ICV) standard. Pertaining information is recorded in the Standard Preparation Log (see Attachment B, as example only; the most current form is maintained in a dedicated folder on the Company network).

5.2.7 SPEX Industries (SM) (or like) – Multielement standard solution containing 1,000 µg/L each of Ca, Mg, K, and Na. This solution is used for the preparation of the initial calibration verification (ICV) standard. Pertaining information is recorded in the Standard Preparation Log (Attachment B, as example only; the most current form is maintained in a dedicated folder on the Company network).

5.2.8 High Purity Standards – Solution B (HB) – 1,000 µg/mL each of Ca, Mg, K, Na. This solution is used for the preparation of the calibration and for the continuing calibration verification (CCV) standards. Pertaining information is recorded in the Standards Preparation Log (see Attachment B). The solution is also used for the preparation of the Laboratory Control Sample (LCS), and for spiking of the MS/MSD samples, during sample preparation. Pertaining information is recorded in the Sample Preparation Log (see Attachment C, as example only; the most current form is maintained in a dedicated folder on the Company network).

5.2.9 High Purity Standards – Solution A (HA) – 100 µg/mL each of Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Ti, Tl, V, Zn. This solution is used for the preparation of the calibration standards and for the continuing calibration verification (CCV) standard. Pertaining information is recorded in the Standards Preparation Log (see Attachment B). The solution is also used for the preparation of the Laboratory Control Sample (LCS), and for spiking of the MS/MSD samples, during sample preparation. Pertaining information is recorded in the Sample Preparation Log (see Attachment C, as example only; the most current form is maintained in a dedicated folder on the Company network).

5.2.9.1 High Purity Standards – Working Solution (HA-WS) – 10 µg/mL each of the elements listed in Section 5.2.9. Prepare this solution, as needed, by transferring 5.0 mL of the HA stock solution to a 50 mL polypropylene tube, add 1 mL of HNO_3 and dilute to volume with reagent water in the hood. The solution is used for the preparation of standards and/or daily spiking of LCS/MS/MSD samples, as needed. Record the preparation information in the ICP-MS Metal Standards Preparation Log and label the working solution vial with the ID of the standard, preparation date, expiration date and initials of the preparer.

5.2.10 High Purity Standards – LLOQ stock standard solution – 2.0 µg/mL each of B, Fe; 1.0 µg/mL each of Al, Zn; 0.1 µg/mL each of Sb, As, Ba, Be, Bi, Cr, Co, Cu, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Ti, Tl, V; 0.02 µg/mL each of Cd, and Ag. This solution is used for the preparation of the lower level of quantitation standard (LLOQ).

5.2.11 High Purity Standards – LRV stock standard solution – 1000 µg/mL each of As, Ba, B, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Sr, Zn. This solution is used for the preparation of the liner range verification standard.

NOTE: The stock solutions are NIST traceable and provided with a certificate of analyses and MSDS sheets by the vendor. A receipt inspection is performed once the standards are received at the Laboratory, following the steps defined in the administrative procedures and LSQA-05, Procurement Control.

NOTE: Exercise caution when analytes, that have low concentrations in most samples, cause the instrument to switch into analog mode due to high signals or currents. Be aware that a fresh dual detector calibration may be needed to ensure linearity.

5.3 CALIBRATION REQUIREMENTS

5.3.1 Multielement calibration standard solutions are prepared by diluting the stock standard solutions to levels in the linear range for the instrument in a solvent consisting of 2% (v/v) HNO_3 in reagent water. The calibration standard solutions must contain a suitable concentration of an appropriate internal standard for each analyte. The calibration standards are kept in polypropylene vessels (50 mL) and prepared as needed. They must be verified by the analysis of a quality control standard (ICV). Tables 2, 3, and 4 (Attachment A) can be used as guidance, when preparing standards.

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- A calibration curve must be analyzed daily. The instrument may be calibrated using a single point standard and a calibration blank, or a multipoint calibration curve.

- For a multilevel calibration curve, a minimum correlation coefficient of 0.995 is required in order for the curve to be considered valid. Generally, a 0.9999 correlation coefficient is achieved for the majority of elements. The lowest standard point must be at or below the LLOQ.

- The mid points of the calibration curve cannot be dropped. If a low point is dropped the reporting limit must be increased to the level of the lowest standard included in the curve. If a high point is dropped samples must be diluted within the concentration range of highest point. When permissible changes (as described above) to the calibration curve are necessary, the date and initials of the person making the adjustment, and the reason for the adjustment are to be documented. The change must be approved by the Technical Director (or delegate) before the curve is used to generate results for analytical samples.

- After the initial calibration is completed, it is verified through the analysis of an initial calibration verification standard (ICV) and an initial calibration blank (ICB). A low-level readback or verification is used to validate the quantitation level. For a multi-point calibration, the low level standard (included as the lowest point in the calibration curve) should quantitate to within 80-120% of the true value. For a single point calibration, a standard from the same source as the calibration standard, and at/or below the LLOQ is analyzed and should recover within 80-120% of the true value.

5.3.2 Blanks – Three types of blanks are required for the analysis. The calibration blank is used in establishing the calibration curve. The preparation blank (LRB) is used to monitor possible contamination resulting from the sample preparation procedure. The rinse blank (also called optional rinse or autosampler wash) is used to flush the system between all samples and standards.

5.3.2.1 The calibration blank and the continuing calibration blank (CCB) consists of the same concentration(s) of the same acid(s) used to prepare the calibration standards, along with the appropriate concentration of internal standard.

5.3.2.2 The preparation (or reagent) blank (LRB) must be carried through the complete preparation procedure and contain the same volumes of reagents as the sample solutions.

5.3.2.3 The rinse blank consists of reagent water only, and is used to flush the system between standards and samples.

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5.3.3 The interference check solution (ICS) is prepared to contain known concentrations of interfering elements that will demonstrate the magnitude of interferences and provide an adequate test of any corrections. Chloride in the ICS provides a means to evaluate software corrections for chloride-related interference such as $^{35}Cl^{16}O^+$ on $^{51}V^+$ and $^{40}Ar^{35}Cl^+$ on $^{75}As^+$. Iron is used to demonstrate adequate resolution of the spectrometer for the determination of manganese. Molybdenum serves to indicate oxide effects on cadmium isotopes. The other components are present to evaluate the ability of the measurement system to correct for various molecular isobaric interferences. The ICS is used to verify that the interference levels are corrected by the data system within quality control limits.

5.3.3.1 Interference check **stock** solution A, containing 1,000 µg/mL each of Al, Mg, P, K, S, 2,000 µg/mL of C, 2,500 µg/mL each of Fe and Na, 3,000 µg/mL of Ca, 21,215 µg/mL of Cl, and 20.0 µg/mL each of Mo and Ti. The ICS-A solution is prepared by transferring 5 mL of the stock solution in a 50 mL polypropylene vessel, followed by the addition of 0.5 mL IS-WS, 1 mL HNO_3, and dilution to 50 mL with reagent water.

5.3.3.2 Interference check **stock** solution B, containing 20.0 µg/mL each of Cr, Co, Cu, Mn, Ni, and V, 10.0 µg/mL each of As, Cd, Se, Zn and 5.00 µg/mL of Ag.

5.3.3.3 The interference check working solution ICS-AB is prepared by transferring 5 mL of the ICS A stock solution into a 50 mL polypropylene vessel, 0.5 mL of the ICS B stock solution, followed by the addition of 0.5 mL IS-WS, 1 mL HNO_3, and dilution to 50 mL with reagent water. The final concentration of the elements in ICS-A and ICS-AB, after the appropriate dilution from the stock, is listed in Attachment A, Table 6. The concentrated stock solution A and B are generally purchased form commercial vendors like Inorganic Ventures, Inc. and come with an expiration date of 1 year. Within the 1 year expiration interval, the diluted solutions A, B and AB are prepared as needed.

5.3.4 The quality control standard is the initial calibration verification solution (ICV), which must be prepared in the same acid matrix as the calibration standards. This solution must be an independent standard near (but not equal to) the midpoint of the calibration curve, at a concentration other than that used for instrument calibration. An independent standard is defined as a standard from a source different from those used in the standards for instrument calibration (see Sections 5.2.6 and 5.2.7).

5.3.5 Mass spectrometer tuning solution – A solution containing elements representing all of the mass regions of interest must be prepared to verify that the resolution and mass calibration of the instrument are within the required specifications (see Section 9.4). This solution is also used to verify that the instrument has reached thermal stability (see Section 9.5).

5.3.5.1 Tuning solution, 10 ppb – In a 1 L volumetric flask, add approximately 200 mL of reagent water, then pipette 10 µL of the 1,000 ppm stock solutions for Indium, Cerium, Rhodium, HPS Solution B, and 100 µL of the 100 ppm HPS Solution A. Add 20 mL of concentrated Nitric Acid, in the hood, and dilute to the 1 L mark. This solution is to be used for daily verifications of the performance of the instrument and mass calibration, and periodical calibration of the static lens and auto-lens of the Elan system.

5.3.5.2 Tuning Solution, 200 ppb – In a 1 L volumetric flask, add approximately 200 mL of reagent water, then pipette 2 mL of the 100 ppm HPS Solution A, and 0.2 mL of HPS Solution B. Add 20 mL of concentrated Nitric Acid, in the hood, and dilute to the 1 L mark. This solution is to be used for the calibration of the Dual Detector, every time the voltage on the detector (analog and/or pulse) has been changed, or when a new detector is installed.

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 **Documents and Records**

5.4.1.1 Keep hard copies and electronic copies of raw data in accordance with LS (Laboratory Services) record retention policy.

5.4.1.2 Back up all files associated with a given run, either on CD/DVDs, external hard drive or on the Company network, as appropriate.

5.4.1.3 Keep electronic records of mass calibration and daily performance and generate hard copies to aid in the peer data review.

5.4.1.4 The printouts of the mass calibration, daily performance results, Sample/Batch Report and Data Set Report are submitted for secondary review. They do not need to become part of the project folder, since the original electronic versions exist. However, it is good practice to scan and archive all of the original hard copy data, including forms that might not necessarily become part of the project folder.

5.4.1.5 Record all maintenance performed on the instrument in the instrument maintenance book, or electronically, in either a spreadsheet summary, or in the comments section available when performing daily instrument performance verifications/optimizations.

5.4.2 **Tables and Forms**

5.4.2.1 Attachment A

- Table 1 List of elements analyzed.
- Table 2 Standard preparation for all elements except Fe, Ca, Mg, K, Na.

- Table 3 Standard preparation for Fe.
- Table 4 Standard preparation for Ca, Mg, K, Na.
- Table 5 Instrument operating parameters.
- Table 6 ICS components and concentration.
- Table 7 Recommended analytical isotopes and additional masses to be monitored.
- Table 8 Quality control items, frequency, and corrective action.

5.4.2.2 Attachment B – Metal Standards Preparation Log (as example only; the most current form is maintained in a dedicated folder on the Company network).

5.4.2.3 Attachment C – Samples Preparation Log (as example only; the most current form is maintained in a dedicated folder on the Company network).

5.4.2.4 Attachment D – Peak Width Relationship at 5% and 10% Height

5.5 PERSONNEL REQUIREMENTS

5.5.1 The use of this procedure is restricted to those analysts experienced in the use of Inductively Coupled Plasma Mass-Spectrometry and who are knowledgeable in the recognition and in the correction of spectral, chemical and physical interferences in ICP-MS. A minimum of six months experience with commercial instrumentation is recommended.

5.5.2 For projects where reporting under the 2009 TNI Standard has been requested, all tests and data reporting shall be performed by analysts with a completed initial, or an on-going Demonstration of Capability (iDOC/DOC), as applicable.

5.6 ENVIRONMENTAL CONDITIONS

5.6.1 The instrument shall be vented to a fume hood or appropriate device.

6.0 PRECAUTIONS

6.1 Observe normal safety practices as specified in the latest online revision of the Environmental and Laboratory Services Accident Prevention Manual and the Consumers Energy Chemical Hygiene Plan.

6.2 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Every effort should be made to minimize the generation of excess waste in the preparation of standards and reagents related to this procedure.

6.3 For guidance on proper disposal of unused samples, stock chemicals and reagents, refer to SOP CHEM-1.2.08 Handling and Disposal of Lab Testing Waste.

7.0 LIMITATIONS AND ACTIONS

7.1 Interferences – There are three fundamentally different sources of interference in ICP-MS: spectroscopic interferences, physical, and memory interferences.

7.1.1 Spectroscopic Interferences – Interferences caused by the presence of compounds or elements entering the mass spectrometer that have the same nominal mass to charge (m/z ratio) as the analyte elements. They can be isobaric elemental and isobaric molecular interferences (polyatomic, refractory oxide, and doubly charged ions).

7.1.2 Isobaric Elemental Interferences in ICP-MS – Caused by isotopes of different elements forming atomic ions with the same nominal mass-to-charge ratio (m/Z) as the analyte element. These can be managed by the selection of an alternate isotope for analysis or by the use of elemental interference equations. These equations use the naturally occurring isotope ratios of most elements to estimate and allow for the subtraction of isobaric interferences. An example of an elemental isobaric interference is ^{40}Ar on ^{40}Ca. In this case, the use of ^{43}Ca or ^{44}Ca is recommended. The appropriate elemental interference equations are incorporated in the methods (or parameter) used for calibration and data acquisition.

7.1.3 Isobaric Molecular and Doubly Charged Ion Interferences in ICP-MS – Caused by ions consisting of more than one atom or charge, respectively. Most isobaric interferences that affect ICP-MS determinations have been identified[3-4]. Examples include $ArCl^+$ ions on the ^{75}As signal and MoO^+ ions on the cadmium isotopes. While the approach used to correct for molecular isobaric interferences is demonstrated below using the natural isotope abundance[5], the most precise coefficients for an instrument can be determined from the ratio of the net isotope signals observed for a standard solution at a concentration providing suitable (<1%) counting statistics.

7.1.3.1 Example for As – Because the ^{35}Cl natural abundance of 75.77% is 3.13 times the ^{37}Cl abundance of 24.23%, the chloride correction for arsenic can be calculated (approximately) as follows (where the $^{38}Ar^{37}Cl^+$ contribution at m/z 75 is a negligible 0.06% of the $^{40}Ar^{35}Cl^+$ signal): Corrected arsenic signal (using natural isotopes abundance for coefficient approximations) = m/z 75 signal) - (3.13) (m/z 77 signal) + (2.73) (m/z 82 signal), (where the final term adjusts for any selenium contribution at 77 m/z).

NOTE: Arsenic values can be biased high by this type of equation when the net signal at m/z 82 is caused by ions other than $^{82}Se^+$, (eg, $^{81}BrH^+$ from bromine wastes[6]).

NOTE: When Selenium concentrations are high, the correction listed above is not always accurate, and it can also lead to a high Arsenic bias. The effect is expected to be even more pronounced in matrices where Chloride is present at low concentrations. The analyst must always compare corrected versus uncorrected Arsenic results to identify if a bias is present. When a high bias occurs, the lower concentration result from the uncorrected Arsenic is to be used for data reporting, provided all other method required QA/QC is found acceptable.

7.1.3.2 Example of Cd – Corrected cadmium signal (using natural isotopes abundance for coefficient approximations) = (m/z 114 signal) - (0.027)(m/z 118 signal) - (1.63)(m/z 108 signal), (where last 2 terms adjust for any Sn or MoO^+ contributions at m/z 114).

NOTES: Cadmium values will be biased low by this type of equation when $^{92}ZrO^+$ ions contribute at m/z 108, but use of m/z 111 for Cd is even subject to direct ($^{94}ZrOH^+$) and indirect ($^{90}ZrO^+$) additive interferences when Zr is present.

Since there is a certain degree of uncertainty as to which equation is better to use, and in what cases, it is up to the analyst to determine how the interference will be corrected, upon evaluation of data. It is suggested that the elemental isobaric interference equations be included in all methods (parameters) at all times, but potential polyatomic species (masses) that could interfere by only monitored. The Elan Data System allows the user to display both type of results, corrected for interference and uncorrected, on a single Quantitative Analysis Summary Report. Corrected elements should be flagged, to distinguish them from the uncorrected ones. Generally, an interference is easy to spot when multiple isotopes of an element show significantly different results. Since the interference is additive, the use of the isotope with the lowest result is suggested for data reporting, providing that all other QC criteria are met.

7.1.4 Abundance Sensitivity – A property defining the degree to which the wings of a mass peak contribute to adjacent masses. Wing overlap interference may occur when a small ion peak is being measured adjacent to a large one. The potential for these interferences should be recognized, and the spectrometer resolution adjusted to minimize them. Although this type of interference is uncommon, it is not easily corrected, and samples exhibiting a significant problem of this type could require matrix separation, or analysis using another verified and documented isotope.

7.1.5 Physical Interferences – Associated with the physical processes, which govern the transport of sample into the plasma, sample conversion process within the plasma and the transmission of ions through the plasma-mass spectrometer interface. These interferences may result in differences between instrument responses for the samples and calibration standards.[9] Physical interferences may occur in the transfer of solution to the nebulizer (eg, viscosity effects), at the point of aerosol formation and transport to the plasma (eg, surface tension effects), during the atomization and ionization process within the plasma itself, or during the transfer of ions through the interface and mass spectrometer (space charge effects). To minimize some of these effects, acid composition and concentration should be matched for all standards, blanks, and samples. Total solid levels below 0.2% (2,000 mg/L) have been currently recommended[10] to minimize solid deposition. Internal standardization may be effectively used [11] to compensate for many physical interference effects. Internal standards should ideally display similar analytical behavior to the elements being determined. Generally, an internal standard should be no more than 50 amu removed from the analyte. However, instances were observed when high levels of easily ionized elements (like Na) in the samples lead to abnormal suppression of the low mass internal standard (ie, ^{45}Sc). As a result, the elements close in mass to 45 amu, which have Scandium assigned as the internal standard would be biased high. A heavier element like ^{103}Rh should be used in those cases as the internal standard. Recommended internal standards include ^{6}Li, ^{45}Sc, ^{70}Ge, ^{103}Rh, ^{115}In, ^{159}Tb, ^{169}Ho, ^{185}Re, and ^{209}Bi.

7.1.6 Memory Interferences – Result when elements in a previous sample contribute to signals measured in a subsequent sample. Memory effects can result from the deposition of sample on various components of the sample introduction system, including sample and peristaltic pump tubing, spray chamber, torch, and interface cones. The site(s) where deposition may occur is dependent on the sample and may need to be minimized through the use of a rinse blank between samples. Routine maintenance (cleaning and/or replacement) of sample introduction components is necessary for long-term minimization of memory effects. The possibility of memory interferences within an analytical run should be recognized and suitable rinse times should be used to reduce them. Memory effects are evaluated by using a minimum of three replicate integrations for data acquisition. High relative standard deviation (% RSD) of the three replicates caused by a consecutive drop in signal intensity is indicative of carryover from the previous sample. If memory interference is suspected, the sample should be reanalyzed after analysis of a blank, which indicates that the carryover has been eliminated.

8.0 ACCEPTANCE CRITERIA

8.1 The initial demonstration of performance is used to characterize instrument performance (determination of linear calibration ranges) and laboratory performance (determination of method detection limits) prior to analyses conducted by this method.

8.2 Linear calibration ranges – Linear calibration ranges are primarily detector limited. The upper limit of the linear calibration range should be established by determining the signal responses from different concentration standards, one of which is close to the

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upper limit of the linear range. Care should be taken to avoid potential damage to the detector during this process. The linear calibration range, which may be used for the analysis of samples, should be judged by the analyst from the resulting data. The upper LDR is defined as the maximum concentration for which the measured concentration is within ±10% of the true value. Sample analyte concentrations that are greater than the upper LDR limit must be diluted and reanalyzed. The LDR should be verified whenever, in the judgment of the analyst, a change in analytical performance caused by either a change in instrument hardware or operating conditions would dictate they be re-determined.

NOTE: The linear range establishes the highest concentration that may be reported without diluting the sample. A liner range standard is analyzed at the beginning of every analytical run, following the calibration. If a linear range standard is not analyzed for any specific element, or if analyzed but fails to be recovered within 90-110% of the true value, the highest concentration standard in the calibration becomes the linear range. For analytes with concentration above the linear range, the samples shall be diluted in the working range of the instrument.

NOTE: When the liner range standard is not analyzed for a particular analyte, an alternative approach that verifies the linear range is to dilute the actual sample with measured concentrations above the highest calibration standard. If the analyte concentration of a sample diluted to read below the highest calibration standard is within 10% of the initial, undiluted result, the response of the instrument is verified to be linear up the concentration of the undiluted sample.

8.3 Method detection limits (MDL) must be established for all analytes, using reagent water (blank) fortified at a concentration of 2 to 10 times the estimated detection limit. To determine MDL values, follow the EPA procedure listed at 40 CFR Part 136. MDL’s should be evaluated annually, when a new operator begins work, or whenever, in the judgment of the analyst, a change in the instrument hardware or operating conditions would dictate they be redetermined.

8.4 To obtain analyte data of known quality, it is necessary to measure more than the analytes of interest in order to apply corrections or to determine whether interference corrections are necessary. If the concentrations of interference sources (such as C, Cl, Mo, Zr, W) are such that, at the correction factor, the analyte is less than the limit of quantification or the concentration of interferents are insignificant, then the data may go uncorrected. Note that monitoring the interference sources does not necessarily require monitoring the interferant itself, but that a molecular species may be monitored to indicate the presence of the interferant. The monitored masses must include those elements whose hydrogen, oxygen, hydroxyl, chlorine, nitrogen, carbon, and sulfur molecular ions could impact the analytes of interest. If an interference source is present, and cannot be corrected, the sample elements impacted must be flagged. When correction equations are used, all QC criteria must also be met.

8.5 The intensities of all internal standards must be monitored for every analysis. When the intensity of any internal standard falls outside limits as compared with the calibration blank, the following procedure is followed: the sample must be diluted at least fivefold (1 + 4) and reanalyzed with the addition of appropriate amounts of internal standards. This procedure must be repeated until the internal-standard intensities fall within the prescribed window. The intensity levels of the internal standards for the ICV/ICB, CCV/CCB, LCS/LRB must also be within the specified acceptance limits (refer to Section 8.11.1.3 and 8.11.2.5 for limits). If they are not within limits, terminate the analysis, correct the problem, recalibrate, verify the new calibration, and reanalyze the affected samples.

8.6 Check the instrument calibration by analyzing appropriate quality control solutions as follows:

8.6.1 Check instrument calibration by analyzing the initial calibration verification solution (ICV), initial calibration blank (ICB), and the LLOQ verification standard.

8.6.2 Verify calibration at a frequency of every 10 analytical samples with the CCV standard, and the continuing calibration blank (CCB). These solutions must also be analyzed for each analyte at the beginning of the sample batch and after the last sample.

8.6.3 The results of the ICV and CCV must agree within ±10%, and the LLOQ standard must agree within ±20% of the expected value. If the ICV or LLOQ are outside limits, terminate the analysis, correct the problem, and recalibrate the instrument. If the CCV's are outside the limits, address the problem according to the requirements of the method to be reported (200.8 or 6020). See Section 8.11.1.1 and 8.11.2.1 or Attachment A, Table 8 for the appropriate corrective action.

8.6.4 The results of the ICB and CCBs must be less than 2.2 times the current MDL for each element or less than the reporting limits for water samples, whichever is greater. With the exception of Ca, Mg, K, Na, Fe, B, Al, Cu, Ni, and Zn, which have fairly high reporting limits, for most of the analytes, a blank level of ≤1 ppb is acceptable, even though higher than 2.2 x MDL in some cases. An exception is Cd and Ag, where the blank level should be < 0.2 ppb, at a minimum. Care must be used when evaluating the blank so that sample results are not impacted by a high blank level. It is also important to take into account the dilution factor associated with sample analysis, which could further exacerbate the problem. If the limit for ICB/CCBs is exceeded, the reason for the out-of-control condition must be found and corrected, and the affected samples must be reanalyzed.

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8.7 A Laboratory Control Sample (LCS) must be analyzed for each analyte using the same sample preparations, analytical methods, and QA/QC procedures employed for the test samples. One LCS must be prepared and analyzed for each sample batch at a frequency of one LCS for each 20 samples or less. The recovery limits for the LCS are 85-115% for Method 200.8 and 80-120% for Method 6020, of the true value (stated in the sequence log or calculated from the volume and concentration of stock solution recorded on the digestion worksheet). If the limits are exceeded, the samples in the associated analytical batch must be prepared again and re-analyzed. If the analysis must continue under the out-of-control condition, the results shall be flagged in the data report.

8.8 The laboratory must analyze at least one LRB with each batch of 20 samples. LRB data are used to assess contamination from the laboratory environment and to characterize spectral background from the reagents used in sample processing. LRB values that exceed the MDL indicate that laboratory or reagent contamination should be suspected. When LRB values are above ½ LLOQ, constitute 10% or more of the analyte level determined for a sample or is 2.2 times the analyte MDL, whichever is greater, the source of contamination must be corrected and samples in the associated analytical batch must be prepared again and re-analyzed. If the analysis must continue under the out-of-control condition, the results shall be flagged in the data report.

8.9 Analyze matrix spike (MS) samples with every batch. For majority of the elements, the aqueous samples are spiked at levels similar to the LCS (50 ppb in the analysis solution for all elements except Ca, Mg, K, Na, which are spiked usually with 1 ppm in the analysis solution). Soils or solid samples can have spike concentrations that vary proportional to the expected analyte level in the samples. Calculate the percent recovery of each analyte, corrected for background concentrations appropriate to the matrix, using the following equation:

$$R = \frac{C_s - C}{S} x100$$

Where: R = percent recovery
C_s = spiked sample concentration
C = sample background concentration
S = concentration equivalent of analyte added to fortify the sample

8.10 Analyze matrix duplicate (Dup) samples with every batch. A matrix spike duplicate (MSD) can be used instead or in addition to the matrix duplicate. The decision on whether to prepare and analyze duplicate samples or an MS/MSD pair must be based on knowledge of the sample in the analysis batch. If samples are expected to contain target analytes above the LLOQ, a duplicate sample could be used. If samples are not expected to contain target analytes above the LLOQ, an MS/MSD pair should be used, to avoid meaningless RPD values. A control limit of 20% RPD should not be exceeded for analyte values measured above LLOQ. If this limit is exceeded and laboratory performance for that analyte is shown to be in control (ICV/ICB, CCV/CCB, and LCS/LRB within the limits), the problem encountered is judged to be matrix related. Reanalyze at the instrument the sample and its duplicate (or MSD) in order to confirm the out-of-control result. Based on project specific requirements, the samples are to be redigested and reanalyzed, or the data user is to be informed that the result for that analyte is suspect due to the heterogeneous nature of the sample. If the performance of the laboratory is not in control (ICV/ICB, CCV/CCB, and/or LCS/LRB outside the limits), the reason for the out-of-control situation must be found and corrected, and any samples analyzed during the out-of-control condition for that analyte must be reanalyzed.

The relative percent difference (RPD) between duplicate (or MSD) determinations must be calculated as follows:

$$RPD = \frac{|D_1 - D_2|}{\frac{D_1 + D_2}{2}} x100$$

Where: RPD = relative percent difference
D_1 = first sample value
D_2 = second sample value (duplicate)

8.11 The quality control requirements and limits vary slightly, based upon the method referenced in the analytical report (i.e., 200.8 vs 6020). For both methods, the calibration is verified through the analysis of ICV/ICB and CCV/CCB. Recalibration is required when either one falls outside the limits. The performance of the method is evaluated by the analysis of the LCS/LRB, and MS/MSD/Dup samples for every batch.

8.11.1 **Method 200.8 Specific Requirements**

8.11.1.1 When the recovery for ICV/CCV falls outside ±10% terminate the analysis and recalibrate the instrument. If the last CCV was within 15% of the true concentration, the results for the samples are still acceptable. If this is not the case, the only acceptable results are the ones corresponding to samples analyzed before the last CCV that was within 15% of the true concentration. All other samples are to be analyzed again, after recalibration of the instrument.

8.11.1.2 Matrix Spike samples are to be analyzed for every 10 samples or two sets for a batch of 20 samples. The recovery limits for MS samples are 70-130%. If the recovery of any analyte falls outside the designated range and the laboratory performance is shown to be in control (ICV/ICB, CCV/CCB, and LCS/LRB within the limits), the recovery problem encountered with the spiked sample is judged to be matrix related, not system related. The data user must be informed that the result for the analyte in the unspiked sample is suspect due to an uncorrected matrix effect. Recovery is not required if the concentration of the analyte added is less than 30% of the concentration of the analyte in the original sample.

8.11.1.3 The absolute response of any one internal standard must not deviate by more than 60 to 125% of the original response in the calibration blank. If deviations greater than these are observed flush the instrument with rinse blank, than analyze a CCB. If the responses of the internal standards are now within the limit proceed with sample dilution as described in Section 8.4. If the responses of the internal standards are not within the limit, terminate the analysis, recalibrate the instrument, and reanalyze the samples from the last CCB with acceptable internal standard recoveries.

8.11.2 **Method 6020 Specific Requirements**

8.11.2.1 When the recovery for ICV/CCV falls outside ±10% or LLOQ falls outside ±20% of the true value terminate the analysis and recalibrate the instrument. The samples from the last CCV that was within limits are to be reanalyzed, after recalibration of the instrument.

8.11.2.2 Post-Digestion Spike Addition – An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 75 to 125% of the known value. The spike addition should be based on the indigenous concentration of each element of interest in the sample. If the spike is not recovered within the specified limits, the original sample must be diluted to compensate for the matrix effect, and reanalyzed, after a new post-digestion spike is added. The same recovery limits apply to the spiked dilution.

8.11.2.3 Digested matrix spike (MS); if the digested spike is not recovered within 75-125%, either because of matrix effects or because the sample background for the analyte is too high, follow 8.11.2.2 above and analyze a post-digested spike (also referred to as “know addition” / KA).

8.11.2.4 Matrix spike duplicate, MSD, for either the Post-Digestion Spike Addition, or the digested spike duplicate; the evaluation of the MSD is similar to the evaluation of the duplicate analysis described in Section 8.10 except that for soil samples the RPD calculation should be performed on the percent recoveries for both, the MS and MSD, in order to account for the different dilution factor resulting from the sample preparation.

8.11.2.5 When the intensity of any internal standard in the sample falls outside 30-130% of the intensity of that internal standard in the calibration blank, follow the procedure described in Section 8.5. The intensity levels of the internal standards for the ICV/ICB and CCV/CCB must agree with 60-125% of the intensity level of the calibration blank. If they do not agree, terminate the analysis, correct the problem, recalibrate, verify the new calibration, and reanalyze the affected samples.

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8.11.2.6 Dilution Test – If the analyte concentration is within the linear dynamic range of the instrument and sufficiently high (minimally, a factor of at least 25 x LLOQ), an analysis of a fivefold (1 + 4) dilution must agree within ±20% of the original determination. If a high concentration sample is not available for performing the dilution test, a post digestion spike could be used instead. The matrix spike is often a good choice of sample for the dilution test, since reasonable concentrations of most analytes are present. One dilution test must be included with every batch of 20 samples. Elements that failed the dilution test are to be flagged.

8.11.2.7 Verify the magnitude of elemental and molecular-ion isobaric interferences and the adequacy of any corrections at the beginning of an analytical run or once every 12 hours of continuing sample analysis, whichever is more frequent. Do this by analyzing the interference check solutions ICS-A and ICS-AB. Results for the unspiked elements in the ICS-A should be less than 2 x LLOQ. The recovery of the spiked/elements of interest in ISC-AB (listed in Attachment A, Table 6) should be between 70-130%.

8.12 Summary of the QC requirements and performance acceptance limits are shown in the following table:

	Method 6020		**Method 200.8**	
QC Type	**Limit %**	**Frequency**	**Limit (%)**	**Frequency**
ICV	90-110	After initial calibration	90-110	After initial calibration
ICB	< ½ x LLOQ	After initial calibration	< ½ x LLOQ	After initial calibration
LLOQ/BS	80-120	After initial calibration*	70-130	After initial calibration*
ERA‡	Variable per lot	After initial calibration	Variable per lot	After initial calibration
CCV	90-110	Every 10 samples	90-110**	Every 10 samples
CCB	< ½ x LLOQ	Following CCV	< ½ x LLOQ	Following CCV
LCS	80-120	Every batch or 20 samples	85-115	Every batch or 20 samples
LRB	< ½ x LLOQ or <10%***	Every batch or 20 samples	< ½ x LLOQ or <10%	Every batch or 20 samples
Dup	0-20	Every batch or 20 samples	0-20	Every 10 samples
MS	75-125	Every batch or 20 samples	70-130	Every 10 samples
MSD	0-20	Every batch or 20 samples	0-20	Every 10 samples
ICS A	< ½ x LLOQ	Beginning of run or 12 hr	NA	NA
ICS AB	70-130	Beginning of run or 12 hr	NA	NA
Int. Std.	60-125 for CCV/CCB 30-135 for samples	Every analysis	60-125 for all	Every analysis

<u>NOTE</u>: * Although not required by the method, running the LLOQ also at the end of the run may be beneficial.
** Sample results are still acceptable if the last CCV is recovered between 85-115%.
*** Percent (<10%) of the analyte found in samples.
‡ Optional 3rd source verification standard.

9.0 PROCEDURE

9.1 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

9.1.1 All samples are collected in appropriate containers. Water samples are collected in HNO_3 pre-preserved plastic container and are acidified to pH of <2. Filtration is required through a 0.45 µm filter before preservation, for dissolved analysis.

9.1.2 If for some reason such as high alkalinity the sample pH is verified to be > 2, more acid must be added, pH verified to be < 2, and the sample held for 16 hours before analysis.

9.1.3 Soil samples are collected without preservation, usually in glass containers with Teflon lined caps. Non-aqueous samples should be refrigerated upon receipt.

9.1.4 Holding times for metals are 6 months from the date of sampling.

9.2 Solubilization and digestion procedures are presented in the applicable Sample Preparation SAPs or Digestion Methods 3015-3051 in SW-846 method compendium, or SM 3030E in Standards Methods for the Examination of Water and Wastewater, 22nd Edition. Samples for dissolved analysis are not digested. Instead, they are only acidified to a 2% (v/v) HNO_3 matrix. Generally, a 2 mL aliquot of a well-mixed sample is taken and brought to a 10 mL final volume, after the addition of 0.2 mL HNO_3 (in the hood), 100 µL of **IS-WS** (2 ppm stock) to all samples, and 50 µL of the **HA-WS** (10 ppm stock) to LCS/MS/MSD.

9.3 INITIATE APPROPRIATE OPERATING CONFIGURATION OF THE INSTRUMENT

9.3.1 Launch Elan software.

9.3.2 Set up the instrument with the proper operating parameters according to the instrument manufacturer's instructions (Attachment A, Table 5).

9.3.3 Ignite plasma and allow a warm-up of 15 - 30 minutes. The tuning procedures may be carried out during warm-up.

9.4 Open the Tuning Workspace and conduct mass calibration and resolution checks in the mass regions of interest by analyzing the 10 ppb tuning solution (Section 5.3.5.1). Required elements for tuning are Li, Be, Mg, Co, Rh, In, Tl and Pb. The mass calibration and resolution parameters are required criteria that must be met prior to any samples being analyzed. If mass calibration differs more than 0.1 amu from the true value, then the mass calibration must be adjusted to the correct value. The resolution must also be verified to be within 0.6-0.8 amu full width at 10% peak height. The Elan system cannot perform resolution checks at 5% peak height, but it was shown by Perkin Elmer that 0.65 amu at 10% peak height would be the equivalent of 0.70 amu at 5% peak height (see Attachment D, Peak Width Relationship at 5% and 10% Peak Height). When Method 200.8 needs to be reported, a resolution of approximately 0.65-0.70 amu at 10% peak height would satisfy the recommendation of having a resolution of about 0.75 amu at 5% peak height.

9.5 Open the Daily Performance workspace and verify that the instrument has reached thermal stability by analyzing the 10 ppb tuning solution. An RSD of 5% or lower for five consecutive replicate measurements is required for the elements specified above. The analysis of the tune solution also provides information about the sensitivity level of the instrument and the level of oxide and doubly charged ions formed in the plasma. At a minimum, the following specifications need to be met:

• Sensitivity	– Mg	> 30,000 cps
	– Rh	> 250,000 cps
	– Pb	> 100,000 cps
• Oxide Ratio	– Ce/CeO	≤ 3.5%
• Doubly Charged Ratio	– Ba^{+}/Ba^{++}	≤ 3%

9.6 When the performance of the instrument is not at the specified level, the Auto Lens needs to be recalibrated and/or the cones need to be cleaned. Calibration of the Auto Lens is performed from the Auto Lens Calibration workspace. The elements selected for calibration, according to the manufacturer instructions are Be, Co and In. Load the workspace, select the Auto Lens tab in the Optimization window, clear the old calibration, load the elements from the method, and calibrate the lens. If the cones need to be cleaned to further improve the performance, record the cleaning or any other maintenance procedure in the instrument maintenance log (the most current form is maintained in a dedicated folder on the Company network).

9.7 If the performance is still not satisfactory, the voltage on the Electron Multiplier Detector might need to be readjusted. Manually change the pulse and analog voltage in steps of 25 V until the desired level of sensitivity is obtained. Adjustments of the voltage, or detector replacement is to be followed with the calibration of the dual detector mode, by the analysis of the 200 ppb tuning solution, from the Dual Detector Calibration workspace. Make sure that the method has all the analytes that are expected to be high, and switch to the analog mode during sample analysis.

9.8 When the performance of the instrument is satisfactory set up the sequence of samples to be analyzed, enter all the information needed for each sample (i.e., sample amount/volume, preparation volume, dilutions at the instrument) and establish a method file with the elements to be measured. Define a new Data Set and calibrate the instrument for the analytes of interest, using the calibration blank and three initial calibration standards according to the instrument manufacturer's procedure. Attachment A, Tables 2, 3, and 4 provide information as to what calibration standards to use. Flush the system with the rinse blank between each standard solution. Use the average of at least three integrations for both calibration and sample analyses.

NOTE: For projects reported under the TNI scope of accreditation all dilution factors shall be entered in LIMS (instead of the analyzer sequence table) in order to allow a consistent evaluation of the effect sample dilution has on PQL and project specific reporting limits.

NOTE: When the quantitation level for all required analytes is confirmed through the analysis of the LLOQ standard to be low, such that the diluting the sample during preparation does not impact the established reporting limits, all calculations can still be performed at the instrument, and only final results transferred into the LIMS.

9.9 All masses that could affect data quality should be monitored to determine potential effects from matrix components on the analyte peaks. The recommended isotopes to be monitored are listed in Attachment A, Table 7. If an element has more than one monitored isotope, examination of the concentration calculated for each isotope, or the isotope ratios, will provide useful information for the analyst in detecting a possible spectral interference. Consideration should therefore be given to both primary and secondary isotopes in the evaluation of the element concentration. In some cases, secondary isotopes may be less sensitive or more prone to interferences than the primary recommended isotopes, therefore differences between the results do not necessarily indicate a problem with data calculated for the primary isotopes.

9.10 Immediately after the calibration has been established, the calibration must be verified and documented for every analyte by the analysis of both the calibration verification solution and low-level calibration verification solution. When measurements exceed ±10% of the accepted value (CCV)the analyses must be terminated, the problem corrected, the instrument re-calibrated, and the new calibration verified. During the course of an analytical run, the instrument may be "re-sloped" or re-calibrated to correct for instrument drift. A re-calibration must then be followed immediately by a new analysis of a CCV and CCB before any further samples may be analyzed. Corrective actions for specific out-of-control situations are summarized in Attachment A, Table 8.

9.1.1 Flush the system with the rinse blank solution until the signal levels return to the method's levels of quantitation (usually about 30 seconds) before the analysis of each sample. Nebulize each sample until a steady-state signal is achieved (usually about 20 seconds) prior to collecting data. Analyze the calibration verification solution

(CCV), and the continuing calibration blank (CCB) at a frequency of at least once every 10 analytical samples.

9.1.1 Dilute and reanalyze samples that are more concentrated than the linear dynamic range of the instrument (LDR Section 8.2) for an analyte or measure an alternate less-abundant isotope. The linearity at the alternate mass must be confirmed by appropriate calibration.

NOTE: Precautions must be taken to protect the channel electron multiplier from high ion currents. The channel electron multiplier suffers from fatigue after being exposed to high ion currents. This fatigue can last from several seconds to hours depending on the extent of exposure. During this time period, response factors are constantly changing, which invalidates the calibration curve, causes instability, and invalidates sample analyses.

10.0 CALCULATIONS

10.1 The quantitative values shall be reported in appropriate units, such as micrograms or milligrams per liter (µg/L or mg/L) for aqueous samples and micrograms or milligrams per kilogram (µg/Kg or mg/Kg) for solid samples.

10.1.1 Calculations performed by the data system include appropriate interference corrections, internal-standard normalization, and the summation of signals at 206, 207 and 208 m/z for lead (to compensate for any differences in the abundances of these isotopes between samples and standards).

10.1.2 The appropriate initial sample weight or volume and the preparation volume resulted from sample preparation is entered in the data system for each sample at the time of programming the sequence to be analyzed. If additional dilutions are performed at the instrument, the appropriate “aliquot” and “diluted to volume” must be entered in the data system as well.

NOTE: For projects reported under the TNI scope of accreditation all dilution factors shall be entered in LIMS (instead of the analyzer sequence table) in order to allow a consistent evaluation of the effect sample dilution has on PQL and project specific reporting limits.

NOTE: When the quantitation level for all required analytes is confirmed through the analysis of the LLOQ standard to be low, such that the diluting the sample during preparation does not impact the established reporting limits, all calculations can still be performed at the instrument, and only final results transferred into the LIMS.

11.0 DATA REPORTING

11.1 After the analysis has been completed generate an electronic .csv file of the raw data. Upload the .csv file in the designated Microsoft Access database for processing and print a results summary with the analytes requested by the client along with a representative QC package for the analytical batch to be placed in the project folder.

11.2 Use the saved export template in the Access database to generate an Excel file for the electronic transfer into the LIMS.

11.3 Open the file and sort all records by sample ID and Analyte Name. This sorting is required before results can be imported into the LIMS. If special letter codes are present following the space next to the aliquot name in Column B, like the F-Dup, F-MS, F-MSD designators for the field QC samples, ensure that those designators are removed before saving the file for importation.

11.4 Copy the file to the metals parser folder to be imported into the LIMS. The folder is located at *\\LIMS Server\Titan Files\ImportDrop\Lims.Result\07-Metals2DRC\07-Metals2DRCMapper\07-Metals2DRCParser*.

11.5 Open the corresponding analytical batch or project/work order in LIMS and validate that all results got transferred, for all samples and all analytes. When all results rows are populated, the status of the analytical batch in LIMS will automatically transition from “created” to “entered”.

11.6 Enter the ID of the instrument run file(s) corresponding to that particular analytical batch, add qualifying statements if necessary, in the “comments” section and save the batch.

11.7 For projects reported under the TNI scope of accreditation, follow to steps below to evaluate the effect of sample dilution on final project reporting limits.

11.7.1 Ensure all sample dilution and/or preparation factors are entered in LIMS, consistent with how they appear on the preparation notebook page (or bench form).

11.7.2 All quantitation limits in LIMS are automatically adjusted (increased) by the dilution factor during the raw data import.

11.7.3 Final results are listed in the “Reported Column” in LIMS. Results found below quantitation are displayed as “< (PQL x Dilution)”.

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11.7.4 Compare the "less than (<)" value with project specific reporting limits and flag data appropriately for the cases where the (PQL x Dilution) limit ends up higher that the project required reporting limit for the given analyte.

NOTE: When the quantitation level for all required analytes is confirmed through the analysis of the LLOQ standard to be low, such that the diluting the sample during preparation does not impact the established reporting limits, all calculations can still be performed at the instrument, and only final results transferred into the LIMS. In those cases, ensure the dilution column in LIMS is set to "1".

11.8 When all data review in LIMS is complete, highlight all rows and transition the analytical batch to "Validated".

11.9 Place a copy of any notebook pages involving the project (i.e. sample preparation log) in the Project Folder.

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Table 1. List of elements analyzed, Typical MDL and Reporting Levels/PQL's.

Element	Symbol	CAS#	Typical MDL* (μg/L)	Reporting Level** (μg/L)	LLOQ Level (μg/L)	LRV*** Level (μg/L)
Aluminum	(Al)	7429-90-5	0.98	10	2	Cal Std
Antimony	(Sb)	7440-36-0	0.05	2	0.2	Cal Std
Arsenic	(As)	7440-38-2	0.07	1	0.2	2000
Barium	(Ba)	7440-39-3	0.05	10	0.2	2000
Beryllium	(Be)	7440-39-3	0.27	1	0.2	Cal Std
Boron	(B)	7440-42-8	0.50	20	4	2000
Cadmium	(Cd)	7440-43-9	0.04	0.2	0.04	Cal Std
Calcium	(Ca)	7440-70-2	1.6	1000	50	10000
Chromium	(Cr)	7440-47-3	0.07	5	0.2	2000
Cobalt	(Co)	7440-48-4	0.13	5	0.2	2000
Copper	(Cu)	7440-50-8	0.09	10	0.2	2000
Iron	(Fe)	7439-89-6	2.38	20	4	2000
Lead	(Pb)	7439-92-1	0.04	3	0.2	2000
Lithium	(Li)	7439-93-2	0.26	10	0.2	Cal Std
Magnesium	(Mg)	7439-95-4	2.5	1000	50	10000
Manganese	(Mn)	7439-96-5	0.08	5	0.2	2000
Molybdenum	(Mo)	7439-98-7	0.07	5	0.2	2000
Nickel	(Ni)	7440-02-0	0.12	5	0.2	2000
Potassium	(K)	7440-09-7	1.8	100	50	10000
Selenium	(Se)	7782-49-2	0.16	5	0.2	Cal Std
Silver	(Ag)	7440-22-4	0.03	0.2	0.04	Cal Std
Sodium	(Na)	7440-23-5	3.2	1000	50	10000
Strontium	(Sr)	7440-24-6	0.06	5	0.2	2000
Tin	(Sn)	7440-31-5	0.04	10	0.2	Cal Std
Titanium	(Ti)	7440-32-6	0.21	5	0.2	Cal Std
Thallium	(Tl)	7440-28-0	0.06	2	0.2	Cal Std
Vanadium	(V)	7440-62-2	0.08	10	0.2	Cal Std
Zinc	(Zn)	7440-66-6	0.17	10	2	2000

NOTE: * Represents an MDL obtained with the Elan 6000 during the initial demonstration of performance. Current MDL might be slightly different.
** Typical reporting level for clean water samples, it can change for other applications/matrices.
*** Cal Std represents the value of the highest calibration standard.

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Table 2. Standard preparation for all elements except Fe, Ca, Mg, K, Na.

Standard type	Concentration	Volume of **S** 100 ppm stock	Volume of **HA-WS** 10 ppm stock	Volume of **HNO_3**	Volume of **IS-WS**	Final volume
	(µg/L)	(µL)	(µL)	(mL)	(mL)	(mL)
Blank	0	-	-	1	0.5	50
Standard1: *HA***100**-*mmddyy*	100	-	500	1	0.5	50
ICV: *S***40**-*mmddyy*	40	20	-	1	0.5	50
BS: *HA***.0.0***4*-*mmddyy*	0.04	-	20uL of HA100	1	0.5	50
BS: HA0.2-mmddyy	0.2	-	100 uL of HA100	1	0.5	50
BS: HA4.0-mmddyy	4.0	-	2mL of HA100	1	0.5	50
CCV: *HA***50**-*mmddyy*	50	-	250	1	0.5	50

Table 3. Standard preparation for Fe.

Standard type	Concentration	Volume of **S** 100 ppm stock	Volume of **H-WS** 10 ppm stock	Volume of **HNO_3**	Volume of **IS-WS**	Final volume
	(µg/L)	(µL)	(µL)	(mL)	(mL)	(mL)
Blank	0	-	-	1	0.5	50
Standard1: *HA***200**-*mmddyy*	200	-	1000	1	0.5	50
ICV: *S***80**-*mmddyy*	80	40	-	1	0.5	50
BS: *HA***4.0**-*mmddyy*	4.0	-	2 mL of HA100	1	0.5	50
CCV: *HA***100**-*mmddyy*	100	-	500	1	0.5	50

Table 4. Standard preparation for Ca, Mg, K, Na from a 1000 ppm stock solution.

Standard type	Concentration	Volume of **S**	Volume of **HB**	Volume of **HNO_3**	Volume of **IS-WS**	Final volume
	(mg/L)	(µL)	(µL)	(mL)	(mL)	(mL)
Blank	0	-	-	1	0.5	50
Standard3: *HB***2.0**-*mmddyy*	2.0	-	100	1	0.5	50
ICV: *S***0.8**-*mmddyy*	1.0	50	-	1	0.5	50
BS: *HB***0.01**-*mmddyy*	0.01	-	500uLof HB2.0	1	0.5	50
BS: HB0.05-mmddyy	0.05	-	2.5mL of HB2.0	1	0.5	50
CCV: *HB***1.0**-*mmddyy*	1.0	-	50	1	0.5	50

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Table 5. Instrument operating parameters.

Instrument Parameter	Operating Condition
Plasma forward power	1300 W
Plasma Argon flow rate	16.0 L/min
Auxiliary Argon flow rate	1.0 L/min
Nebulizer Argon flow rate	~0.9 L/min
Spray chamber temperature	2°-25°C
Analyzer vacuum	3 x 10^{-5} – 6x10^{-4} Torr

Table 6. Interference Check Solutions Components and Concentration.

Solution Component	ICS-A (ppm)	ICS-AB (ppm)
Al	100.0	100.0
Ca	300.0	300.0
Fe	250.0	250.0
Mg	100.0	100.0
Na	250.0	250.0
P	100.0	100.0
K	100.0	100.0
S	100.0	100.0
C	200.0	200.0
Cl	2121.5	2121.5
Mo	2.0	2.0
Ti	2.0	2.0
As	0.0	0.100
Cd	0.0	0.100
Cr	0.0	0.200
Co	0.0	0.200
Cu	0.0	0.200
Mn	0.0	0.200
Ni	0.0	0.200
Se	0.0	0.100
Ag	0.0	0.050
V	0.0	0.200
Zn	0.0	0.100

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Table 7. Recommended analytical isotopes (underlined) and additional masses to be monitored.

MASS	ELEMENT	I.S. USED	ELEMENTAL CORRECTION	POTENTIAL INTERFERENCES
6	Li	**I.S.**	$-(0.0813)(^{7}C)$	
7	Li	^{6}Li or Sc		
9	Be	^{6}Li or Sc		
10	B	^{6}Li or Sc		
11	B	^{6}Li or Sc		
19	K	Sc or Rh		
23	Na	Sc or Rh		
24	Mg	Sc or Rh		
27	Al	^{6}Li or Sc		
43	Ca	Sc or Rh		
44	Ca	Sc or Rh	$(-0.0271)(^{88}C)$	Sr^{++}
45	Sc	**I.S.**		CO_2H^+
47	Ti	^{6}Li or Sc		
49	Ti	^{6}Li or Sc		
51	V	^{6}Li or Sc	$-(3.127)(^{53}C)+(0.352)(^{52}C)$	$^{35}ClO^+$, $^{34}SOH^+$
52	Cr	Sc, Ge or Rh		ArC^+, ArO^+, $^{35}ClHO^+$
53	Cr	Sc, Ge or Rh		$^{37}ClHO^+$
54	Fe	Sc, Ge or Rh	$-(0.0284)(^{52}C)$	
55	Mn	Sc, Ge or Rh		$ArNH^+$
57	Fe	Sc, Ge or Rh		
59	Co	Sc, Ge or Rh		
60	Ni	Sc, Ge or Rh		
62	Ni	Sc, Ge or Rh		TiO
63	Cu	Sc, Ge or Rh		$^{31}PO_2^+$, $^{40}ArNa^+$, TiO
65	Cu	Sc, Ge or Rh		TiO
66	Zn	Sc, Ge or Rh		TiO
68	Zn	Sc, Ge or Rh		
74	Ge	**I.S.**		
75	As	Ge or Rh	$-(3.132)(^{77}C)+(2.736)(^{83}C)$	$^{40}Ar^{35}Cl^+$
76	$^{40}Ar^{36}Ar^+$	Ge or Rh		$^{40}Ar^{37}Cl^+$
77	Se	Ge or Rh		
78	Se	Ge or Rh	$-(0.1869)(^{76}C)^{\ddagger}$	$^{40}Ar^{38}Ar^+$
82	Se	Ge or Rh		$^{81}BrH^+$
83	Kr	Ge or Rh		
88	Sr	Ge or Rh		
90	Zr	Ge or Rh		
95	Mo	Ge or Rh		$^{79}BrO^+$
98	Mo	Ge or Rh	$-(0.146)(^{99}C)$	$^{79}BrHO^+$
103	Rh	**I.S.**		
105	Pd	Rh		
106	Pd, Cd	Rh		ZrO,
107	Ag	Rh		ZrO
108	MoO	Rh		ZrO, MoO
109	Ag	Rh		ZrO, MoO
111	Cd	Rh		ZrO, MoO
112	Cd	Rh	$-(0.040)(^{118}C)$	ZrO, MoO
114	Cd	Rh	$-(0.0269)(^{118}C)$	MoO
118	Sn	Rh		
119	Sn	Rh		
120	Sn	Rh	$-(0.0127)(^{125}C)$	
121	Sb	Rh	$-(0.124)(^{125}C)$	$^{40}Ar^{81}Br^+$
123	Sb	Rh		
137	Ba	Rh		
138	Ba	Rh	$-(8.91E-04)(^{139}C)-(2.82E-04)(^{140}C)$	
140	Ce	Rh		
185	Re	**I.S.**		
203	Tl	Re		
205	Tl	Re		
206	Pb	Re		
207	Pb	Re		
208	Pb	Re	$+(1.0)(^{206}C)+(1.0)(^{2.07}C)$	

NOTES: 1) C = Counts at specified mass.
2) When the concentration of Na in the samples is high, the ionization of Sc is suppressed leading to positive bias of the results, therefore Rh or Ge should be used as the internal standard, even if more than 50 amu removed from the element of interest.

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Table 8. Quality Control Items, Frequency, and Corrective Action.

QC Item	Frequency	Acceptance Criteria	Corrective Action
Tuning	After warm-up. Every 12 hours.	Manufacturer specifications	Check operating parameters, clean cones, replace malfunctioning components if necessary. Re-evaluate the tuning.
ICV	After initial calibration.	90-110%	Verify that method parameters are valid, check calibration tables, replace calibration standards if necessary, and recalibrate the instrument.
ICB	Following ICV.	< 2.2 x MDL, or < ½ LLOQ, or < RL for water samples	Prepare fresh calibration blank and/or increase the rinse time between analyses; reanalyze ICB; if within limits, continue the run; if still outside limits, determine the source of the problem, make the necessary corrections, and start from the beginning with a new calibration.
LLOQ	After initial calibration.	80-120% if above RL	Verify that method parameters are valid, check calibration tables, replace calibration standards if necessary, prepare a fresh calibration blank, and recalibrate the instrument.
CCV	Before and after each batch. Every 10 sample. After re-calibration.	90-110%	Recalibrate the instrument. Follow method specific requirements (6020 or 200.8) as to what data prior to the CCV can be used.
CCB	Following CCV.	< 2.2 x MDL, or < ½ LLOQ, or < RL for water samples	Prepare fresh calibration blank; reanalyze CCB; if within limits, continue the run; if still outside limits, eliminate the source of the contamination, clean the sample introduction system if necessary, and recalibrate the instrument. Reanalyze all samples from the last good CCB.
LCS	Every batch of 20 samples.	80-120%for 6020 85-115% for 200.8	Stop analysis, re-prep samples and reanalyze. Look for any project specific requirements.
LRB	Every batch of 20 samples.	< 2.2 x MDL, or < ½ LLOQ, or < RL for water samples < 10% of analyte in samples	Stop analysis, re-prep samples and reanalyze if it adversely impacts project specific data or requirements.
Dup	Every 20 samples (6020) Every 10 samples (200.8)	0-20%	If all other QC is acceptable continue the run; sample result should be flagged; otherwise recalibrate instrument and reanalyze samples.
MS	Every 20 samples (6020) Every 10 samples (200.8)	70-130% with 200.8 75-125% with 6020	For 200.8 flag data if all other QC met; otherwise recalibrate instrument and reanalyze affected samples. For 6020 dilute original sample, re-spike dilution, and reanalyze until within limits.
MSD†	Every 20 samples (6020) Every 10 samples (200.8)	0-20%	Same as for duplicate.
Dil‡	Every batch of 20 samples.	0-20%	If concentration analyzed >100 x MDL, flag data for possible matrix interference.
ICS-A‡	Begging and every 12 hours.	< 2.2 x MDL, or < ½ LLOQ, or < RL for water samples < 10% of analyte in samples	Reevaluate the equations used for corrections, make the necessary adjustments, and recalibrate the instrument. If changes in the optimization parameters do not improve instrument response, add explanatory note in the report case narrative.
ICS-AB‡	Begging and every 12 hours.	75-125	Re-evaluate the equations used for corrections, make the necessary adjustments, and recalibrate the instrument.
IS	With every analysis.	60-125% with 200.8 30-135% samples with 6020 80-125% for CCB with 6020	For samples, dilute 4+1 and reanalyze until in control. For CCV/CCB's recalibrate the instrument and reanalyze the affected samples.

NOTE:
- RL = Reporting Limit.
- Dil = Dilution Test.
- † MSD optional instead of duplicate sample.
- ‡ When Method 6020 referenced in the analytical report.

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

METALS STANDARDS PREPARATION LOG

Pipettor ID: LS021386 ☼ 10-100 µL
LS021384 ♣ 100-1000 µL
LS021385 ♯ 0.5-5 mL

Perkin Elmer: Elan / NexION
HNO_3 Lot # ____________
Internal Std ID # ____________

Date	Analyst	Working Standard ID conc.* (ppm, bold)	Source	Lot Number	Exp. Date	Remarks
		HA-WS**10**-	HPS-A	1913438	05/31/2020	

Date	Analyst	Standard ID and conc.* (µg/L, bold)	Source	Lot No or Source ID	Exp. Date	Remarks
		HPS **LLOQ**-	HPS	1913533	05/31/2020	
		HA**50**-	HA-WS	HA-WS**10**-	05/31/2020	
		HA**100**-	HA-WS	HA-WS**10**-	05/31/2020	
		HA**200**-	HA-WS	HA-WS**10**-	05/31/2020	
		HPS **LRV**-	HPS	1913504	05/31/2020	
		S**40**-	SPEX	52-021CR	05/30/2020	
		S**80**-	SPEX	52-021CR	05/30/2020	
		ERA-	ERA	P282-500	10/31/2020	
		A-	IV	N2-MEB671037	04/29/2020	
		AB-	IV	N2-MEB664996	04/29/2020	
		HB**0.01**-	HPS-B	1913435	05/31/2020	
		HB**0.05**-	HPS-B	1913435	05/31/2020	
		HB**1.0**-	HPS-B	1913435	05/31/2020	
		HB**2.0**-	HPS-B	1913435	05/31/2020	
		SM**0.8**-	SPEX	52-022CR	05/30/2020	
		ERA-M	ERA	P269-506-507	09/30/2020	
		IVSi**0.05**-	IV-Si	P2-SI676242	09/11/2020	
		IVSi**1.0**-	IV-Si	P2-SI676242	09/11/2020	
		IVSi**2.0**-	IV-Si	P2-SI676242	09/11/2020	
		SSi**0.8**-	SPEX-Si	24-93SIX	09/30/2020	

Date	Analyst	Internal Standard (IS) ID and PPM conc.	Source	Lot Number	Exp. Date	Remarks
		IS**2.0**-	IV-Li^6	P2-LI677020	09/11/2020	
			IV-Sc	P2-SC677026	09/11/2020	
			IV-Ge	P2-GE677722	09/11/2020	
			IV-Rh	N2-RH673649	09/11/2020	
			IV-Re	M2-RE656694	09/11/2020	

NOTES: 1) The following abbreviations were used:
- HPS = High Purity Standards, Inc.
- SPEX = SPEX CertiPrep, Inc.
- WS = Working Standard, 10 ppm solution, a 10/1 dilution of the HPS-A stock solution.
- A, IV = Interference Check Solution, SIC A, from Inorganic Ventures, Inc.
- AB, IV = Interference Check Solution, SIC AB, from Inorganic Ventures, Inc.

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

2) Stock solutions used, source, concentration and the elements present:

- HA-WS = HPS, 10 ppm each of Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Tl, Ti, V, Zn.
- S = SPEX, 100 ppm each of Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Tl, Ti, V, Zn.
- A = IV, 1000 µg/ml each of Al, Mg, P, K, S, 2000 mg/mL of C, 2500 mg/mL each of Fe and Na, 3000 mg/mL of Ca, 21215 mg/mL of Cl, and 20.0 mg/mL each of Mo and Ti.
- AB = IV, 20.0 mg/mL each of Cr, Co, Cu, Mn, Ni, and V, 10.0 mg/mL each of As, Cd, Se, Zn and 5.00 mg/mL of Ag.
- HB = HPS solution B, 1000 ppm each of Ca, Mg, Na, and K.
- SM = SPEX, 1000 ppm each of Ca, Mg, Na, and K.
- HPSLLOQ = HPS, 2 ppm each of Fe, B; 1 ppm each of Al, Li, Zn; 0.2 ppm each of Sb, As, Ba, Be, Bi, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Sr, Sn, Tl, Ti, V; 0.02 ppm each of Cd, Ag.
- HPSLRV = HPS, 1000 ppm each of Al, Sb, As, Ba, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, Se, Ag, Sr, Sn, Tl, Ti, V, Zn.

3) * Working solution, HB/SM and Silicon stock standards concentrations are listed in ppm.

PREPARATION GUIDE

Standard		**Pipettor**	**HA**	**HPS**	**SPEX**	**ERA**	**A**	**AB**	**HB**	**SM**	**Si****	**IS*****	**HNO_3**	**IS**	**Final volume**
			(µL)	(µL)	(µL)	(µL)	(µL)	(µL)	(µL)	(µL)	(µL)	(µL)	(mL)	(mL)	(mL)
Cal Blank	0 ppb		-	-	-	-	-	-	-	-	-	-	1	0.5	50
HPS-**LLOQ**	LL ppb	☼	-	100	-	-	-	-	-	-	-	-	1	0.5	50
HA**50**	50 ppb	♣	250	-	-	-	-	-	-	-	-	-	1	0.5	50
HA**100**	100 ppb	♣	500	-	-	-	-	-	-	-	-	-	1	0.5	50
HA**200**	200 ppb	♣	1000	-	-	-	-	-	-	-	-	-	1	0.5	50
HPS-**LRV**	2000 ppb	☼	-	100	-	-	-	-	-	-	-	-	1	0.5	50
S**40**	40 ppb	☼	-	-	20	-	-	-	-	-	-	-	1	0.5	50
S**80**	80 ppb	☼	-	-	40	-	-	-	-	-	-	-	1	0.5	50
ERA	varies	☼	-	-	-	20	-	-	-	-	-	-	1	0.5	50
A-	varies	♯	-	-	-	-	5000	-	-	-	-	-	1	0.5	50
AB-	varies	♯, ♣	-	-	-	-	5000	500	-	-	-	-	1	0.5	50
HB**0.01**	0.01 ppm	♣	-	-	-	-	-	-	250*	-	-	-	1	0.5	50
HB**0.05**	0.05 ppm	♣	-	-	-	-	-	-	1250*	-	-	-	1	0.5	50
HB**1.0**	1.0 ppm	☼	-	-	-	-	-	-	50	-	-	-	1	0.5	50
HB**2.0**	2.0 ppm	☼	-	-	-	-	-	-	100	-	-	-	1	0.5	50
SM**0.8**	0.8 ppm	☼	-	-		-	-	-	-	40	-	-	1	0.5	50
ERA-M	varies	♣	-	-	-	1000	-	-	-	-	-	-	1	0.5	50
HSi**0.05**	0.05 ppm	☼	-	-	-	-	-	-	-	50	1250*	-	1	0.5	50
HSi**1.0**	1.0 ppm	☼	-	-	-	-	-	-	-	-	50	-	1	0.5	50
HSi**2.0**	2.0 ppm	☼	-	-	-	-	-	-	-	-	100	-	1	0.5	50
SSi**0.8**	0.8 ppm	☼	-	-	-	-	-	-	-	-	40	-	1	0.5	50
IS**2.0**	2.0 ppm	♣	-	-	-	-	-	-	-	-	-	2000	20	-	1000

* The volume stated for the HB and Si low level check standard is taken from the 2.0 ppm calibration standard (serial dilution).

** The volume stated applies to both HPS and SPEX Si sources.

*** The volume stated applies to all sources used as analytes for the Internal Standard (IS) mix.

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

DIGESTION WORKSHEET

LCS/MS/MSD - added 75uL of 10ppm of HPS-A 1913438, Procurement #19050680

added 15uL of HPS-B 1913435, Procurement #19050680

Pipette M&TE#/ Range/ Cal: LS021380/ 0.5-5mL/ 03-2020 LS021486/20-200uL/03-202 LS021488/100-1000uL/03-2020
LS021486/5-50uL/03-2020

HNO_3 - Lot# 18417996, Item# 63, Exp. Date: 09/12/23, Procurement: 19050760
15 mL Tube: Lot# 1812114
Hot Block M&TE#: 024242
Start Time/Temp: __________________ **Thermocouple M&TE#:** LS011969 (10/09/20) **Probe M&TE#:** CP3464
End Time/Temp: _____________________
Position: ____________

Sample ID	Volume (mL)	Final Vol (mL)	Remarks
LCS	3	15	
LRB	3	15	
		15	
		15	
		15	
		15	
		15	
		15	
		15	
		15	
		15	
		15	
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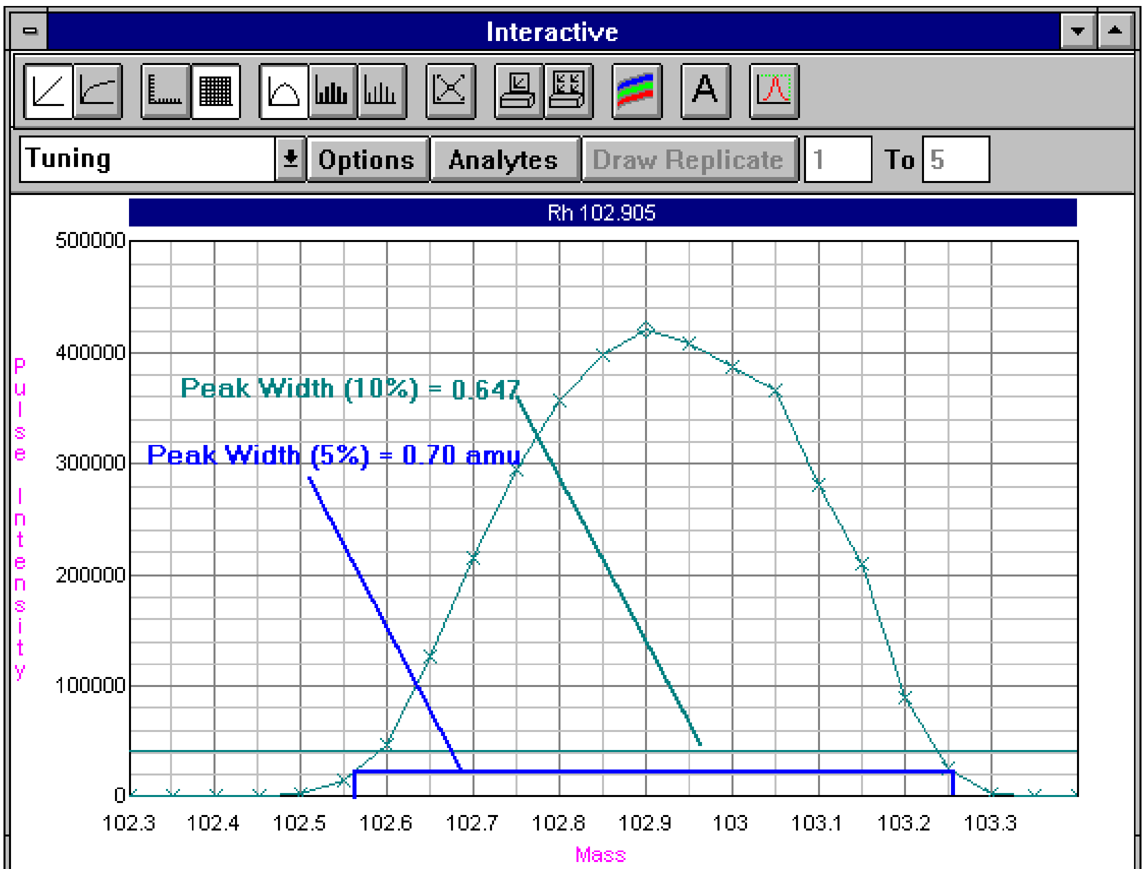
		15	
		15	
		15	

Analyst: _________________________ Date: _________________________

TITLE: METALS ANALYSIS BY INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY

Peak Width Relationship at 5% and 10% Peak Height



	Analyte	Mass (amu)	Measured Mass (amu)	Mass Calibration DAC Value	Resolution DAC Value	Measured Peak Width (amu)
4	Rh	102.905	102.901	24877	2855	0.647

TITLE: ANIONS ANALYSIS BY ION CHROMATOGRAPHY

Written or Revised by Dawn Williams Date 6.18.20
Level I or Above

Technical Review / Approval by ____________ Date 06/18/20
Level III (not author)

Administrative Approval by ____________ Date 06/18/20
Department Head

TITLE: ANIONS ANALYSIS BY ION CHROMATOGRAPHY

1.0 SCOPE

1.1 The purpose of this procedure is to set forth a method by which the Chemistry Department of Laboratory Services will determine following inorganic anions:
- Bromide
- Nitrite
- Chloride
- Ortho-Phosphate-P
- Fluoride
- Sulfate
- Nitrate

1.2 The method is applicable to the analysis of drinking water, surface water, mixed domestic and industrial wastewaters, groundwater, reagent waters, solids (after the extraction step described in section 9.1), and leachates (when no acetic acid is used)

1.3 When this method is used to analyze unfamiliar samples for any of the above anions, anion identification should be supported by the use of a fortified sample matrix covering the anions of interest.

1.4 This SAP follows the guidelines of USEPA Method 300.0 “Determination of Inorganic Anions by Ion Chromatography” Revision 2.1 August 1993.

1.5 Typical Method Detection Limits (MDL’s) and practical quantitation levels (PQL’s) for anions determined with this procedure are listed in the following table:

Fluoride	9.9	100
Chloride	8.4	100
Nitrite as N	5.6	50
Bromide	19.6	100
Nitrate as N	4.7	50
Sulfate	4.7	50
Phosphate (-ortho)	16.0	500

Current MDL’s and PQL’s are listed on the Company Network, at K:\CHEM\MDLs_Current.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 Chemistry Department Standard Operating Procedures, as applicable

2.2 Laboratory Services Quality Assurance (LSQA) Procedures, as applicable

2.3 Pfaff, John D. USEPA Method 300.0 Determination of Inorganic Anions by Ion Chromatography Revision 2.1 August 1993

2.4 Instrument Manual, as applicable

2.5 USEPA Method 26A "Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources – Isokenetic Method."

3.0 DEFINITIONS

3.1 Continuing Calibration Blank (CCB) -- A volume of reagent water fortified with the same matrix as the calibration standards, but without the analytes.

3.2 Calibration Standard (CAL) -- A solution prepared from the primary dilution standard solution or stock standard solutions. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration.

3.3 Field Duplicates (FD) -- Two separate samples collected at the same time and placed under identical circumstances and treated exactly the same throughout field and laboratory procedures. Analyses of field duplicates indicate the precision associated with sample collection, preservation and storage, as well as with laboratory procedures.

3.4 Continuing Calibration Verification (CCV) -- A solution of one or more method analytes used to evaluate the performance of the instrument system with respect to a defined set of criteria.

3.5 Matrix Spike (MS) -- An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The MS is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the MS corrected for background concentrations.

3.6 Laboratory Reagent Blank (LRB) or Method Blank (MB) -- An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment and reagents used with other samples. The LRB is used to determine if method analytes or other interferences are present in the laboratory environment, the reagents, or the apparatus.

NOTE: The CCB's, LRB's or MB's are all reagent blank water for this method.

3.7 Linear Calibration Range (LCR) -- The concentration range over which the instrument response is linear.

3.8 Safety Data Sheet (SDS) -- Written information provided by vendors concerning a chemical's toxicity, health hazards, physical properties, fire, and reactivity data including storage, spill, and handling precautions.

3.9 Method Detection Limit (MDL) -- The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

3.10 Proficiency Testing Sample (PT) -- A solution of method analytes distributed by various PT providers to multiple laboratories for analysis. A volume of the solution is added to a known volume of reagent water and analyzed with procedures used for samples. Results of analyses are used by the PT provider to determine statistically the accuracy and precision that can be expected when a method is performed by a competent analyst. Analyte true values are unknown to the analyst.

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3.11 Laboratory Control Sample (LCS) -- A solution of method analytes of known concentrations that is used to fortify an aliquot of LRB or sample matrix. The LCS is obtained from a source external to the laboratory and different from the source of calibration standards. It is used to check laboratory performance with externally prepared test materials.

3.12 Stock Standard Solution (SSS) -- A concentrated solution containing one or more method analytes prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source.

3.13 Sample Batch -- A set of 20 samples validated by at least an LCS, LRB and a matrix spike.

3.14 ERA – An optional secondary standard, in addition to the LCS, purchased from Environmental Resources Associates and provided with a certificate of analysis and acceptance criteria limits by the vendor, per each lot.

4.0 SUMMARY OF METHOD

4.1 A small volume of sample is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, analytical column, suppressor device, and conductivity detector.

4.2 An extraction procedure must be performed to use this method for solids (See Section 9.1).

4.3 Limited performance-based method modifications may be acceptable provided they are fully documented and meet or exceed requirements expressed in Section 8.0, Acceptance Criteria.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Balance -- Analytical, capable of accurately weighing to the nearest 0.000l g.

5.1.2 Ion chromatograph – Dionex ICS-5000 analytical system complete with ion chromatograph and all required accessories including analytical columns and detectors.

5.1.2.1 Anion guard column: Dionex IonPac AG22 (4mm) or equivalent.

5.1.2.2 Anion analytical column: Dionex IonPac AS22 (4mm) or equivalent.

5.1.2.3 Anion suppressor device: Dionex ASRS 300 4mm Self-regenerating or equivalent.

5.1.2.4 Detector: Conductivity cell, Dionex ICS-5000+ Electrochemical detector or equivalent.

5.1.2.5 Autosampler: Dionex ASDV Autosampler or equivalent.

5.1.2.6 Software: Dionex Chromeleon Version 7.0 or equivalent.

5.1.3 Vials and Caps: Dionex Polyvial 5mL Vials and Filter Caps or equivalent.

5.2 REAGENTS

5.2.1 Reagent water: Distilled or deionized water, free of the anions of interest. Water should contain particles no larger than 0.20 microns.

Eluent Solution: 4.5 mM Sodium Carbonate/1.4mM Sodium Bicarbonate from AS22 Eluent Concentrate (ICS-5000 system).

5.2.2 Individual stock standard solutions, l000mg/L (1mg/mL): Stock standard solutions may be purchased as certified solutions or prepared from ACS reagent grade materials (dried at 105°C for 30 minutes) as listed below.

5.2.2.1 Bromide 1000mg/L: Dissolve 1.2876g sodium bromide (NaBr, CASRN 7647-15-6) in reagent water and dilute to 1L.

5.2.2.2 Chloride l000mg/L: Dissolve 1.6485g sodium chloride (NaCl, CASRN 7647-l4-5) in reagent water and dilute to 1L.

5.2.2.3 Fluoride 1000mg/L: Dissolve 2.2100g sodium fluoride (NaF, CASRN 7681-49-4) in reagent water and dilute to 1L.

5.2.2.4 Nitrate 1000mg/L: Dissolve 6.0679g sodium nitrate ($NaNO_3$, CASRN 7631-99-4) in reagent water and dilute to 1L.

5.2.2.5 Nitrite 1000mg/L: Dissolve 4.9257g sodium nitrite ($NaNO_2$, CASRN 7632-00-0) in reagent water and dilute to 1L.

5.2.2.6 Phosphate 1000mg/L: Dissolve 4.3937g potassium phosphate (KH_2PO_4, CASRN 7778-77-0) in reagent water and dilute to 1L.

5.2.2.7 Sulfate 1000mg/L: Dissolve 1.8141g potassium sulfate (K_2SO_4, CASRN 7778-80-5) in reagent water and dilute to 1L.

5.2.3 Seven Anion Stock Solution (alternative to 5.2.2): Contains fluoride, chloride, nitrite, bromide, nitrate, phosphate, and sulfate. Dionex Seven Anion Standard II (part #57590) or equivalent.

5.2.4 Seven Anion Check Standard: Contains all anions listed in 5.2.4, but procured from a separate source. (SPEX Certiprep)

5.2.5 Chloride 10,000 mg/L for soil preparation, such as Inorganic Ventures part # ICCL10-125ML.

5.2.6 Sulfate 10,000 mg/L for soil preparation, such as Inorganic Ventures part # ICSO410-125ML.

5.3 CALIBRATION REQUIREMENTS

5.3.1 The IC is calibrated prior to use with standards.

5.3.2 The calibration curve is composed of a sufficient number of standards to ensure that the resulting curve is linear, at a minimum three concentration levels and a blank. The calibration curve should be of sufficient range to bracket the expected concentration of the sample analytes of interest. Each standard level is prepared by pipetting the corresponding volume of the stock standard and diluent (method dependent) into the autosampler vial. The exact volumes and the resulting calibration standard concentrations are listed in the Dionex folder on the Company network.

5.3.3 The calibration curve for each analyte should achieve a minimum correlation coefficient of 0.995 in order to be considered valid.

5.3.4 The mid points of the calibration curve cannot be dropped. If a low point is dropped the reporting limit must be increased to the level of the lowest standard included in the curve. If a high point is dropped samples must be diluted within the concentration range of highest point. When permissible changes (as described above) to the calibration curve are necessary, the date and initials of the person making the adjustment, and the reason for the adjustment are to be documented. The change must be approved by the Technical Director (or delegate) before the curve is used to generate results for analytical samples.

5.3.5 The calibration curve should be determined with every new lot of standards, when the CCV results show signs of shifting, are not within the required limits, and if a significant change in instrument response is observed or expected.

5.3.6 See section 10.2 of USEPA Method 26A for requirements.

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 Chromatograms associated with samples are printed and provided to the project lead along with the data summary, including all recovery calculations for QC elements (i.e. CCV/LCS/Duplicates/MS/MSD). They are stored in the project folder and scanned with the completed project report.

5.5 PERSONNEL REQUIREMENTS

5.5.1 All tests and data reporting shall be performed by certified persons of Level I or above, in the appropriate discipline. The project report shall be issued and reviewed by a certified person of Level II or above, in the appropriate discipline. The project report, if so indicated on the work request (or form similar in intent,) may require approval from a certified person of Level III, in the appropriate discipline.

5.5.2 This method is recommended for use only by or under the supervision of analysts experienced in the use of ion chromatography and in the interpretation of the resulting ion chromatograms.

5.5.3 For projects where reporting under the 2009 TNI Standard has been requested, all tests and data reporting shall be performed by analysts with a completed initial, or an on-going Demonstration of Capability (IDOC/DOC), as applicable.

5.6 ENVIRONMENTAL CONDITIONS

5.6.1 Aqueous samples should be collected in plastic or glass bottles. All bottles must be thoroughly cleaned and rinsed with reagent water. Volume collected should be sufficient to insure a representative sample, allow for replicate analysis, if required, and minimize waste disposal.

5.6.2 Sample preservation and holding times for the anions that can be determined by this method are as follows:

Analyte	**Preservation**	**Holding Time**
Bromide	None	28 Days
Chloride	None	28 Days
Fluoride	None	28 Days
Nitrate-N	Cool to 4˚C	48 Hours
Combined (Nitrate/Nitrite)	Conc. H_2SO_4 to a pH < 2	28 Days
Nitrite-N	Cool to 4˚C	48 Hours
o-Phosphate-P	Cool to 4˚C	48 Hours
Sulfate	Cool to 4˚C	28 Days

5.6.3 The method of preservation and the holding time for samples analyzed by this method are determined by the anions of interest. In a given sample, the anion that requires the most preservation treatment and the shortest holding time will determine the preservation treatment. It is recommended that all samples be cooled to 4°C and held for no longer than 28 days.

5.6.4 Soil samples are collected without preservation, usually in glass containers with Teflon lined caps. Non-aqueous samples should be stored at 4˚C upon receiving.

5.6.5 Sample preservation, containers and hold times are also detailed in Standard Operating Procedure CHEM-1.2.02.

6.0 PRECAUTIONS

6.1 Observe normal practices as specified in the latest online revision of the Consumers Energy Accident Prevention Manual and the Consumers Energy Chemical Hygiene Plan.

6.2 Safety glasses should be worn at all times, because the ion chromatograph is a pressurized system.

6.3 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Every effort should be made to minimize the generation of excess waste in the preparation of standards and reagents related to this procedure.

6.4 For guidance on proper disposal of unused samples, stock chemicals and reagents refer to SOP CHEM-1.2.08 Handling and Disposal of Lab Testing Waste.

7.0 LIMITATIONS AND ACTIONS

7.1 Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or fortification can be used to solve most interference problems associated with retention times.

7.2 The water dip or negative peak that elutes near, and can interfere with, the fluoride peak can usually be eliminated by the addition of the equivalent of 1mL of concentrated eluent (5.2.2 100X) to l00mL of each standard and sample.

7.3 Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baseline in ion chromatograms.

7.4 Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow systems.

7.5 Any anion that is not retained by the column or only slightly retained will elute in the area of fluoride and interfere. Known co-elution is caused by carbonate and other small organic anions. At concentrations of fluoride above 1.5 mg/L, this interference may not be significant; however, it is the responsibility of the user to generate precision and accuracy information in each sample matrix.

7.6 The acetate anion elutes early during the chromatographic run. The retention times of the anions also seem to differ when large amounts of acetate are present. Therefore, this method is not recommended for leachates of solid samples when acetic acid is used for pH adjustment.

7.7 The quantitation of un-retained peaks should be avoided, such as low molecular weight organic acids (formate, acetate, propionate etc.) which are conductive and co-elute with or near fluoride and would bias the fluoride quantitation in some drinking and most waste waters.

8.0 ACCEPTANCE CRITERIA

8.1 Initial Demonstration of Performance

8.1.1 The initial demonstration of performance is used to characterize instrument performance (determination of linear calibrated range or LCR and analysis of laboratory control sample or LCS) and laboratory performance (determination of MDLs) prior to performing analyses by this method.

8.1.2 The linear calibrated range or LCR must be determined initially and verified every six months or whenever a significant change in instrument response is observed or expected. The initial demonstration of linearity must use sufficient standards to ensure that the resulting curve is linear. If any portion of the range is shown to be nonlinear, sufficient standards must be used to clearly define the nonlinear portion.

8.1.3 When beginning the use of this method, on a quarterly basis or as required to meet data-quality needs, verify the calibration standards and acceptable instrument performance with the preparation and analyses of a LCS. If the determined concentrations are not within ±10% of the stated values, performance of the determinative step of the method is unacceptable. The source of the problem must be identified and corrected before either proceeding with the initial determination of MDLs or continuing with on-going analyses.

8.1.4 Method detection limits or MDLs must be established for all analytes, using reagent water (blank) fortified at a concentration of two to three times the estimated instrument detection limit. To determine MDL values, take seven replicate aliquots of reagent water fortified with 1-5

TITLE: ANIONS ANALYSIS BY ION CHROMATOGRAPHY

times the estimated detection concentration for the analyte and process through the entire analytical method. Perform all calculations defined in the method and report the concentration values in the appropriate units. To calculate the MDL see Section 10.1. MDLs should be determined annually or whenever there is a significant change in the background or instrument response.

8.2 Assessing Laboratory Performance

8.2.1 Analyze a laboratory reagent blank or LRB for every batch of 20 samples. The data produced is used to assess contamination from the laboratory environment. Values that exceed the 2.2 x MDL or are more than 10% of the background measured in the analytical samples indicate contamination and corrective actions must be taken before continuing the analysis (re-prep and reanalyzed affected sample batch).

8.2.2 Analyze a laboratory control sample (LCS) for every batch of 20 samples. The LCS is purchased from a source independent of the laboratory and different from the source of calibration standards. If its determined concentrations are not within ±10% of the stated values then analysis must be suspended until the source of the problem is identified and corrected.

8.2.3 For all determinations the laboratory must analyze the continuing calibration verification or CCV (a mid-range check standard) and a continuing calibration blank or CCB following the calibration, after every tenth analytical sample (or more frequently, if required) and at the end of the sample run. Analysis of the CCV and CCB following the calibration must verify that the instrument is within ±10% of true value for the standard. Subsequent analyses of the CCV must verify the calibration is still within ±10%. If the calibration cannot be verified within the specified limits, reanalyze the CCV. If the second analysis of the CCV confirms calibration to be outside the limits, sample analysis must be discontinued, the cause determined and/or in the case of drift, the instrument recalibrated. All samples following the last acceptable CCV must be reanalyzed once the problem has been corrected. The analysis data of the CCB and CCV must be kept on file with the sample analyses data.

8.2.4 Analyze an ERA sample with each analytical batch, and evaluate the results using the acceptance criteria limits provided on the certificate of analysis from the vendor, per each lot.

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8.2.5 See section 11.1.3 of USEPA Method 26A for requirements.

8.3 Assessing Analyte Recovery and Data Quality

8.3.1 The laboratory must add a known amount of analyte to a minimum of 10% of the routine samples. Analyze one matrix spike (MS) and one matrix spike duplicate (MSD) for every 10 samples. Calculate accuracy as percent recovery (Section 10.2). In each case the MS aliquot must be a duplicate of the aliquot used for sample analysis. The analyte concentration must be high enough to be detected above the original sample and should not be less than four times the MDL. If the recovery of any analyte falls outside the required control limits of 80-120%, that analyte is judged out of control, and the source of the problem should be identified and resolved before continuing analyses. If the relative percent difference (%RPD) between the MS/MSD pair falls outside the required 0-20% limits the analyte is judged out of control, and the source of the problem should be identified and resolved before continuing analyses. The affected samples batches must be re-prepped and reanalyzed.

8.3.1.1 If the concentration of a spike is less than 25% of the background concentration of the matrix the matrix recovery should not be calculated.

8.3.1.1 If the recovery of any analyte falls outside the designated MS recovery range and the laboratory performance for that analyte is shown to be in control (Section 8.2), the recovery problem encountered with the MS is judged to be either matrix or solution related, not system related.

8.3.2 In recognition of the rapid advances occurring in chromatography, the analyst is permitted certain options, such as the use of different columns and/or eluents, to improve the separations or lower the cost of measurements. Each time such modifications to the method are made, the analyst is required to repeat the initial demonstration of performance procedure in Section 8.1.

8.3.3 It is recommended that other lab performance procedures be adopted when applicable, depending on the nature of the samples. Some productive quality assurance practices to utilize are: analyzing field duplicates, participating in performance evaluation sample studies, dilution tests, and analyzing other certified check standards.

8.3.4 Matrix spikes are not required for Method 26A.

8.3.5 The acceptance criteria, frequency of control items and appropriate corrective action is listed in the table below:

Quality Control Items, Frequency and Corrective Action

QC Item	Frequency	Acceptance Criteria	Corrective Action
LRB	Every batch of 20 samples.	2.2 x MDL	Reanalyze to confirm. If confirmed, re-prep and reanalyze batch.
LCS	Every batch of 20 samples.	90-110%	Reanalyze to confirm. If confirmed, re-prep and reanalyze batch.
CCV	Before and after each batch. Every 10 samples.	90-110%	All samples following the last acceptable CCV must be reanalyzed.
CCB	Every 10 samples.	2.2 x MDL	All samples following the last acceptable CCB must be reanalyzed
MS	Every 10 samples.	80-120%	See Section 8.3.1
MSD	Every 10 samples.	80-120%, RPD 0-20%	Same as MS. RPD - See Section 8.3.1
ERA	Once per analysis. Applies to Chloride only.	As per Certificate of Analysis for given lot for PT acceptance.	Reanalyze to confirm. If confirmed, investigate and address the problem, recalibrate if needed. Re-prep and reanalyze batch once issue is resolved.
Soil/Solid LCS	Every batch of 20 extracted samples.	See In-House criteria.	Re-prep batch, reanalyze.
Soil/Solid MS/MSD	Every batch of 20 extracted samples.	See In-House criteria.	Re-prep batch, reanalyze.

9.0 PROCEDURE

9.1 The following extraction should be used for solid materials prior to analyzing (all other samples start at 9.2):

9.1.1 In a 15mL plastic centrifuge tube, weigh out approximately 1g of sample. Add an amount of reagent water equal to 10 times the weight of solid material taken as a sample. Different amounts of sample may be used as needed. Maintain same ratio of reagent water to sample.

9.1.2 Mix the slurry for 10 minutes using a tumbler or a mechanical shaker.

9.1.3 Filter the resulting slurry before injecting using a 0.45μ membrane type filter. This can be done using vacuum filtration or filter and syringe set up. For turbid samples, centrifuging may be necessary before filtration.

9.1.4 Care should be taken to show that good recovery and identification of peaks is obtained with the matrix through the use of spiked samples (Section 5.2).

9.2 Launch Chromeleon software.

9.3. Confirm that the instrument is set to the proper operating parameters according to the manufacturer's instructions.

9.4 Enter start-of-run batch QC. A typical opening QC consists of:

- Blank
- CCV-(date of run)
- CCB
- LCS-(date of run)
- LRB
- ERA-(date of run)

9.5 Add standards, at their appropriate dilution, to clean vials and cap.

9.6 Place vials into autosampler.

9.7 Ready check the software and start the batch through Chromeleon.

9.8 After analysis refer to the spectra and data table that is generated by the software. Assign and adjust peaks as needed (including manual integration for consistent baseline linearity). Confirm that the laboratory standards and other quality control are within the appropriate range.

9.9 Repeat Section 9.2 through 9.6 with unknown samples, analyzing appropriate QC (CCV, CCB, MS, and MSD) as frequently as previously stated in Section 8.0.

9.10 If peak response exceeds the calibration range, dilute the sample and reanalyze.

10.0 CALCULATIONS

10.1 MDL - Calculate the MDL as follows:

$$MDL = t \times S$$

where,
t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t= 3.14 for seven replicates]
S = standard deviation of the replicate analyses

10.2 Percent Recovery – Calculate percent recovery using the following equation:

$$R = \frac{C_s - C}{s} \times 100$$

where,
R = percent recovery
C_s = fortified sample concentration
C = sample background concentration
s = concentration equivalent of analyte added to sample

10.3 Relative Percent Difference - Calculate RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{\frac{C_1 + C_2}{2}} \times 100$$

where,
RPD = relative percent difference,
C_1 = first analyte concentration,
C_2 = second analyte concentration.

11.0 DATA REPORTING

11.1 The data is formatted, evaluated and summarized in a table that provides the sampling site, date and time of the analysis, method, sample description, analyst, dilution factor, all applicable QC evaluations and the result. Each requested ion is reported on a separate table and all tables are attached to the printed sample ion chromatogram(s) for review. An example of a data table can be found on the Company network, in the Archived Chromeleon Data Folder.

TITLE: ANIONS ANALYSIS BY ION CHROMATOGRAPHY

11.2 All data results are to be entered into the Laboratory Information Management System (LIMS), with hard copies of the data to be retained in project folder, as referenced in Section 5.4.1.

11.3 Chromeleon raw data archiving should be performed quarterly, or as often as necessary to prevent data loss due to computer malfunction. This is done by exporting the sequences as .cmbx files onto an external hard drive or Company network. In the Data tab of Chromeleon, perform the following steps to export the sequence:

- Click on “Audit Trails”
- Highlight the sequence(s) to save
- Click **File** and select **Send To** from the drop-down box; a Send To window will open
- Click **Start;** a Save As window will open
- **Save** to the external hard drive or Company network as .cmbx file (Chromeleon Back up)

TITLE: FILTERABLE (TDS) RESIDUE

Written or Revised by Deanne Turrell Date 6/18/2020
Level I or Above

Technical Review / Approval by ______________________ Date 06/18/20
Level III (not author)

Administrative Approval by ______________________ Date 06/18/20
Department Head

TITLE: FILTERABLE (TDS) RESIDUE

1.0 SCOPE

1.1 The purpose of this procedure is to set forth a method by which the Chemistry Department of Laboratory Services will analyze environmental and processed waters for filterable residue (TDS).

1.2 This SAP follows the guidelines of SM 2540C, Total Dissolved Solids Dried at 180ºC.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 Chemistry Department Standard Operating Procedures, as applicable

2.2 Standard Methods for the Examination of Water and Wastewater, 23rd Edition.

3.0 DEFINITIONS

3.1 Total Residue – The sum of the homogenous suspended and dissolved materials in a sample.

3.2 Filterable (Dissolved) Residue – Solids capable of passing through a glass fiber filter and dried to constant weight at 180°C. Total Dissolved Solids (TDS) – The portion of sample that passes through a filter.

4.0 SUMMARY OF METHOD

4.1 Total Dissolved Solids – A well-mixed sample is filtered through a standard glass fiber filter and dried to constant weight at 180°C.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Glass Fiber Filter Discs – 4.7 cm without organic binder as listed below:

- TDS – Environmental Express # F92447MM1.5 micron, binderless Borosilicate Glass Fiber or equivalent.

5.1.2 StableWeigh 6-Place Filling Station or Suction Flask, Filter Holder, and Membrane Filter Funnel.

5.1.3 Modular oven rack and weighing bracket.

5.1.4 StableWeigh TDS Sample Vessels (sample bags) or 100 mL Gooch Crucibles.

5.1.5 Heater – 24-Position, StableWeigh TDS HotBlock or a controlled electric hot plate, heat lamp, or steam bath for maintaining temperature of evaporating sample near boiling point.

5.1.6 Drying Oven – 180°C ± 2°C

5.1.7 Desiccator.

5.1.8 Analytical Balance – Capable of weighing to 0.1 mg along with static diffuser such as Mettler Toledo Balance Deionizer & Power Supply, Item No.: EE1133696.

5.1.9 100 mL Class A Graduated Cylinder.

5.2 REAGENTS

5.2.1 Water – Distilled water shall be ASTM D1193, Type III, or better

5.2.2 Laboratory Control Sample – ERA Cat# 506 or equivalent.

5.3 CALIBRATION REQUIREMENTS

5.3.1 The balance must be calibrated according to CHEM-1.2.7, Balance Calibration, Verification and Usage.

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 The Quality Control elements required for this SOP are listed in Tables 2020: I and 2020: II of the Standards Methods referenced in Section 2.2.

5.4.2 Due to the nature of the analysis and consistent with the requirements of the approved analytical method for NPDES (SM2540C), some of the twelve essential quality control elements published at 40 CFR Part 136.7 are not applicable for Total Dissolved Solids determination. They are the following:

- Method Detection Limit (MDL)
- Matrix Spike and Matrix Spike Duplicate (MS/MSD)
- Internal Standards or Surrogate Standards
- Calibration, initial and continuing (ICV/CCV)

5.4.3 The precision and bias of the method is evaluated through the analysis of duplicate samples, along with a Laboratory Reagent Blank (MB or LRB) and a Laboratory Control Sample (LCS) with each analytical batch. The frequency requirements and acceptance criteria are listed in Section 8.

5.5 PERSONNEL REQUIREMENTS

All tests and data reporting shall be performed by certified persons of Level I or above, in the appropriate discipline. The project report shall be issued and reviewed by a certified person of Level II or above, in the appropriate discipline. The project report, if indicated on the work request (or form similar in intent), may require approval from a certified person of Level III, in the appropriate discipline.

For projects where reporting under the 2009 TNI Standard has been requested, all tests and data reporting shall be performed by analysts with a completed initial, or an on-going Demonstration of Capability (IDOC/DOC), as applicable.

5.6 ENVIRONMENTAL CONDITIONS

5.6.1 Containers – Generally, samples are collected in plastic containers.

5.6.2 Preservation – Upon collection, samples are refrigerated at ≤ 6°C to minimize microbiological decomposition of solids. Bring samples to room temperature before analysis.

5.6.3 Maximum holding time for refrigerated sample is 7 days from sample collection. Begin analysis as soon as possible because of the impracticality of preserving samples.

6.0 PRECAUTIONS

Observe normal safety practices as specified in the latest online revision of the Consumers Energy Chemical Hygiene Plan.

Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. For guidance on proper disposal of unused samples, stock chemicals and reagents refer to SOP CHEM-1.2.08 “Handling and Disposal of Lab Testing Waste”.

7.0 LIMITATIONS AND ACTIONS

7.1 INTERFERENCES

7.1.1 For all residue determinations – Excessive residue is sample vessel will crust over and entrap water that will not be driven off during drying. Total residue should be limited to approximately 200 mg (allowance for the limit to be within 10% for brine samples).

7.2 CORRECTIVE ACTION

Initiate corrective action to identify and correct the issues whenever results for LCS, LRB and duplicate sample analysis or are outside the limits summarized in Section 8, below.

8.0 ACCEPTANCE CRITERIA

Quality Control Items, Frequency and Corrective Action

QC Item	Frequency	Acceptance Criteria	Corrective Action
LCS (ERA)	Every batch of 20 samples.	As stated on the certificate of analysis or in-house derived limits	Re-prep and reanalyze batch.
LRB	Every batch of 20 samples.	< 2.5 mg/L	Re-prep and reanalyze batch.
Duplicate	Every batch and every 10 samples.	RPD of 0-5% of average weight	Re-prep and reanalyze batch.
Drying cycle	Every sample	4% of previous weight or 0.5 mg, whichever is less	Repeat drying cycle until within limits

9.0 PROCEDURE (Using 6-Place Filling Station)

9.1 PREPARATION OF EQUIPMENT

9.1.1 Pre-heat TDS Hot Block.

9.1.2 Insert pre-weighed sample vessel into support holder of the 6-place filling station.

9.1.3 Insert filter into filtration apparatus and replace filter funnel. Apply vacuum and wash filter with three successive 20 mL rinses of reagent water. Continue suction to remove all traces of water. Discard washings. If using washed and dried filters, there will be no need to rinse the filter.

9.2 SAMPLE ANALYSIS

9.2.1 Remove samples from refrigerator and allow them to equilibrate to room temperature, ±2°C. Measure and record room temperature and the min/max sample temperature prior to analysis on the worksheet presented as an example in attachment A, bench book, electronic spreadsheet, or equivalent form in intent.

9.2.2 Transfer 50-100 ml of well mixed sample using a 100 mL graduated cylinder to a filter funnel with applied vacuum.

9.2.3 Wash with three successive volumes of approximately 10 mL of reagent water. Then rinse sides of filtering funnel. This will ensure complete transfer of sample. Continue suction until all visible water has been removed from the filter.

9.2.4 Place sample vessel in TDS Hot Block until evaporated to dryness.

9.2.5 Place sample vessel in drying rack and dry evaporated sample for at least 1 hour in an oven at 180 ± 2ºC, cool in a desiccator to balance temperature, and weigh. Repeat drying cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of previous weight or 0.5 mg, whichever is less. Record all weights and reweighs on the worksheet presented as an example in Attachment A, bench book, electronic spreadsheet, or equivalent form in intent.

9.3 Analyze an LCS (reference standard), LRB and a sample duplicate through all procedure steps in section 9.2 above, as applicable for TDS.

10.0 PROCEDURE (Using Suction Flask, Filter Holder, and Membrane Filter Funnel)

10.1 PREPARATION OF EQUIPMENT

10.1.1 Insert filter with wrinkled side up into filtration apparatus. Apply vacuum and wash filter with three successive 20 mL rinses of reagent water. Continue suction to remove all traces of water. Discard washings.

10.1.2 Preparation of evaporating dishes: Heat a clean dish to 180 ±2°C for one hour. Cool in desiccator and store until needed. Weigh immediately before use.

NOTE: Record all weights to nearest 0.1 mg

10.2 SAMPLE ANALYSIS

10.2.1 Remove samples from refrigerator and allow them to equilibrate to room temperature, ±2°C. Measure and record room temperature and the min/max sample temperature prior to analysis on the worksheet presented as an example in attachment A, bench book, electronic spreadsheet, or equivalent form in intent.

10.2.2 Transfer 50-100 ml of well mixed sample using a 100 mL graduated cylinder to a glass fiber filter with applied vacuum.

10.2.3 Wash with three successive 10 ml volumes of reagent water and continue suction for about three minutes after filtration is complete.

10.2.4 Transfer filtrate and washings to a weighed evaporating dish and evaporate to dryness using heat lamp. If necessary, add additional portions of sample to the same dish after evaporation.

10.2.5 Dry evaporated sample for at least 1 hour in an oven at 180 ± 2ºC, cool in a desiccator to balance temperature, and weigh. Repeat drying cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of previous weight or 0.5 mg, whichever is less. Record all weights and reweighs on the worksheet presented as an example in Attachment A, bench book, electronic spreadsheet, or equivalent form in intent.

10.3 Analyze an LCS (reference standard), LRB and a sample duplicate through all procedure steps in section 9.2 and 9.3 above.

11.0 CALCULATIONS

11.1 SAMPLE CONCENTRATION DETERMINATION

11.1.1 TDS concentration in mg/L = $\frac{(A-B)\ x\ 1000}{C}$

Where: A = Weight of sample vessel + dried residue, mg
B = Weight of sample vessel, mg
C = Sample volume, mL

TITLE: FILTERABLE (TDS) RESIDUE

12.0 DATA REPORTING

12.1 Report the results on the worksheet presented as an example in Attachment A. An electronic spreadsheet or an equivalent form in intent can be used as well. If a spreadsheet is used for calculation and/or reporting, it shall be validated before use, with the cells used for calculation protected. Save the spreadsheet on the company network, at K:\CHEM\Total Suspended or Dissolved Solids.

12.2 Place the completed Attachment A (or equivalent reporting form) into the project folder and scan it as a PDF document into the corresponding analysis batch in LIMS.

TITLE: TOTAL, FILTERABLE AND NONFILTERABLE RESIDUE

Filterable (TDS) Residue Worksheet

SM2540C

Analysis Batch: ____________________
Analysis Date: ____________________
Analysis By: ____________________
Reviewed By: ____________________
Review Date: ____________________
Vessel Lot No.: ____________________
Vessel Item No.: ____________________

Analytical Balance M&TE No: ____________________
Balance Calibration Due Date: ____________________
LCS Lot No. /Proc. No./ Exp. Date: ____________________
Measured Concentration: ____________________
Acceptable Range Concentration: ____________________
Min/Max Sample Temperature: ____________________
IR M&TE No/Exp. Date: ____________________
Room Temperature: ____________________
Thermocouple M&TE#: ____________________

	In / Time	In / Temp (°C)	Out / Time	Out / Temp (°C)
1st Weighing				
2nd Weighing				

Oven M&TE No: ____________ Thermocouple M&TE No: ____________ Probe M&TE No: ____________

ANALYSIS RESULTS NOTE: Limit load to 2.5 - 200 mg NOTE: Record all weights to nearest 0.1mg

Sample Vessel ID	Sample Aliquot ID	Sample Volume (mL) **(C)**	1st Vessel and dry sample (mg) **(A_1)**	2nd Vessel and dry sample (mg) **(A_2)**	Dry Sample Differenc (mg) **(A_1-A_2)**	Vessel Mass (mg) **(B)**	Sample Load (mg) **(A_2-B)**	Final Concentration (mg/L) $\frac{(A_2 - B)x1000}{C}$

Appendix E
Statistical Evaluation Methods

Groundwater Statistical Evaluation Plan

JH Campbell Power Plant
Dry Ash Landfill
West Olive, Michigan

October 2017, Revised October 2020

Prepared For:

Consumers Energy Company
1945 W. Parnall Road
Jackson, MI 49201

Prepared By:

TRC
1540 Eisenhower Place
Ann Arbor, Michigan 48108

Graham Crockford, C.P.G.
Senior Project Geologist

Sarah B. Holmstrom, P.G.
Project Hydrogeologist

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1.0 Introduction

1.1 Regulatory Framework

Pursuant to the Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule) and the State of Michigan enacted Public Act No. 640 of 2018 (PA 640) to amend the Natural Resources and Environmental Protection Act, also known as Part 115 of PA 451 of 1994, as amended (a.k.a., Michigan Part 115 Solid Waste Management), the owner or operator of a CCR unit must develop the groundwater sampling and analysis program to include selection and certification of the statistical procedures to be used for evaluating groundwater in accordance with §257.93 and R 299.4908 of the Part 115 Solid Waste Management Rules. This certification must include a narrative description of the statistical method that will be used for evaluating groundwater monitoring data.

TRC prepared this Groundwater Statistical Evaluation Plan (Statistical Plan) for the JH Campbell (JHC) Dry Ash Landfill on behalf of Consumers Energy. This Statistical Plan was prepared in accordance with the requirements of §257.93 and R 299.4908 and describes how data collected from the groundwater monitoring system will be evaluated. As part of the evaluation, the data collected during detection monitoring events are evaluated to identify statistically significant increases (SSIs) in detection monitoring constituents (Section 11511a.(3)(c) of PA 640) to determine if concentrations in detection monitoring well samples exceed background levels. Data collected from assessment monitoring events are evaluated for statistically significant exceedances of an established groundwater protection standard (GWPS) for constituents in Sections 11511a(c)(3) and 11519b(2) of PA 640 to evaluate the risk associated with those constituents.

The CCR Rule and Part 115 are not prescriptive with regards to the actual means and methods to be used for statistically evaluating groundwater data, and there is flexibility in the method selection, as long as specific performance metrics are met. Statistical methods that meet the performance objectives of the CCR Rule and Part 115 are described in USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* (*Unified Guidance,* USEPA, 2009).

2.0 Groundwater Monitoring System

2.1 Groundwater Monitoring System

A groundwater monitoring system has been established for the JHC Dry Ash Landfill, which established the following locations for detection monitoring. The locations are shown on Figure 1.

Background:

- JHC MW-15023
- JHC MW-15024
- JHC MW-15025
- JHC MW-15026
- JHC MW-15027
- JHC MW-15028

Downgradient:

- JHC MW-15017
- JHC MW-15018
- JHC MW-15019
- JHC MW-15031
- JHC MW-15035
- JHC MW-15036
- JHC MW-15037
- MW-B1 REPLACEMENT
- MW-B2 REPLACEMENT
- MW-B3 REPLACEMENT
- MW-B4 REPLACEMENT

2.2 Constituents for Detection Monitoring

R 299.4440 describes the requirement for detection monitoring. The detection monitoring parameters are identified in Section 11511a(3)(c) of PA 640 and consist of the following:

- Boron
- Calcium
- Chloride
- Fluoride
- Iron
- pH
- Sulfate
- Total Dissolved Solids (TDS)

2.3 Constituents for Assessment Monitoring

Assessment monitoring per R 299.4441 is required when a SSI over background has been detected for one or more of the detection monitoring constituents identified in Section 11511a(3)(c). As required in Section 11519b(2) the following assessment monitoring constituents will be monitored:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Fluoride
- Lead
- Lithium
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc
- Radium 226 and 228 (combined)

3.0 Statistical Analysis

Groundwater sampling and analytical requirements are described in R 299.4908. The owner or operator of the CCR unit must select a statistical method specified in R 299.4908(1) to be used in evaluating groundwater monitoring data. The test shall meet the performance standards outlined in R 299.4908(2). The goal of the statistical evaluation plan is to provide a means to formulate an opinion or judgement as to whether the CCR unit has released contaminants into groundwater. This plan describes the statistical procedures to be used to determine if a statistically significant increase (SSI) or in the case of pH, a statistically significant difference (SSD), indicating that data is from a different population than background. This plan was developed using applicable guidance, including the Unified Guidance. In addition to using applicable guidance documents, commercially available statistical evaluation tools will be applied to the JHC Dry Ash Landfill groundwater data to develop statistically derived limits so that detection monitoring results can be compared to background.

The CCR Rule and Part 115 allow a variety of methods for conducting statistical evaluations. The specific procedure for a given data set depends on several factors including the proportion of the data set with detected values and the distribution of the data. It is generally anticipated, that the tolerance or prediction interval procedure will be the preferred method of conducting detection monitoring data evaluation to the extent that the data support the use of that method. For assessment monitoring, the preferred statistical evaluation method for comparisons to a fixed standard will be confidence limits as detailed in Section 5.0. This statistical procedure is described below in this section of the plan and in detail in the Unified Guidance.

3.1 Establishing Background

Background groundwater monitoring was conducted for constituents in Appendix III and Appendix IV of the CCR Rule from December 2015 through August 2017 using the background monitoring wells in accordance with the JH Campbell Monitoring Program Sample and Analysis Plan (SAP) (ARCADIS, 2016). Background will be established for the Section 11511a(3)(c) constituents not already included in the CCR Rule Appendix III (i.e., iron) throughout eight sampling events. Per R 299.4907(7), the owner or operator of the CCR unit must establish background groundwater quality in hydraulically upgradient or background well(s). The development of a groundwater statistical evaluation program for detection monitoring involves the proper collection of background samples, regardless of whether an inter-well or intra-well monitoring strategy is implemented. Background may be established at wells that are not located hydraulically upgradient from the unit if it meets the requirement of R 299.4906(1)(a). A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where:

1. Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or
2. Sampling at other wells will provide an indication of background groundwater quality that is as representative as or more representative than that provided by the upgradient wells.

The purpose of obtaining adequate background groundwater data is to approximate, as accurately as possible, the true range of ambient concentrations of targeted constituents. Background groundwater data should eliminate, to the extent possible, statistically significant concentration increases not attributable to the CCR unit. Specifically, the owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. The sampling frequency should be selected so that the samples are physically independent. These background groundwater parameters can be adequately qualified by doing the following:

- Collecting the minimum number of samples that satisfy the requirements of the statistical methods that are used (*i.e.,* that result in adequate statistical power);
- Incorporating seasonal and/or temporal variability into the background data set; and
- Incorporating the spatial component of variability into the background data set (*i.e.,* the variability that comes with obtaining samples from different locations within the same groundwater zone).

The initial background/baseline sampling period is at least eight independent events. This provides a minimal background data set to initiate statistical comparisons. Over time, the short baseline period may result in a high risk of false positive statistical results. The facility may periodically update background data to account for variability in background conditions. The *Unified Guidance* recommends that background data be updated every 4 to 8 measurements (i.e., every two to four years if samples are collected semi-annually, or one to two years if samples are collected quarterly). The background data will be reviewed for trends or changes that may necessitate discontinuation of earlier portions of the background data set. Updates to the background statistical limits will be submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for approval.

3.2 Data Evaluation and Data Distributions

Consumers Energy will evaluate the groundwater data for each constituent included in the groundwater monitoring program using inter-well tolerance or prediction limits. The tolerance or prediction interval statistical procedure establishes an interval that bounds the ranges of expected concentrations representative of unaffected groundwater using the distribution of background data. The upper tolerance or prediction limit of that interval is then used for comparison to the concentration level of each constituent in each compliance well. Development of the tolerance or prediction limits used for comparison during detection monitoring will be conducted in accordance with the Unified Guidance. The following is a summary of descriptive statistics and tolerance or prediction limit choices.

3.2.1 Background Determination

Statistical limits will be calculated after the collection of a minimum of eight independent samples. The analytical results from the eight “background” samples will be used to determine the statistical limits for each individual parameter. For inter-well comparisons, background data should be “pooled” creating a single, combined background dataset from the background monitoring wells.

The background dataset (and hence the prediction limits) will be updated as appropriate (as discussed above in Section 3.1) to maintain necessary statistical sensitivity. New data will be compared to the existing background data set to determine if there are outlier values, and whether the data are statistically similar. If there are no outliers and the data are statistically similar, the new data will be added to the existing background data set.

3.2.2 Outlier Evaluation

Outliers and anomalies are inconsistently large or small values that can occur as a result of sampling, analytical, or transcription errors; laboratory or field contamination; or shelf-life exceedance; or extreme, but accurately detected environmental conditions (*e.g.*, spills). Data will be reviewed graphically using tools such as time concentration trend plots, box and whisker plots and/or probability plots to illustrate and identify outliers, trends, or otherwise unusual observations at each monitoring location. This will be accomplished prior to further in-depth review of the data sets to identify any obvious field or laboratory anomalies. Data points that are determined to be non-representative will be ‘flagged’ for further detailed evaluation prior to removing from the background data or designating as an outlier.

3.2.3 Testing for Normality

Statistical tests often assume that data are normally distributed or that data can be normalized by various standard methods. The assumption of normality can be tested in various ways. Formal normality testing such as utilizing the Shapiro-Wilk test (for $n<50$) or the Shapiro-Francia Test (for $n>50$) or calculation of a coefficient of skewness may be utilized in accordance with the *Unified Guidance*. Alternatively, graphing data on a probability plot can also be used to test for normality. If the data appear to be non-normal, mathematical transformations of the data may be utilized such that the transformed data follow a normal distribution (e.g., lognormal distributions). Alternatively, non-parametric tests may be utilized when data cannot be normalized.

The following are guidelines for decision making during normality testing:

1. If the original data show that the data are not normally distributed, then apply a natural log-transformation to the data and test for normality using the above methods.
2. If the original or the natural log-transformed data confirm that the data are normally distributed, then apply a normal distribution test.
3. If neither the original nor the natural log-transformed data fit a normal distribution, then apply a distribution-free test.

3.2.4 Evaluation of Non-Detects

Background concentrations that are reported as less than the practical quantitation limit (PQL) (herein referred to as non-detects) will be evaluated differently, depending upon the percentage of non-detects to the reported concentrations for a given parameter at a given monitoring well.

The evaluation of non-detects was as follows:

Less Than 15% Non-detects

For data that was normally or lognormally distributed and less than 15% non-detects, one-half the value of the method detection limit will be used to calculate the prediction limit. If normally or lognormally cannot be met using one-half of the method detection limit, and if the method detection limits were equal, alternating zero with the value of the method detection limit will be considered in order to determine the normality of the data set.

15% to 50% Non-detects

If more than 15% but less than 50% of the overall data are less than the detection limit, either Aitchison's adjustment, or Cohen's adjustment, or the Kaplan Meijer adjustment will be used to determine the statistical limits in accordance with the *Unified Guidance*.

51% to 100% Non-detects

For data sets that contain greater than 50% non-detects, the non-parametric statistical limits will be utilized as described below.

3.3 Parametric Tolerance or Prediction Limits

Tolerance and prediction intervals are similar approaches to establish statistical ranges constructed from background or baseline data. However, tolerance limits define the range of data that fall within a specified percentage with a specified level of confidence (where a proportion of the population is expected to lie), whereas prediction limits involve predicting the upper limit of possible future values based on a background or baseline data set and comparing that predicted limit to compliance well data.

Inter-well tolerance or prediction limits are calculated using the pooled background data set. The tolerance or prediction limit will be calculated in accordance with the Unified Guidance. If the data set is log-normally distributed, the tolerance or prediction limits will be calculated using the log-normally transformed data, and subsequently un-transformed to normal units.

R 299.4908(2)(b) states that for multiple comparisons, each testing period should have a Type I error rate no less than 0.05 while maintaining an individual well Type I error rate of no less than 0.01. Per R 299.4908(2)(d), these Type I limits do not apply directly to tolerance intervals or prediction intervals; however, the levels of confidence for the tolerance or prediction limit approach must be at least as effective as any other approach based on consideration of the number of samples, distribution, and range of concentration values in the background data set for each constituent.

3.4 Non-Parametric Tolerance or Prediction Limits

Parameters that consist of mainly non-detect data usually violate the assumptions needed for normal based parametric tolerance or prediction intervals. Therefore, as recommended in the Unified Guidance, the non-parametric tolerance or prediction limit method will be chosen.

A non-parametric upper tolerance or prediction limit is constructed by setting the limit as a large order statistic selected from background (*e.g.*, the maximum background value). This method has lower statistical power than parametric methods; therefore, it is important to control outliers within the dataset to maintain adequate statistical power that this method can provide. Due to the lack of statistical power of this method, it will only be used when other methods are not available.

3.5 Double Quantification Rule

The double quantification rule is discussed in Section 6.2.2 of the Unified Guidance. In the cases where the background dataset for a given well is 100% non-detect, a confirmed exceedance is registered if any well-constituent pair exhibits quantified measurements (i.e., at or above the reporting limit) in two consecutive sample and resample events. This method will be used for non-detect data sets.

3.6 Verification Resampling

In order to achieve the site wide false positive rates (SWFPR) recommended in the Unified Guidance, a verification resampling program is necessary. Without verification resampling, the SWFPR cannot be reasonably met, and much larger statistical limits would be required to achieve a SWFPR of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. Under these circumstances, if there is an exceedance of a tolerance limit or prediction limit for one or more of the parameters, the well(s) of concern will be resampled within 30 days of the completion of the initial statistical analysis. Only constituents that initially exceed their statistical limit (i.e., have no previously recorded SSIs) will be analyzed for verification purposes. This verification sampling must be performed within the same compliance period as the event being verified. If the verification sample remains statistically significant, then statistical significance will be considered. If the verification sample is not statistically significant, then no SSI will be recorded for the monitoring event.

4.0 Evaluation of Detection Monitoring Data

4.1 Statistical Evaluation during Detection Monitoring

According to R 299.4440(8), if the facility determines, pursuant to R 299.4908(5), that there is a statistically significant increase (SSI) over background levels for one or more of the detection monitoring constituents, the facility will, within 14 days of the determination of a SSI, place a notice in the operating record that indicates which constituents show a SSI and notify EGLE. Within 45 days of detecting a SSI, the facility will prepare an assessment monitoring plan **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

The owner or operator must complete a written demonstration (i.e., Alternative Source Demonstration, ASD), of the above within 30 days of confirming the SSI and submit the ASD to EGLE as required by R 299.4440(9). If a successful ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring. If a successful ASD is made, the facility must determine if the constituents in groundwater render the unit unmonitorable in accordance with R 299.4440(9)(b).

If a successful ASD is not completed within the 30-day period, within 15 days of notification from EGLE that the demonstration is unsuccessful, the owner or operator of the CCR unit must prepare an assessment monitoring plan as required in R 299.4441 and submit a response action plan as required in R 299.4442. The facility will initiate an assessment monitoring program within 60 days of the submittal of the assessment monitoring plan as required in R 299.4441 and within 90 days of detecting a SSI, described further in Section 5.

5.0 Assessment Monitoring

As discussed in Section 4, the facility must begin assessment monitoring for the CCR unit if a SSI is identified, and the SSI cannot be attributed to an ASD. Per R 299.4441, assessment monitoring must begin within 60 days of submitting an assessment monitoring plan. Per the CCR Rule, assessment monitoring must begin within 90 days of identification of a SSI that is not attributed to an alternative source. Wells included in the groundwater monitoring system will be sampled for assessment monitoring constituents included in Section 11519b(2) of PA 640. Within 14 days of receiving sample results, the owner or operator will place a notice of the detected assessment monitoring parameters in the operating record and notify EGLE as required under R 299.4441(4)(a). Within 90 days of obtaining the results from the first assessment monitoring event, all of the wells will be sampled for detection monitoring constituents and the detected assessment monitoring constituents in the initial assessment monitoring event. Background will be established for the Section 11519b(2) constituents not already included in the CCR Rule Appendix IV (i.e., copper, nickel, silver, vanadium, and zinc) throughout eight sampling events in accordance with R 299.4441(4)(c).

If assessment monitoring is triggered pursuant to R 299.4440(8), data are compared to Groundwater Protection Standards (GWPSs) or background groundwater quality. The CCR Rule [§257.95(h)] and the Part 115 Rules [R 299.4441(4)(d)] require GWPSs to be established for assessment monitoring constituents (Section 11519b(2)) that have been detected during baseline sampling, per Part 115 this includes establishing GWPSs for all detected detection monitoring constituents listed in Section 11511a(3(c)). The GWPS will be set at the lowest of the EPA maximum contaminant level (MCL), the EPA Regional Screening Level (RSL), or the lowest applicable Michigan Part 201 residential criteria (Part 201 RC), or a value based on background data. The lowest of the MCLs or RSLs or applicable Part 201 RC will be the GWPSs unless the background concentration is greater than the MCL or RSL or applicable Part 201 RC, in which case, the statistically-determined background value becomes the GWPS. For GWPSs that are established using background, tolerance limits are anticipated to be used to calculate the GWPS. It is anticipated that the background will be updated every two years, along with the resulting GWPS, consistent with the *Unified Guidance*. If additional assessment monitoring constituents become detected during the assessment monitoring, GWPSs will be developed for those constituents in the same manner as the initial parameters.

Consistent with the *Unified Guidance*, the preferred method for comparisons to a fixed standard will be confidence limits. An exceedance of the standard occurs when the 99 percent lower confidence level of the downgradient data exceeds the GWPS. Confidence intervals will be established in a manner appropriate to the data set being evaluated (proportion of non-detect data, distribution, etc.). If the statistical tests conclude that an exceedance of the GWPS or background has occurred, verification resampling may be conducted by the facility. Once the resampling data are available, the comparison to the GWPS or background will be evaluated.

Additionally, it is noted in R 299.4441(5) that if the concentrations of all assessment monitoring constituents are shown to be at or below background values using statistical procedures in R 299.4908 for two consecutive sampling events, the owner or operator may return to detection monitoring of the CCR unit. A notification must be prepared stating that the detection monitoring is resuming for the CCR unit.

If the statistical tests and verification resampling conclude that an exceedance of the GWPS has occurred, the facility will conduct an assessment of corrective measures, select a remedy for affected groundwater, and implement a remedial action plan in accordance with the requirements and schedules outlined in R 299.4443, R 299.4444, and R 299.4445.

6.0 References

ARCADIS. May 18, 2016. Electric Generation Facilities RCRA CCR Detection Monitoring Program. JH Campbell Monitoring Program Sample and Analysis Plan, West Olive, Michigan. Prepared for Consumers Energy Company.

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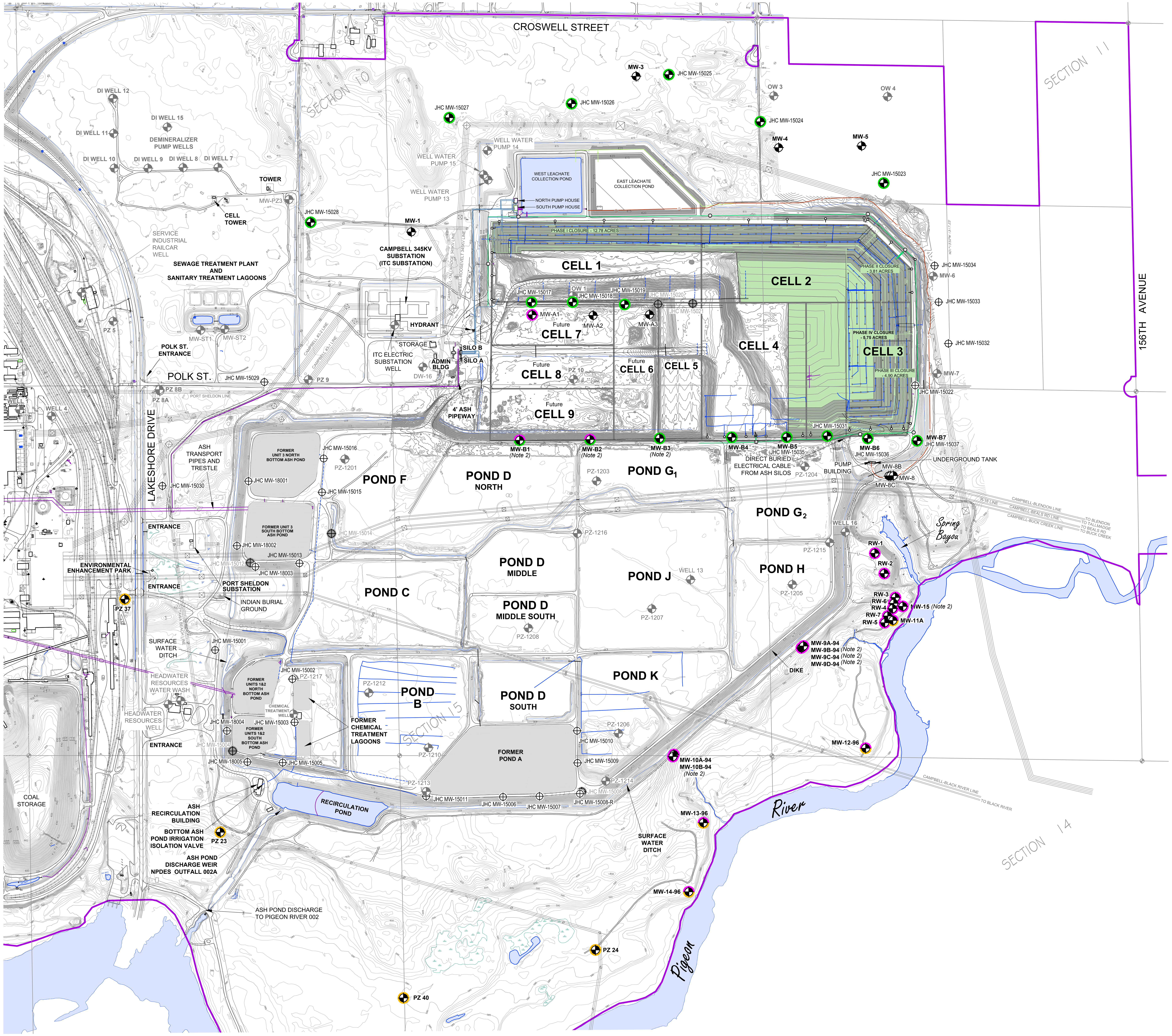
USEPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Unified Guidance*. Office of Conservation and Recovery. EPA 530/R-09-007.

Figures



LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- SECTION LINE
- RAILROAD TRACKS
- CELL BOUNDARY
- FENCELINE
- DITCH
- UNPAVED ROAD OR DRIVE
- OVERHEAD POWER LINES
- ELECTRIC LINE
- SANITARY PIPE
- UTILITY
- LEACHATE PIPE
- ASH PIPE
- PIPELINE
- IRRIGATION PIPE
- WATER
- FACILITY COVER
- WETLAND
- POLE
- MW-1 MONITORING WELL
- MW-7 WELL
- JHC MW-15034 RCRA MONITORING PROGRAM WELL
- JHC MW-15004 DECOMMISSIONED RCRA MONITORING PROGRAM WELL
- MW-5 DRY ASH LANDFILL HMP MONITORING WELL
- PZ-23 CELLS B-K HMP WELL
- RW-1 RAP MONITORING WELL
- P-4D RAP PIEZOMETER

NOTES

1. BASEMAP DEVELOPED FROM CONSUMERS ENERGY, "CAMPBASE.DWG", DATED 02/10/2014 AND NEDERVELD "CAMPBELL PLANT MONITORING WELLS-CCR MONITORING" , DATED 11/25/2015. PROVIDED BY CONSUMERS ENERGY.
2. RAP SENTINAL WELL

0 360' 720' 1080' 1440'

APPROXIMATE SCALE IN FEET

PROJECT:	CONSUMERS ENERGY JH CAMPBELL POWER PLANT WEST OLIVE, MICHIGAN
TITLE:	SITE FEATURES MAP WITH TOPOGRAPHIC CONTOURS
DRAWN BY:	D.STEHLE
CHECKED BY:	K.LOWERY
APPROVED BY:	S.HOLMSTROM
DATE:	AUGUST 2020
PROJ. NO.:	367390.0001.01.03
	FIGURE 1
FILE NO.:	367390.0001.01.03.02 Hydro.dwg

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080
www.trccompanies.com

22x34 --- USER: DStehle --- ATTACHED XREFS: CAMPBASE; Contours Misc; Contours Topo 2020-07-22 --- ATTACHED IMAGES:
DRAWING NAME: J:_TRC\Consumers\JH Campbell\367390\0001\01\03_Hydro Rpt\ 367390.0001.01.03.02 Hydro.dwg --- PLOT DATE: August 06, 2020 - 10:07AM --- LAYOUT: FIG02 Site Features

REPORT

Section E - Topographic Maps

JH Campbell Generating Facility - Dry Ash Landfill, Type III Expansion
Facility ID 395496

Submitted to:

J.H. Campbell Generating Facility
Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50 Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

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E. TOPOGRAPHIC MAPS

E.1 Maps Referenced to U.S.G.S. Datum Showing Character of Land and Land uses within 1,500-ft of the Solid Waste Units

See Engineering Drawings, Sheets 100-1 and 200-2.

E.2 Specific Information

E.2.1 Legal Description of Landfill Property

See Section A.12.

E.2.2 Proposed Solid Waste Disposal Unit

The cell layout and final grading plan for the Type III vertical expansion is found on Sheets 400-1 and 400-3 of the Engineering Drawings.

E.2.3 Structures on the Site

Site structures are shown on Sheets 200-1 and 200-7 of the Engineering Drawings.

E.2.4 Existing and Proposed Utilities

See Engineering Drawings, Sheets 200-7, 600-1, and 700-1.

E.2.5 Borrow Areas

Soils to be used for construction will be obtained from off-site sources, see Sheets 400-4 through 400-8 of the Engineering Drawings, and Section F for soil phasing information.

E.2.6 Surface Waters, Wetlands or Floodplains

See Engineering Drawings, Sheets 200-2 through 200-6, and the Environmental Assessment, Section B.

E.2.7 Special Drainage Devices if Necessary

Not applicable for this site.

E.2.8 On Site Roads

See Engineering Drawings, Sheet 200-1.

E.2.9 Public Access Roads

See Engineering Drawings, Sheet 200-1.

E.2.10 Fencing and Other Means of Controlling Access

See Engineering Drawings, Sheet 200-7, and the Operational Plan, Section G.

E.2.11 The Location of All Residences

See Engineering Drawings, Sheets 200-2 through 200-6, and the Environmental Assessment, Section B.

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REPORT

Section F - Engineering Report

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion
Facility ID 395496

Submitted to:

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+1 517 482-2262

19132873

June 2021

Executive Summary

The J.H. Campbell (JHC) Dry Ash Landfill (Landfill) is a licensed Type III low hazard industrial waste landfill which is owned and operated by Consumers Energy Company (CEC). The JHC landfill is located in Port Sheldon Township, Ottawa County, Michigan (Site).

Table 1: J.H. Campbell Dry Ash Landfill Facility Summary

Property Area (acres)	Solid Waste Boundary Area (acres)	Permitted Airspace (cubic yards)	Airspace Gained from Proposed Expansion (cubic yards)	Total Proposed Airspace (cubic yards)
410	104	9,500,000	532,000	10,032,000

Type III Expansion

JHC proposes to increase the permitted landfill airspace through an expansion over top of the existing landfill Cells 1, 2, 4, and 5. The proposed expansion is also laterally and over top of future Cells 6, 7, 8, and 9. The area encompassed by this expansion totals to 42.9 acres. The expansion will crest at an elevation of 707.5-feet above mean sea level (ft-amsl).

This section is being prepared in accordance with the Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act (NREPA), Public Act (PA) 451 of 1994, as amended and any regulations promulgated pursuant to this act (Part 115 Rules). Part 115 Rules require the submittal of an engineering design report with the Construction Permit Application (CPA). This Engineering Report for JHC has been prepared in accordance with the requirements of Rules 299.4902(1)(g) and Rule 299.4910.

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TABLES

APPENDICES

F. ENGINEERING PLANS AND REPORTS

This section of the J.H. Campbell (JHC) Dry Ash Landfill Expansion Construction Permit Application (CPA) addresses the Engineering Plan and Report requirements. It has been structured to parallel the format of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Office of Waste Management and Radiological Protection checklist and contains the following items:

- Written explanation of design relative to the EGLE Administrative Completeness Checklist;
- Calculations (where appropriate) following a similar order as the EGLE checklist;
- Engineering plans representing the detailed design of the Type III expansion are presented with this application as a separate package of Engineering Drawing Sheets entitled “J.H. Campbell Dry Ash Landfill, Expansion Construction Permit Application”; and
- Appendix A – Global Material Properties (some information also shown on Sheet 500-3 on the Engineering Drawings) and Appendix B – Geotechnical Information, represent information that is used throughout the Section F calculations package.

The JHC Dry Ash Landfill is a licensed and captive Type III Low Hazard Industrial Landfill owned by the Consumers Energy Company (CEC). Only coal combustion residuals (CCR) generated by CEC’s J.H. Campbell Generating Facility will be disposed in the landfill. The currently permitted airspace volume for the JHC Dry Ash Landfill is 9,500,000 cubic yards.

CEC is proposing an expansion of the currently permitted JHC Dry Ash Landfill to include an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill. As such, the lateral extent of the landfill boundary will remain unchanged. As part of the construction permit modification that was approved by the Michigan Department of Environment, Great Lakes and Energy (EGLE) in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. An expansion within the currently permitted solid waste boundary is proposed to regain the lost airspace and to provide sufficient capacity for the remaining life of the generating facility. The proposed expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area. The proposed increase in airspace will provide an estimated additional 2 years of site life with a total remaining site life of approximately 22.5 years.

The expansion updated design will be consistent with current rules developed under Part 115 of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, as amended (Part 115).

The proposed Type III expansion is consistent with Section 111.16.5 of the April 2000 Ottawa County Solid Waste Management Plan (and approved Plan amendment) as documented in Section B of this Construction Permit Application (CPA).

1.1 TYPE III LANDFILL UNIT BASE LINER SYSTEM DESIGN

The design for the future Cells 6, 7, 8, and 9 (see Sheet 400-1 for Subgrade Plan) incorporates engineered environmental control systems that will serve to prevent the migration of leachate from the Type III Landfill disposal unit. The primary control system proposed is the engineered liner system to be constructed at the floor and side slopes of the landfill. The components of the base liner system will be installed in accordance with the Construction Quality Assurance (CQA) Plan included in Section H of this application.

The components of the liner system on the floor include, from the bottom upwards:

- a prepared subgrade;
- a smooth or textured high-density polyethylene (HDPE) 60-mil liner or equivalent;
- a single-sided geocomposite drainage layer exhibiting a normally loaded Transmissivity (T) of T ≥ 5×10^{-4} square meters per second (m^2/sec);
- a geosynthetic clay liner (GCL);
- a smooth or textured high-density polyethylene (HDPE) 60-mil liner or equivalent;
- a single-sided geocomposite drainage layer exhibiting a normally loaded T ≥ 1×10^{-3} m^2/sec;
- a 12-inch-thick soil protective layer with a minimum permeability (K) of K ≥ 1×10^{-3} centimeters per second (cm/sec).

The components of the liner system on the side slope include, from the bottom upwards:

- a prepared subgrade;
- a textured high-density polyethylene (HDPE) 60-mil liner or equivalent;
- a double-sided geocomposite drainage layer exhibiting a normally loaded T ≥ 5×10^{-4} m^2/sec;
- a geosynthetic clay liner (GCL);
- a textured high-density polyethylene (HDPE) 60-mil liner or equivalent;
- a 24-inch-thick drainage layer with a minimum K ≥ 1×10^{-3} cm/sec <u>OR</u> a 12-inch-thick drainage layer with a minimum K ≥ 1×10^{-3} cm/sec plus a 10 ounce per square yard (oz/sy) non-woven geotextile <u>OR</u> a 12-inch-thick drainage layer with a minimum K ≥ 1×10^{-3} cm/sec plus a double-sided geocomposite drainage layer exhibiting a normally loaded T ≥ 1×10^{-3} m^2/sec;

Overliner System

A portion of the proposed expansion of the Type III unit will be placed over the side slope of the active portions of the existing Cells 1 and 2. The net result is a final cover system that meets or exceeds the required standard for final closure of a Type III area, and also serves as the floor liner system for the new unit.

The Type III unit expansion landfill overliner construction will remove the existing access road and any vegetation. The overliner will ultimately consist of the following layers, from the bottom upwards:

- existing ash fill;
- a 12-inch-thick drainage layer with a minimum K ≥ 1×10^{-3} cm/sec. This drainage layer may be natural sand or bottom ash within the landfill footprint.

For the overliner system, and at CEC's discretion, an additional double-sided geocomposite may be placed.

1.2 TYPE III EXPANSION FINAL COVER SYSTEM DESIGN

The purpose of the final cover system design for the Type III expansion is to minimize infiltration and promote drainage to minimize leachate generation. Furthermore, the cover system provides adequate surface water management and controls erosion. Construction of the final cover will be constructed in larger increments after filling progresses and areas reach final grade as shown in the Closure Plan, Section F.1.h. The components of the final cover system will be installed in accordance with the CQA Plan included in Section H of this application.

As shown on the Final Cover Details, Sheets 500-8 and 500-9 of the engineering drawings included with this application, the proposed final cover will consist of the following layers, from top down:

- a 6-inch-thick vegetative support layer (Topsoil);
- a 24-inch-thick soil erosion layer;
- a 6-inch diameter socked perforated piping network;
- a flexible membrane liner (40-mil textured linear low-density polyethylene (LLDPE) geomembrane); and
- ash fill to the top of waste grades.

1.3 GEOTECHNICAL SOILS SUMMARY

Based on a review of previous hydrogeologic information, Golder anticipates that the subsurface conditions within the proposed expansion area should be similar to those encountered in previous investigations of the existing Type III landfill. Geologic cross-sections/profiles have been prepared to illustrate subsurface conditions. The cross-sections are presented in the Figures in Section C – Hydrogeological Report, provided by TRC.

As stated in the Hydrogeological Report, Section C, prepared by TRC, the surface soils at the site range from organic silts near the Pigeon River to sand in the area within the project boundary (USDA, 1972. Soil Survey of Ottawa County, Michigan conducted by the United States Department of Agriculture, December 1972). The two dominant soil associations onsite are:

- The Croswell and Au Gres sands, 0 to 6 percent slopes. This soil consists of moderately well drained dark brown to gray sand of former outwash and lake plains.
- The Rubicon sands, 0 to 6 percent slopes. This well-drained soil occurs as large areas on outwash and lake plains, as long narrow areas on dunes, and as small, irregularly shaped areas on parts of the uplands. The surface soils consist of very dry gray sand.

The uppermost unlithified deposits in the area of the Site consist of coarse glacial lacustrine deposits, principally sand and silt with varying amounts of gravel. Along the shore of Lake Michigan these deposits take the form of sand dunes. The lacustrine deposits are principally coarse-grained materials, but varying amounts of silt and clay occur within the sand, and silt and clay layers of varying thickness and lateral continuity may also occur in some areas. The coarse upper lacustrine deposits can exceed 100 feet (ft) in the vicinity of the Site. Beneath the surficial lacustrine deposits is till, which underlies most of Ottawa County, including the vicinity of the Site. The till layer extends to the top of bedrock; although it is typically less than 100 feet (ft) in thickness it may exceed 100 ft in some areas.

Regional geologic maps show the immediate vicinity of the Site is underlain by the Coldwater Shale which is a major confining unit within the Michigan Basin that ranges in thickness from 500 to 1,300 ft. Deep drilling associated with the JH Campbell Power Plant demonstrated that the till material extends to shale bedrock, to a depth of approximately 140 ft below the existing ground surface at the Site. Additional geological and hydrogeological information can be found Section C, prepared by TRC, of this CPA.

GEOTECHNICAL

F.1.a. Soils Underlying the Liner System

F.1.a.(1). Settlement Analysis

Type III Expansion

Settlement of the soils forming the foundation of upgraded Cells 5 through 9 has been estimated. This analysis calculates immediate and differential settlement resulting from the maximum loading from land filling. Given the granular foundation soils, immediate settlement was assumed to account for the total settlement. This calculation also estimates differential settlement by comparing the maximum total settlement at the maximum load at the upslope end of the leachate pipe to the down slope end of the leachate pipe in each cell.

The settlement calculation shows, based on engineering judgment, that the total and differential settlements are within acceptable limits and will not affect leachate movement on the liner or induce unacceptable stresses into the liner and the resulting slope of the leachate collection pipe will be greater than 1-percent (%) after settlement.

The proposed design considers consolidation of areas that will be landfilled and the areas where the newly constructed Type III cells will be placed over the side slope of the existing Cells 1 and 2, as well as the underlying soils. A portion of the proposed expansion of the Type III unit will be placed over the side slope of existing Cells 1 and 2. At these locations the units will be kept separate and distinct through the use of an overliner system and leachate collection system.

Settlement calculations are included in Appendix C.

F.1.a.(2). Slope Stability Analysis

Detailed slope stability analyses have been performed for this facility. These analyses examine the performance of the liner and final cover at the most critical (worst case) cross-section locations for various stages of construction, operation and closure. The two cross sections have been selected at locations of substantial waste height, limited buttressing waste fill slopes and where forward sloping liner gradients might contribute to embankment instability.

Slope stability analyses have been performed using the Koerner Method for cover and liner stability, anchor trench stability, etc., while Rocscience SLIDE2 program has been used to consider closure condition stability when the landfill has reached its maximum height. Additional safety has been included in the slope stability analyses of the closure condition by using a static condition and also superimposing an earthquake loading. Summaries of input parameters and results are provided with the calculations. The slope stability calculations show that an adequate factor of safety is maintained for all operational and closure conditions evaluated.

The interface friction angles used in the stability calculations were taken along or below the “best fit” line representing the shear strength values appropriate for each scenario (low normal loads - cover, high normal loads - base, peak - short term, residual-long term, etc.), however; an adhesion of 0 pounds per square foot (psf) was used to be conservative. These values were chosen based on creating Mohr-Coulomb failure envelopes for each interface based on industry interface shear data. These failure envelopes are included with Appendix A of Section F of this Construction Permit Application. For purchasing materials, the owner should compare the actual strength of the material/interface to the Mohr-Coulomb envelopes used in the models. An acceptable interface shear strength would fall above the envelope line. References: Golder’s internal interface shear database, GRI report #30, dated 06/14/05 and GRI White Paper #11, dated 09/11/07.

a) Soil Drainage Layer Placement Limits Calculation

This calculation estimates the maximum limits of soil drainage layer placement such that tension is minimized in the geosynthetics. The calculation results shows that to maintain a reasonable factor of safety of 1.4 under saturated condition and 1.3 under unsaturated condition with equipment forces added, the maximum slope length for the placement of granular material is 20 feet along the slope.

These calculations are included in Appendix D.

b) Anchor Trench Calculation

This calculation estimates the capacity of the anchor trench against tension in the geosynthetics during construction or operation of the landfill. The results indicate an acceptable factor of safety under static and seismic forces.

The calculations are included in Appendix D.

c) Final Cover Stability Calculation

Calculations to determine the stability of the final cover system with respect to interfacial and internal friction angles for the various components without tension induced on the geosynthetics located within the cap was performed. This was performed for both short (equipment and seepage forces), and long (seepage and seismic forces) term conditions. The final cover stability evaluation is found to be acceptable.

The calculations are included in Appendix D.

d) SLIDE model Calculations

This calculation is used to consider closure condition stability when the landfill has reached its maximum height as well as operational slopes, excavation slopes, and liner failure possibilities. Additional safety has been included in the slope stability analyses of the closure condition by using a static condition and also superimposing an earthquake loading and saturated conditions. This slope stability analyses indicate that the proposed design slopes for the Type III expansion are stable.

The SLIDE calculations are included in Appendix E.

F.1.a.(3). Performance Analysis Under Varying Groundwater

The slope stability calculations discussed previously include consideration of the estimated worst-case ground water conditions across the landfill area.

F.1.a.(4). Calculations for Heave/Blowout Potential

Given that the Type III landfill is underlain by native sands that are approximately 100-feet thick, there is no potential for heave or blowout.

F.1.b. Compacted/Natural Soil Liner

There are no compacted or natural soil barriers or liner considered for this site.

F.1.c. Flexible Membrane Liners

F.1.c.(1). Methods of Storage, Handling, Installation

The GCL, geocomposite, geotextiles, and flexible membrane liner (FML) materials proposed for the Type III expansion will be obtained and installed in a manner consistent with good industry practice. A Construction Quality Assurance Plan (CQA Plan) has been developed for guidance purposes and outlines the procedures for storage, handling, and installation of these materials. This plan meets or exceeds the requirements put forth by the material manufacturers. The CQA Plan is included as Section H in this permit application.

F.1.c.(2). Physical Specifications

Physical properties of the geocomposite, geotextiles, and the FML materials have been addressed in the CQA Plan, included as Section H of this permit application, and Engineering Drawing Sheet 500-3, as well as Appendix A in this Section F.

a) Puncture Resistance of Geomembrane Calculation

There are two puncture resistance calculations. The first calculation evaluates the cushion geotextile mass per unit area necessary to achieve a minimum factor of safety of 2.0 against geomembrane puncture on the floor. The second calculation evaluates the minimum factor of safety against geomembrane puncture on the side slope, without using a geotextile cushion. The results of the first calculation determine that a 6 oz/sy cushion geotextile (as part of the single sided geocomposite) provides an acceptable factor of safety. The second calculation demonstrates that the 2-foot-thick soil layer placed on the side slope results in an acceptable factor of safety.

The calculations for Puncture Resistance are included in Appendix F.

F.1.c.(3). Physical Resistance

The CQA Plan, provided in Section H of this construction permit application, along with Engineering Drawing Sheet 500-3, specifies the physical/mechanical properties of the various geosynthetic materials to be used. The CQA Plan has been developed to allow selection between a wide range of manufacturer products at the time of construction. Therefore, it is not feasible to provide physical resistance data for a specific product at this time. From a survey of different manufacturers, compatibility and resistance test information is available for these products. This information for a new product, should one be used, will be submitted as part of the construction documentation for each phase of construction.

LEACHATE COLLECTION

F.1.d. Primary Leachate Collection System

F.1.d.(1). Material Specifications

The primary leachate collection system design within the JHC Landfill includes a 1-foot-thick layer of sand on the floor and a 2-foot-thick layer of sand on the slopes with a permeability, K $\geq$ $1x10^{-3}$ cm/sec. There is also a geocomposite layer (minimum transmissivity of $1x10^{-3}$ m^2/sec) on the floor with an option to use a geocomposite on the side slope or an option to use geotextile and 1 foot of sand on the side slope.

Leachate collection piping within the JHC Landfill consists of an 8-inch diameter SDR 11 (or SCH 80 PVC) perforated pipe, installed in graded low points in each cell. Floor grades have a 2.0-percent minimum slope towards each pipe resulting in a flow length of 50-foot or less along the floor. The leachate collection piping will be installed over the geocomposite layer and surrounded with drainage stone and a geotextile filter. This leachate collection pipe configuration is depicted on Engineering Drawing Sheets 400-2, and 500-5 through 500-7. The leachate collection piping drains at a minimum slope of 1.5% to a collection sump located within each cell. The leachate collection sump within each cell is backfilled with drainage stone and encapsulated by a geotextile wrap.

Leachate is evacuated from each primary sump within the JHC Landfill using an 18-inch diameter side slope riser and pump with a separate dedicated discharge line. The 18-inch diameter SDR 17 HDPE primary riser pipe will extend from the crest of the landfill down to the sump, with a horizontal section in the sump. An additional 18-inch diameter SDR 17 HDPE riser will be placed in the secondary sump and extend up the slope. A submersible pump will be lowered into the primary and secondary risers to the horizontal portion of the riser pipe. The pump is controlled with “on” and “off” depths set within compliance parameters. The leachate collected by the system from Cells 6 through 9 will be pumped from the riser to a manhole and then gravity fed to the existing leachate ponds. The overall configuration of the leachate collection system is shown on Engineering Drawing Sheet 400-2, while the gravity transfer system is shown on Engineering Drawing Sheets 600-1 through 600-3.

F.1.d.(2). System Design

F.1.d.(2).(a) and (b). Pipe Sizes and Perforations

The minimum diameters for the leachate collection pipes within the Cells 6 through 9 have been calculated. These sizes have been determined using the conservative peak daily leachate flow rates from the HELP model (see Appendix K). Leachate collection pipe sizes have been further increased, larger than those required hydraulically, to allow for ease of cleaning and sediment accumulation between cleanings. The resulting diameter for the leachate collection pipe is 8-inches, as shown in the leachate pipe size calculation.

The perforation size selected for the leachate collection pipe within the JHC Landfill is 3/8-inch diameter. The perforation spacing for the leachate collection pipe has been calculated based on the perforation size and the peak daily flow generated from the HELP model analysis. The perforation quantity was further increased to account for possible perforation blockage from drainage stone fines or chemical growth, even though the capacity of the redundant systems is likely to transmit all leachate to the sumps without the leachate piping. Additionally, the option to use bottom ash in the leachate collection system was removed to reduce to potential for fines accumulation in the leachate collection system. The hole spacing calculation estimates the quantity of holes required to allow the peak daily leachate flow-rate for the worst-case condition to completely enter the pipe.

Piping size and perforation calculations are included in Appendix G.

Leachate Collection Pipe and Riser Pipe (at sump) Hole Spacing Calculation

The hole spacing calculation estimates the quantity of holes required to allow the peak daily leachate flow-rate for the worst-case condition to completely enter the pipe.

Calculations for the riser pipe sizes are included in Appendix G.

F.1.d.(2).(c). Slope

As per Rule 299.4308.(2). Leachate collection piping will be installed within the Type III expansion with a design slope of 1.5-percent and will result in a calculated slope after settlement of at least 1.0-percent.

F.1.d.(2).(d). Spacing

Engineering Drawing Sheet 400-2 of the Engineering Drawings depicts the location of the leachate piping within the Type III expansion. As depicted within calculation F.1.d.5, the maximum head on the liner is calculated to be less than 12 inches and is contained within the soil drainage layer.

Toe Drains

Toe drains have been included for the site in Cells 6 through 9, designed as 8-inch diameter SDR 11 HDPE perforated pipes along the toe of the 3H:1V slopes where it connects to the landfill floor at 2-percent slopes and at 50-foot intervals.

F.1.d.(2).(e). Leachate Compatibility

Leachate piping is currently proposed as HDPE or PVC pipe. HDPE and PVC products and piping have shown historical performance for resistance to degradation under widespread biological attack. HDPE and PVC pipe manufacturers maintain test results showing compatibility and performance following exposure to a wide range of leachate qualities.

F.1.d.(2).(f). Structural Stability

The structural stability of the proposed leachate pipes within the JHC Landfill Cells 5 through 9 has been analyzed considering the estimated worst-case static loading (worst case static loading has been determined to be more damaging to the pipe than estimated dynamic loading during construction and waste placement activities). The pipe stability calculations have been based on lengthy conversations with industry representatives, pipe manufacturers and are also based on accepted engineering practices. The failure modes considered for each application include wall crushing, buckling, and deflection. A minimum factor of safety of 1.5 (4.0 for buckling) was required and achieved with the proposed design.

The 8-inch diameter SDR 11 HDPE or SCH 80 PVC leachate collection pipe and the 18-inch diameter SDR 17 HDPE riser pipe have been selected and demonstrated to be suitable for the leachate collection system.

Calculations for pipe crushing are included in Appendix H.

This calculation evaluates the structural stability of HDPE pipes through analysis of wall crushing, buckling, and deflection, with final vertical load.

An 8-inch diameter SDR 11 HDPE pipe has been selected and demonstrated to be suitable for the leachate collection system.

Leachate Sump HDPE Pipe Strength and Stability Calculation

This calculation determines the structural stability of the sump riser pipe through analysis of wall crushing, buckling, and deflection.

An 18-inch diameter HDPE SDR 17 pipe has been selected and demonstrated to be suitable for the leachate collection system sump.

Calculations for pipe crushing are included in Appendix H.

F.1.d.(3). Design Features That Allow Cleaning or Drainage of Pipe

Within the Type III expansion the leachate piping has been designed, where possible, with cleanouts extending to the perimeter crest of the landfill. Additionally, the leachate collection pipes have been oversized relative to the leachate transmission requirements to allow for easier cleaning access. The pipe cleanouts along the perimeter of the landfill provide access for jet, snake, or other mechanical/hydraulic cleaning devices.

Additionally, the design provides a redundant system. Each pipe is underlain by a geotextile and surrounded by stone that, in the event of a pipe clogging/failure, has the capacity to convey the calculated worst case peak daily flow volumes of leachate.

F.1.d.(4). Prevention of Clogging

Leachate collection piping within the JHC Landfill will be surrounded with drainage stone and a geotextile separator to limit the particle size of solids entering the piping. Pipe installations will be monitored by CQA personnel, who will observe placement and backfilling to minimize clogging potential. Additionally, leachate collection piping has been designed and located to eliminate the need for temporary terminations. At the end of each construction phase, prior to placement of the drainage stone and drainage layer, no open pipe end will be present. As noted previously, the option to use bottom ash in the leachate collection system was removed to reduce to potential for fines accumulation in the leachate collection system

The filtration calculation determines the material criteria for preventing clogging with respect to the leachate collection pipe hole diameter, filtration material, and geotextile wrap. The selected materials to prevent clogging in the pipes, stone, and the 6 oz/sy nonwoven geotextile, met the specification of gradation restraints and Part 115 Rule 423.(4).(b).

Geotextile filter calculations are included in Appendix I.

Regular preventative maintenance measures shall be performed on the leachate collection and transmission piping to prevent clogging. These measures may include:

- Pressurized water (jetting) used to flush the system by gaining access through the cleanouts.
- Mechanical equipment or chemical cleaning agents to prevent or mitigate clogging.

Maintenance requirements should be re-evaluated if there is an unexpected change in leachate production rates or if more frequent cleaning to correct blockages is needed.

F.1.d.(5). Leachate Head Calculations

Consistent with Rule 299.4423, the combination of floor grades, drainage layer thickness permeability, and geocomposite option transmissivity have been used to provide adequate control of leachate head on the liner within the Type III expansion. Within the sump, pump “on” and “off” trigger depths will ensure that compliant leachate levels will be maintained. The maximum head on the liner is less than 12 inches.

Mounding calculations are included in Appendix J.

F.1.d.(6). Obstacle Removal

The design of the leachate collection piping and cleanouts within the Type III expansion provides for access with standard cleaning equipment. This cleaning equipment is capable of breaking up and removing the obstructions that would occur from biological growth and build-up of scale within the pipes.

F.1.d.(7). Leachate Generation Volumes

Leachate quantity modeling has been performed with application of the Hydrologic Evaluation of Landfill Performance (HELP) model. Modeling has been performed for a unit area (1 acre) for different development stages of landfill operations. The results from this modeling were then applied over each phase of landfill operation and closure. A summary of input parameters, model results and calculation of leachate quantities for each phase of development is included within the calculation. The HELP modeling results were also used to estimate flow-rates for sizing leachate collection piping and leachate pumps.

a) Leachate Volume Estimate Calculation

This calculation includes a number of Visual HELP model runs to estimate leachate generation rates for various landfill development phases. Utilizing these leachate generation rates, leachate production rates per unit area have been multiplied by measured areas to develop a peak daily and daily average leachate estimate for all sequences of landfill construction (OPEN-10 years – Case 1), operation (INTERMEDIATE-10 years – Case 2), and closure (FINAL-30 years – Case 3).

HELP Model calculations are included in Appendix K.

b) Leachate Sump Volume Estimate Calculation

This calculation determines the dimensions of the sump required for the largest contributing area to one sump within the Type III expansion. This sizing was used as conservative for the other cells.

Sump volume calculations are included in Appendix L.

c) Gravity Sewers Calculation

There is a 3-inch by 6-inch diameter SDR 11 HDPE dual-contained forcemain to be used in proposed Cells 6-9. Leachate will be pumped out of the sumps into a 3-inch diameter HDPE SDR 11 forcemain enclosed in a 6-inch diameter HDPE SDR 32.5 pipe (for dual containment). The forcemain then conveys the leachate from the expansion cells to a manhole and the gravity sewer pipe. Since the contributing area and flow to the gravity leachate transfer system piping has not increased, the gravity system for the originally permitted Cells 6 through 9 remains the same as the currently permitted system, a 12-inch diameter HDPE SDR 32.5 gravity line that flows to the existing leachate collection ponds.

The forcemain and gravity sewer are shown on Engineering Drawing Sheet 600-3.

Calculations for the sump pumps within the Type III expansion are included in Appendix L.

F.1.d.(8). Leachate Disposal

Leachate from the primary and secondary leachate collection systems, the Remedial Action Plan (RAP) pumping system, and stormwater run-off from active landfill areas (contact water) will be collected in the sumps and pumped to a gravity transfer lines which flow to the existing leachate retention ponds. The leachate retention ponds have adequate capacity to handle the run-off from the design storm.

F.1.e. Secondary Leachate Collection Systems

There have been no changes to the secondary leachate collection system and calculations for the secondary piping systems are included with Section F.1.d and Appendices G, H and I.

F.1.f. Dewatering Systems

The proposed landfill does not require a dewatering system because the groundwater is beneath the lowest elevation of the landfill.

SURFACE WATER

F.1.g. Operational Controls

The Type III expansion includes a storm water management system for the JHC Dry Ash Landfill. In general, a well-designed and maintained storm water system does the following:

- Reduces excess runoff in operational areas;
- Directly removes runoff from the landfill to minimize leachate generation; and
- Provides controlled runoff removal from the landfill slopes to reduce soil erosion.

A combination of the following structures will comprise the storm water collection system within the JHC Dry Ash Landfill:

- Soil drainage layer within the landfill final cover cap;
- Drain tiles;
- Final cover surface water control berms;
- Armored storm water down chutes; and
- Storm water landfill perimeter and access road ditches and culverts.

The Type III I expansion will control storm water through the use of a constructed perimeter berm, controlling water outside the perimeter and containing contact water inside the perimeter berm. Upon closure, a traditional cap will be installed across the Type III expansion grades.

The location of the storm water management system structures are shown on Sheets 700-1 through 700-3 of the Engineering Drawings. The Engineering Design plans and calculations depict the management of surface water at JHC; however, the owner may choose to route surface water in a different manner in the future if and when site conditions change.

F.1.g.(1). Run-on

Run-on to the active portions of the Dry Ash Landfill is controlled using two methods. The first method is a perimeter berm around the landfill that creates a barrier that does not allow stormwater to enter the active areas. A drainage channel exists on the outboard slope of the perimeter berm that collects stormwater from the adjacent areas and directs it towards the site’s National Pollutant Discharge Elimination System (NPDES) outfall in accordance with Permit No. MI0001422.

The second method is positive grading away from the active areas so that run-off from closed areas (non-contact water) is not diverted into the leachate collection system. The South Drainage Ditch collects stormwater from the South Drainage Watershed that includes closed portions of Cells 1 through 4. The South Drainage Ditch directs stormwater from closed portions of the landfill to the site’s NPDES outfall.

Additionally, since the soils surrounding the site are sands, most of the stormwater collected in perimeter ditches infiltrates.

The location of the storm water management system structures are shown on Sheets 700-1 through 700-3 of the Engineering Drawings.

F.1.g.(2). Run-off

Surface water run-off occurring within developed areas of the facility will be managed to control erosion, sedimentation and storm water discharges. Storm water and erosion run-off will be controlled by utilizing the following controls:

- Grass lined final cap diversion channels;
- Downslope chutes;
- Perimeter facility drainage channels, culverts and sediment traps;
- Silt fencing; and
- Establishment of vegetative buffers between construction and storm water channels.

Within the landfill areas, storm water diversion channels will collect and divert run-off to downslope structures. At the bottom of each downslope structure, a riprap energy dissipater will be constructed. Run-off will discharge from the landfill site through perimeter ditches and culverts and then infiltrate into the sandy soils. The riprap energy dissipater shall be a minimum 15 feet wide and shall be extended onto the floor of each of the ditches from the culverts and extend approximately ten feet to minimize scouring.

Run-off will again be directed towards the perimeter of the landfill where it will be routed through a ditch system for storm water that will infiltrate into the sandy soils.

a) Design of Run-on and Run-off Surface Water Controls

Surface water run-on and runoff calculations were performed for the Type III expansion and are included in Appendix M.

F.1.g.(3). Wind Dispersal of Particulate Matter

Daily landfill operational procedures will minimize the potential for windblown dust. Procedures may include:

- A sheltered working face and/or a working face perpendicular to the direction of the wind, as practicable, for a majority of landfilling;
- Maintaining the working face size to a minimum; and
- The adequate use of moisture.

To minimize blowing dust; water and/or leachate (only areas within the cells) will be applied, as necessary, via a water truck to unpaved roads or other areas within the landfill facility. Paved roads will be cleaned with mechanical equipment and water as needed to minimize windblown particle matter, see Section G, Operations Plan.

F.1.g.(4). Gas Generation

Coal combustion residuals are not expected to generate gas. CEC will not allow organic material to grow or be placed in the landfill. As such, Type III waste specified to be received at the expansion area is not expected to generate methane or carbon dioxide.

F.1.h. Closure/ Final Cover Criteria

F.1.h.(1). Methods, Procedure & Processes for Closure

Several other sections reference closure activities including: F.1.h.(4) - Design of final cover and F.1.h.(5) - Schedule; Closure Plan; Section H - Quality Assurance; and the Engineering Drawings which depict the closure design. The construction will be carried out using recognized equipment, materials, and practices as referenced in the Sections above.

F.1.h.(2). Maximum Extent of Operation

While final closure operations may be delayed until the end of the active life of the Type III landfill unit, CEC intends to maintain interim cover over areas that have received waste but are not actively receiving waste.

AIRSPACE

F.1.h. Closure/Final Cover Criteria

F.1.h.(3). Maximum Inventory of Waste

The airspace was calculated for the proposed Type III expansion. For this calculation, several cross-sections were taken across the landfill and the average end area method was used to calculate a total volume. The volume was also determined using a computerized design package (AutoCAD Civil 3D version 2020).

a) Airspace Calculation

The proposed expansion and redesign is expected to provide approximately 532,000 cubic yards of additional airspace to the facility. This will provide an estimated total facility design of approximately 10,032,000 cubic yards when combined with the existing permitted disposal capacity of 9,500,000 cubic yards.

The J.H. Campbell Generating Facility Dry Ash Landfill currently places approximately 265,200 cubic yards of solid waste per year, which is subject to change based on power usage. Based on the remaining permitted airspace and proposed expansion increase of approximately 532,000 cubic yards, the proposed expansion will increase the life expectancy of the existing facility by approximately 2 years (total remaining would be 22.5 years) at current disposal rates.

Airspace calculations are included in Appendix N.

Phasing and Earthworks calculations are include in Appendix O.

F.1.h.(4). Description of Final Cover

a) Final Cover Berm Spacing Calculation

This calculation uses the Universal Soil Loss Equation (USLE) to establish the spacing for the final cover berms such that the total erosion is less than 2 tons/acre/year. Drainage swales shall be placed every 50 vertical feet or less given that the total erosion is less than 2 tons/acre/year.

The USLE calculations are included in Appendix P.

b) Berm Capacity Calculation

This calculation is included Appendix M.

c) Down-Chute Ditch Design

This calculation is included Appendix M.

F.1.h. Closure/Final Cover Criteria

F.1.h.(5). Schedule

As stated in Section B, based on an anticipated CCR waste receipt rate of 265,200 cubic yards per year, the proposed expanded facility will provide approximately 2 years of additional life to the overall facility. As closure cover construction of any given portion of the landfill commences, it is anticipated that the waste will be at or near approximate grade and interim cover will be in place. The incremental acreage remaining after the last load of Type III waste is placed is approximately 20.5 acres. To estimate the number of workdays required during closure of the 20.5 acres, the following unit rates were applied to determine approximate closure quantities anticipated for each closure component (this assumes closure will happen in one construction season).

Table 2: 20.5-Acre Closure Schedule at End of Site Life

Type III Cap Component	Quantity	Unit	Construction Rate per Day (approximate)	Rate Units	20.5 acres - Required Time in Days
Ash Grading Layer (12-inch thick)	33,073	cubic yards	3,500	cubic yards per day	9
40-mil LLDPE Cap Geomembrane	892,980	square feet	60,000	square feet per day	15
24-inch-thick Erosion Layer plus piping	66,147	cubic yards	3,000	cubic yards per day	22
6-inch-thick Topsoil Layer	892,980	square feet	100,000	square feet per day	9
Seed, Mulch, Erosion Blankets	892,980	square feet	300,000	square feet per day	3
Total Number of Working Days, Approximate =					**58**

It should be noted that portions of the above components may proceed concurrently. Further ancillary activities such as site grading and seeding may also proceed concurrently and should not significantly impact the schedule. Although the workdays shown represent an estimate, the actual schedule may vary and may require more than the 365-day period. A revised estimate will be developed before actual closure.

The site Closure Plan is included in Appendix Q.

F.1.i. Post –Closure Maintenance & Monitoring

F.1.i.(1). Description of Activities

The activities on-site following closure will include:

- Monitoring and maintaining restriction of access to facility (maintain fence and gates)
- Monitoring and maintaining the cover systems (erosion checks, vegetation control)
- Monitoring and maintaining leachate collection and removal systems
- Maintaining groundwater sampling program.

The proposed end use for Type III expansion area is anticipated to be green space with the possibility of extending a renewable energy footprint using solar arrays and/or wind turbines for power generation. Further, space has been allocated for other potential operations that would be ancillary and in support of the overall site's waste management functions.

The site Post-Closure Plan is included in Appendix R.

F.1.i.(2). Contact person or office.

J.H. Campbell Generating Facility Dry Ash Landfill
17000 Croswell Street
West Olive, MI 49460-9748
Contact: Caleb Batts, P.E.
Phone: 989-891-3019
Email: Caleb.Batts@cmsenergy.com

F.1.i.(3). Planned post-closure uses.

Currently, the end use plans for the Type III expansion include green space areas. Other developments which are consistent with EGLE post-closure requirements may be agreed to by CEC and the local community. Any proposed use will not disturb the integrity of the final cover, liner, or any other component of the containment system, nor will it inhibit the function of the monitoring systems.

F.2. Professional Engineer Seal

Golder Associates Inc. submits these supporting documents to fulfill the requirements for issuance of a construction permit pursuant to Part 115 of the Natural Resources and Environmental Protection Act of 1994, PA 451, as amended.

Tiffany D. Johnson, P.E.
Michigan Professional Engineer License Number 6201049160

STATE OF MICHIGAN
TIFFANY D. JOHNSON
ENGINEER NO. 49160
LICENSED PROFESSIONAL ENGINEER

July 7, 2021

Date

APPENDIX A

Material Properties Table

Table 1: Global Material Properties Used for Calculations - JH Campbell Expansion

	Material	Cohesion (psf)	Effective Stress Friction Angle φ'(°)	Total Stress Friction Angle φ(°)	Undrained Shear Strength (psf)	High Normal Loads (Base): Peak Interface Friction Angle, ϕ (°)	High Normal Loads (Base): Peak Interface Adhesion, C (psf)	Unit Weight γ_d (pcf) (dry)	Unit Weight, γ (pcf) (wet)	Thickness (ft) (or as shown)	Reference #
Landfill Floor	Coal Combustion Residuals (CCR)	0	30	30	0	n/a	n/a	95	100	Varies	7
	Sand Protective Layer	0	32	32	0	n/a	n/a	115	130	1.0	4
	Single-Sided Geocomposite, Geotextile on Upper Layer	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	250-mil	n/a
	Primary Flexible Membrane Liner - smooth HDPE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	60-mil	n/a
	Primary Geosynthetic Clay Liner (GCL)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	240-mil	n/a
	Single-Sided Geocomposite, Geotextile on Upper Layer	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	250-mil	n/a
	Secondary Flexible Membrane Liner - smooth HDPE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	60-mil	n/a
	Foundation Soils - Sand	0	32	32	0	n/a	n/a	115	130	Varies	4
	Geocomposite (Geotextile Side) vs Sand	n/a	n/a	n/a	n/a	27	0	n/a	n/a	n/a	1
	Smooth HDPE Geomembrane vs Geocomposite (Geonet side)	n/a	n/a	n/a	n/a	16.5	0	n/a	n/a	n/a	3
	GCL (nonwoven side) vs Smooth HDPE Geomembrane	n/a	n/a	n/a	n/a	13.5	0	n/a	n/a	n/a	3
	GCL (woven side) vs Geocomposite (Geotextile Side)	n/a	n/a	n/a	n/a	17	0	n/a	n/a	n/a	3
	Smooth HDPE Geomembrane vs Geocomposite (Geonet side)	n/a	n/a	n/a	n/a	16.5	0	n/a	n/a	n/a	3
	Smooth HDPE Geomembrane vs Foundation Sand	n/a	n/a	n/a	n/a	21	0	n/a	n/a	n/a	1
Landfill Side Slope	Coal Combustion Residuals (CCR)	0	30	30	0	n/a	n/a	95	100	Varies	7
	Sand Drainage Layer	0	32	32	0	n/a	n/a	115	130	2.0	4
	Primary Flexible Membrane Liner - textured HDPE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	60-mil	n/a
	Primary Geosynthetic Clay Liner (GCL)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	240-mil	n/a
	Double-Sided Geocomposite	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	250-mil	n/a
	Secondary Flexible Membrane Liner - textured HDPE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	60-mil	n/a
	Foundation Soils - Sand	0	32	32	0	n/a	n/a	115	130	Varies	4
	Textured HDPE Geomembrane vs Sand	n/a	n/a	n/a	n/a	34	0	n/a	n/a	n/a	1
	GCL (nonwoven side) vs Textured HDPE Geomembrane	n/a	n/a	n/a	n/a	23	0	n/a	n/a	n/a	1
	GCL (woven side) vs Geocomposite - Double Sided	n/a	n/a	n/a	n/a	20	0	n/a	n/a	n/a	3
	Textured HDPE Geomembrane vs Geocomposite - Double Sided	n/a	n/a	n/a	n/a	26	0	n/a	n/a	n/a	1
	Textured HDPE Geomembrane vs Foundation Sand	n/a	n/a	n/a	n/a	34	0	n/a	n/a	n/a	1
Final Cover	Vegetative Support Layer	0	32	32	0	n/a	n/a	115	130	6-inches	4
	Soil Erosion layer	0	32	32	0	n/a	n/a	115	130	24-inches	4
	Double-Sided Geocomposite - under downchutes locations only	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	200-mil	n/a
	Final Cover Flexible Membrane Liner - textured LLDPE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	60-mil	n/a
	Subgrade Layer - Select Fill/CCR	0	32	32	0	n/a	n/a	115	130	12-inches	4 and 7
	Textured LLDPE Geomembrane vs Sand	n/a	n/a	n/a	n/a	25	108	n/a	n/a	Post-Peak	1
	Textured LLDPE Geomembrane vs Geocomposite - Double Sided	n/a	n/a	n/a	n/a	17	195	n/a	n/a	Post-Peak	1

Note: BOLD items indicate interfaces.

SEISMIC COEFFICIENT:

For pseudo-static analyses, Hynes-Griffin and Franklin (1984) recommend using a seismic coefficient equal to 0.5 times the peak horizontal acceleration at bedrock (PHA). The PHA using the United States Geological Survey (USGS) seismic design maps (2014) application (Beta - Unified Hazard Tool) with a 2% probability of exceedance in 50 years (2,475-year return period) is 0.0394g, which corresponds to a seismic coefficient of 0.0197. However, the Natural Resources Conservation Service (NRCS) recommends a minimum seismic coefficient of 0.05 for Michigan, so a seismic coefficient of 0.05 was used in pseudo-static analyses.

UNITS:

Commonly used units for this application:

acre	1 acre = 43,560 square feet	**ksf**	kips per square foot
cf, ft^3	cubic feet	**mil**	mil thickness (0.001 inch)
cf/acre/day	cubic feet per acre per day	**mm**	millimeter
cm	centimeter	**mph**	miles per hour
cm/s	centimeter per second	**pcf**	pounds per cubic foot
cy, yd^3	cubic yards	**psf**	pounds per square foot
°	degrees	**psi**	pounds per square inch
ft	feet	**s, sec**	seconds
ft^2	square feet	**yr**	year
g	gravity = 9.81 meters/square second	**oz/sy**	ounce per square yard
g/cm^3	grams per cubic centimeter	**gpad**	gallons per acre per day
gal	gallons	**in**	inch
ipad	inches per acre per day	**in^2**	square inches
kPA	kilopascals		

REFERENCES:

1.) Koerner, R.M., and Narejo, D., 2005. "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to- Soil Interfaces", GRI Report #30.

2.) The United States Geological Survey (USGS), https://earthquake.usgs.gov/hazards/interactive/.

3.) Golder Associates, Inc. Atlanta Laboratory, Direct Shear Data Base, 2019.

4.) Qian, Xuede, Robert M. Koerner and Donald H. Gray, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002.

5.) Engineering & Environmental Solutions, LLC (EES), 2012. Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation – December 2012.

6.) Golder Associates, October 2016, "J.H. Campbell Generating Facility Pond A Structural Stability and Safety Factor Assessment Report".

7.) Golder Associates, July 2017, "J.H. Campbell Landfill Test Fill Report".

APPENDIX B

Geotechnical Laboratory Data

EXCERPTS FROM:

Resource Conservation and Recovery Act
Vertical Expansion Feasibility Investigation - 2012

- J.H. Campbell Solid Waste Disposal Area

CONSUMERS ENERGY

17000 Croswell Street
West Olive, Michigan

December 2012

EES Project No. 005-12-003

ENGINEERING & ENVIRONMENTAL SOLUTIONS, LLC
400 136th Avenue, Building 100, Suite B, Holland, MI 49424
www.goEESolutions.com

Golder Associates

APPENDIX C

Boring Logs

Engineering & Environmental Solutions, LLC

400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

Log of Borehole: PZ/SB-1201

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜ od: 8.25" OD HSA
Sampling Met˜ od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 630.5
Top of Casing Ele˜ation ˜feet˜: 632.49
Logged By: Kurt Van Appledorn
Comments:

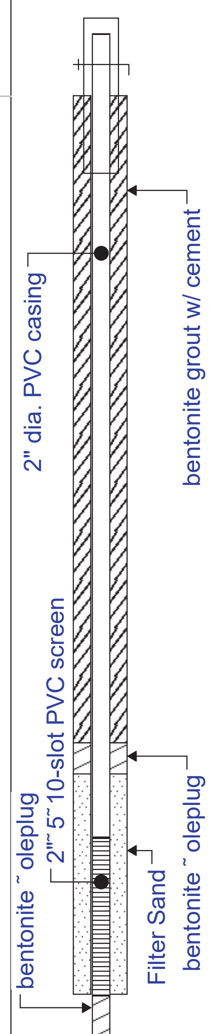
Start Date: 6-6-12
End Date: 6-6-12
Driller: Remedial Ser˜ ices Di˜ ision
Crew C˜ ief: Da˜ e Hill
Dept˜ to Water ˜ft BGS during drilling˜: ˜2 4
Easting: 2744.3
Nort˜ ing: 690.9

S˜ BS˜ RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
0	Ground Surface	630.5 / 0.0				
0-0.4	0-0.4˜ Very dark grayis˜ brown fine ASH˜ some roots		2	1.7	1-1-2-2	3
0.4-13	0.4-13˜ Dark gray fine sand si˜ e to silt si˜ e ASH˜ moist.					
5-7			2	1.5	2-2-2-2	4
	Wet at 5.9˜ in silt si˜ e layers ˜˜ 5" seams˜˜ moist in fine sand si˜ e layers					
10-12			2	1.8	1-1-1-1	2
13	13-29.0˜ Dark gray silt si˜ e ASH˜ wet	617.5 / 13.0				
15-17			2	1.7	0-1-0-1	1
20-22			2	1.9	0-1-0-1	1
22-24			2	1.9	1	1
24-26	Some fine sand si˜ e as˜ @ 24.9-26˜	606.5 / 24.0	2	2.0	1	1
26-28			2	2.0	1	1
28-30	29.0-30.0˜ Fine SAND˜ wet˜ gray 29-29.2˜ brown 29.2-30˜.	601.5 / 29.0	2	1.9	0-1-9-11	10
30	End of Boring					

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



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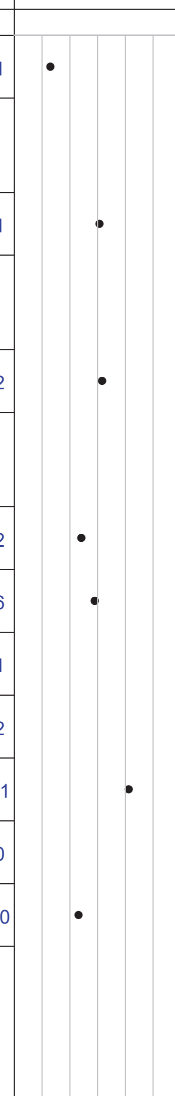
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

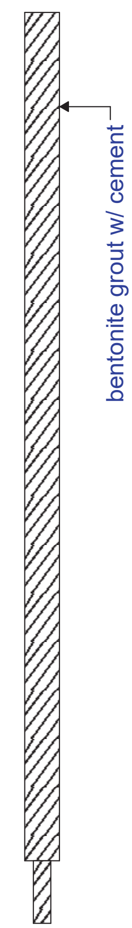
Log of Borehole: SB-1202

Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	6-6-12
Project Number:	005-12-003	End Date:	6-6-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜od:	8.25" OD HSA	Crew C˜ief:	Da˜e Hill
Sampling Met˜od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	
Ground Ele˜ation ˜feet˜:	629.2	Easting:	3879.2
Top of Casing Ele˜ation ˜feet˜:	NA	Nort˜ ing:	595.3
Logged By:	Kurt Van Appledorn		
Comments:			

S˜ BS˜ RFACE PROFILE		SAMPLE				
Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Well Completion Details
Ground Surface	629.2 / 0.0					
0.0-16.8˜ Very dark gray fine sand and silt si˜e ASH˜ moist.		2	1.1	0-1-0-1	1	
Moist to wet silt si˜e seam@ 1˜						
Moist to wet silt si˜e 0.3˜seams @ 5-7˜	624.2 / 5.0	2	1.9	0-1-0-1	1	
		2	1.2	1-1-1-1	2	
Wet silt si˜e @ 15 to 16.8˜	614.2 / 15.0	2	2.0	0-1-1-2	2	
16.8-19.0˜Very dark gray fine sand si˜e ASH˜ wit˜ silt si˜e as˜ ˜ moist	612.4 / 16.8	2	0.9	0-2-4-3	6	
19.0-27.0˜ Silt si˜e ASH˜ some fine sand si˜e as˜ ˜ wet	610.2 / 19.0	2	2.0	0-0-1-1	1	
		2	2.0	0-1-1-3	2	
		2	2.0	1-3-8-5	11	
		2	1.5	0	0	
27.0-29.0˜ Brown fine SAND˜ some 1" darker gray layers˜ wet	602.2 / 27.0	2	1.5	1-4-6-7	10	
End of Boring	600.2 / 29.0					

Dept˜ ˜feet BGS˜ (0–34) | Symbol | Water Content ˜Percent˜ (10, 30, 50)





Sheet: 1 of 1

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Holland, Michigan 49424
Phone/Fax: (616) 994-6541
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Log of Borehole: PZ/SB-1203

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-7-12
Project Number: 005-12-003	End Date: 6-7-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜ od: 8.25" OD HSA	Crew C˜ ief: Da˜e Hill
Sampling Met˜ od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 25
Ground Ele˜ation ˜feet˜: 628.7	Easting: 4542.2
Top of Casing Ele˜ation ˜feet˜: 631.60	Nort˜ ing: 505.8
Logged By: Kurt Van Appledorn	
Comments:	

S˜ BS˜ RFACE PROFILE

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .
	Ground Surface	628.7
0	0-0.7˜ Fine sand si˜e ASH˜ dry	0.0
0.7	0.7-3˜ Silt si˜e ASH˜ wit˜ 2-3" seams of fine sand si˜e as˜ ˜ moist.	
3	3-26˜ Gray fine sand si˜e ASH˜ dry˜ wit˜ wet dark gray 0.2 to 0.4˜ silt si˜e as˜ seams.	625.7 3.0
25	Wet at 25˜	603.7 25.0
26	26.0-28.5˜ Silt si˜e ASH˜ little fine sand si˜e as˜ ˜ wet T˜ in ˜˜1 /8"˜ black material between as˜ and sand	600.2 28.5
28.5	28.5-30˜ Brown fine SAND	598.7 30.0
30	End of Boring	

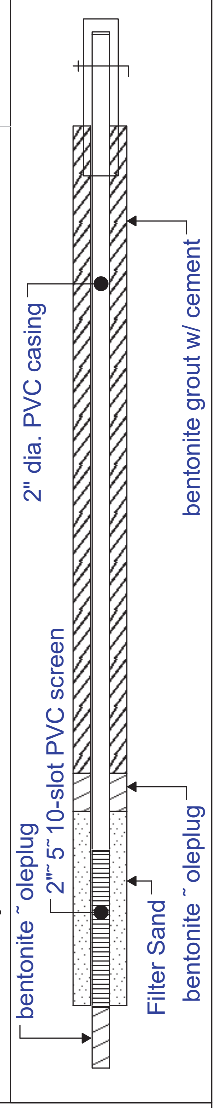
SAMPLE

Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	2.0	0-1-1-1	2
2	1.3	0-1-1-1	2
2	1.7	0-0-1-1	1
2	1.6	0-0-0-1	0
2	0	0-1-0-1	1
2	2.0	0-1-1-2	2
2	1.9	0-1-0-1	1
2	1.9	0	0
2	1.5	0-3-8-15	11

Water Content ˜Percent˜

10 30 50

Well Completion Details



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Solutions, LLC

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Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
www.goEESolutions.com

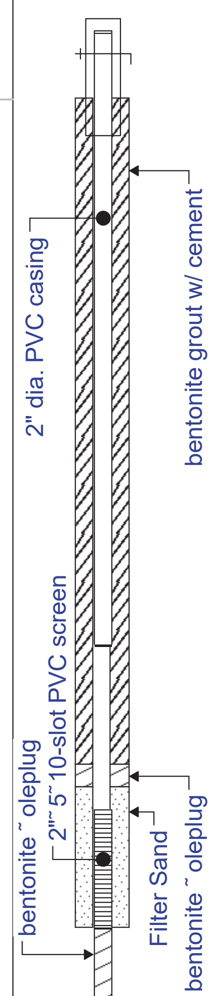
Log of Borehole: PZ/SB-1204

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜od: 8.25" OD HSA
Sampling Met˜od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 629.3
Top of Casing Ele˜ation ˜feet˜: 631.92
Logged By: Kurt Van Appledorn
Comments:

Start Date: 6-7-12
End Date: 6-7-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ief: Da˜e Hill
Dept˜ to Water ˜ft BGS during drilling˜:
Easting: 6033.8
Nort˜ing: 585.6

S˜BS˜RFACE PROFILE		SAMPLE				
Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)
Ground Surface	629.3 0.0					
0-3.0˜ Very dark gray silt si˜e ASH wit˜ 1" fine sand si˜e seams˜ wet seam at 1.8-2˜.		2	2.0	0-1-2-2	3	
3.0-16.1˜ Fine sand wit˜ silt si˜e ASH˜ moist	626.3 3.0					
wet at 5-5.7˜		2	1.7	0-1-1-1	2	
		2	2.0	0-0-0-1	0	
dark gray and lig˜t brown at 15.9-16.1˜	614.3 15.0	2	2.0	1-2-3-3	5	
16.1-35.5˜ Silt si˜e ASH˜ moist						
Wet at 16.9˜						
20-21.1˜ Find sand and silt si˜e ASH˜ moist	609.3 20.0	2	2.0	1-2-3-2	5	
Wet at 21.1˜						
1" to 2" fine sand si˜e seam @ 22˜		2	1.9	1-1-1-2	2	
1" to 2" fine sand si˜e seam @ 23˜						
		2	2.0	0-1-0-1	1	
		2	2.0	0-1-0-1	1	
		2	1.8	0	0	
		2	2.0	0	0	
32-35.5˜Silty fine sand si˜e as˜	597.3 32.0	2	1.7	0	0	
1" dense fine material at bottom of as˜.		2	2.0	0-1-3-10	4	
35.5-38.0˜ Black fine SAND˜ wet Gray to brown at 37˜to tip	593.8 35.5	2	1.4	1-10-16-19	26	
End of Boring	591.3 38.0					

Well Completion Details



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Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
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Log of Borehole: PZ/SB-1205

Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	6-7-12
Project Number:	005-12-003	End Date:	6-7-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜ od:	8.25" OD HSA	Crew C˜ ief:	Da˜e Hill
Sampling Met˜ od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	
Ground Ele˜ation ˜feet˜:	627.0	Easting:	5930.8
Top of Casing Ele˜ation ˜feet˜:	629.60	Nort˜ ing:	-256.7
Logged By:	Kurt Van Appledorn		
Comments:			

S˜ BS˜ RFACE PROFILE

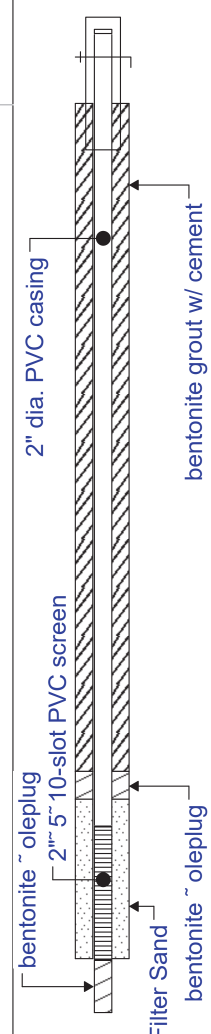
Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .
	Ground Surface	627.0
0	0-3.0˜ Dark gray silt si˜e ASH˜ little fine sand si˜e˜ moist.	0.0
3	3.0-7.0˜ Gray fine sand and silt si˜e ASH˜ slig˜ tly moist to dry˜ 1" seams of sandier si˜e as˜ wit˜ t˜ in black layers. wet at 5-5.7˜	624.0 / 3.0
7	7.0-18.0˜ Dark gray SILT si˜e as˜˜ some fine SAND si˜e˜ 1/4" seams of sandier si˜e as˜˜ becomes sandier wt˜ dept˜˜ slig˜ tly moist. 15.3-15.7˜ fine sand si˜e seam. 15.8˜ 1" wet seam. 16.5-16.7˜ fine sand seam.	620.0 / 7.0
15		612.0 / 15.0
18	18-23.7˜ Dark gray silt si˜e ASH˜ wet at 20.4.	609.0 / 18.0
23.7	23.7-26.0˜ Dark gray fine sand si˜e ASH˜ slig˜ tly moist.	603.3 / 23.7
26	26.0-32.0˜ Alternating 3-5" seams of silt and fine sand si˜e ASH˜ wet˜ 1-3" sand si˜e seams below 28˜ wet	601.0 / 26.0
32	32.0-33.6˜ Silty si˜e ASH˜ wet. 1/4" -1/2" clay between as˜ and natural sand.	595.0 / 32.0
33.6	33.6-34.0˜ Gray fine SAND˜ wet	593.4 / 33.6
	End of Boring	

SAMPLE

Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	1.8	1-1-2-2	3
2	2.0	1-2-2-4	4
2	1.9	1-3-4-5	7
2	1.7	1-1-1-1	2
2	2.0	0	0
2	1.8	0	0
2	1.4	0-1-2-1	3
2	1.6	0-0-0-1	0
2	2.0	0	0
2	2.0	0	0
2	2.0	0-0-0-2	0

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



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400 136th Avenue
Building 100, Suite B
Holland, Michigan 49424
Phone/Fax: (616) 994-6541
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Log of Borehole: PZ/SB-1206

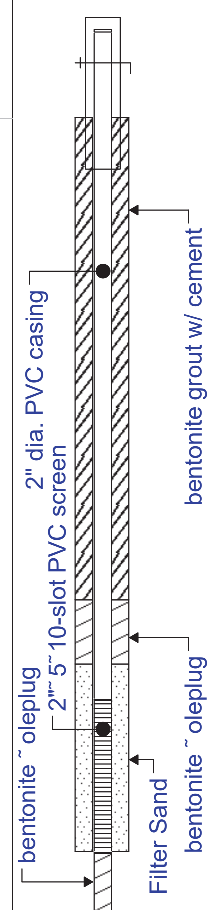
Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-7-12
Project Number: 005-12-003	End Date: 6-7-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA	Crew C˜ief: Da˜e Hill
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:
Ground Ele˜ation ˜feet˜: 623.8	Easting: 4669.7
Top of Casing Ele˜ation ˜feet˜: 629.69	Nort˜ ing: -1302.5
Logged By: Kurt Van Appledorn	
Comments:	

S˜ BS˜ RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
	Ground Surface	623.8 / 0.0				
0	0-03˜ Gray wit˜ t˜ in black layers˜ sand si˜e ASH˜ dry.					
0-2			2	1.5	0-2-1-1	3
	0.3-0.9˜ Dark gray silt si˜e ASH˜ slig˜ tly moist.					
3	0.9-3.0˜ Black and gray layers˜ fine sand si˜e ASH.	620.8 / 3.0				
3	3.0-8.0˜ Fine sand si˜e ASH˜ some silt si˜e˜ moist˜ dark gray 3-6.2˜ and gray 6.2-8˜.					
5-7			2	2.0	1-1-2-2	3
8	8.0-13.0˜ Gray wit˜ 1" black layers˜ fine sand si˜e ASH˜ little silt si˜e˜ slig˜ tly moist.	615.8 / 8.0				
10-12			2	1.7	2-2-2-2	4
13	13.0-15.9˜ Gray wit˜ t˜ in blacklayers˜ fine sand si˜e ASH˜ slig˜ tly moist.	610.8 / 13.0				
15.9	15.9-18.0˜ Dark Gray silt si˜e ASH˜ wet.	607.9 / 15.9				
15-17			2	2.0	1-1-1-1	2
18	18.0-25.1˜ Dark gray silt si˜e ASH˜ wet.	605.8 / 18.0				
20-22			2	20	0-1-0-1	1
22-24			2	1.8	1-1-1-1	2
24-26			2	1.9	1-1-2-6	3
25.1	25.1-26.0˜ Brown fine SAND˜ wet˜ 1/2" of sand directly below as˜ o˜erlaying 1" clayey silt	598.7 / 25.1				
	End of Boring					

Water Content ˜Percent˜ (10 30 50)

Well Completion Details



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Building 100, Suite B
Holland, Michigan 49424
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Log of Borehole: PZ/SB-1207

Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	6-8-12
Project Number:	005-12-003	End Date:	6-8-12
Site Location:	J.H.Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜od:	8.25" OD HSA	Crew C˜ief:	Da˜e Hill
Sampling Met˜od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	
Ground Ele˜ation ˜feet˜:	628.9	Easting:	4922.8
Top of Casing Ele˜ation ˜feet˜:	631.98	Nort˜ing:	-414.3
Logged By:	Kurt Van Appledorn		
Comments:			

S˜ BS˜ RFACE PROFILE

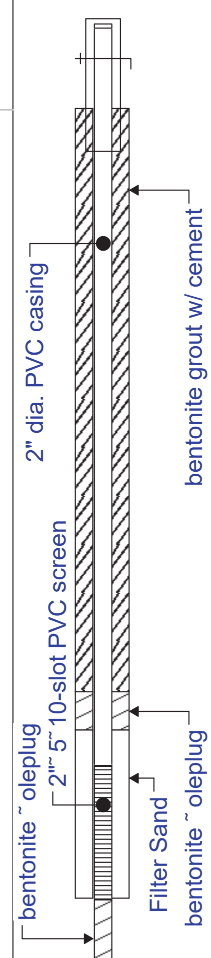
Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜.
0	Ground Surface	628.9 / 0.0
0-0.6	0-0.6˜ Gray fine sand si˜e ASH˜ dry.	
0.6-1.1	0.6-1.1˜ Dark gray silt si˜e ASH wit˜ 1" sand si˜e as˜.	
1.1-3.0	1.1-3.0˜ Gray fine sand si˜e ASH.	625.9 / 3.0
3.0-8.0	3.0-8.0˜ Fine sand si˜e ASH˜ some silt si˜e moist˜ 2" seams of silt si˜e as˜.	620.9 / 8.0
8.0-10.5	8.0-10.5˜Dark gray fine sandy silt si˜e ASH˜ wet seam @ 10.3-10.4˜.	618.4 / 10.5
10.5-13.0	10.5-13.0˜Gray fine sand si˜e ASH˜ moist.	615.9 / 13.0
13.0-15.7	13.0-15.7˜ Dark gray silty fine SAND si˜e ASH˜ moist.	613.2 / 15.7
15.7-18.0	15.7-18.0˜ Black and gray t˜in layers˜ fine sand si˜e ASH˜ moist.	610.9 / 18.0
18.0-22.0	18.0-22.0˜Dark gray sandy silt si˜e ASH˜ ˜ery moist wit˜ wet seam @ 20.4-20.7˜.	606.9 / 22.0
22.0-22.7	22.0-22.7˜Dark gray and gray silty fine sand si˜e ASH˜ moist.	605.1 / 23.8
22.7-23.8	22.7-23.8˜ Sandy silt si˜e ASH˜ wet˜ loose 23.3-23.6˜.	
23.8-24.0	23.8-24.0˜ Black fine sand si˜e ASH˜ moist.	
24.0-30.0	24.0-30.0˜Dark gray silt si˜e ASH˜ wet˜ loose.	598.9 / 30.0
30.0-32.0	30.0-32.0˜ Black fine SAND˜ color grades into gray and brown below 30.7˜ ˜ery wet to wet.	596.9 / 32.0
32.0	End of Boring	

SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	1.5	0-0-0-1	0
2	2.0	1-1-1-1	2
2	1.4	0-1-2-2	3
2	1.8	1-1-1-1	2
2	1.6	0-1-5-5	6
2	2.0	0-1-0-1	1
2	2.0	0	0
2	2.0	0	0
2	1.3	0	0
2	1.6	5-10-19-30	29

Water Content ˜Percent˜ 10 30 50

Well Completion Details



Sheet: 1 of 1

Engineering & Environmental Solutions, LLC

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Holland, Michigan 49424
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Log of Borehole: PZ/SB-1208

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜od: 8.25" OD HSA
Sampling Met˜od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 629.6
Top of Casing Ele˜ation ˜feet˜: 633.57
Logged By: Kurt Van Appledorn
Comments:

Start Date: 6-11-12
End Date: 6-11-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ief: Da˜e Hill
Dept˜ to Water ˜ft BGS during drilling˜: 29
Easting: 4037.5
Nort˜ing: -538.0

S˜BS˜RFACE PROFILE

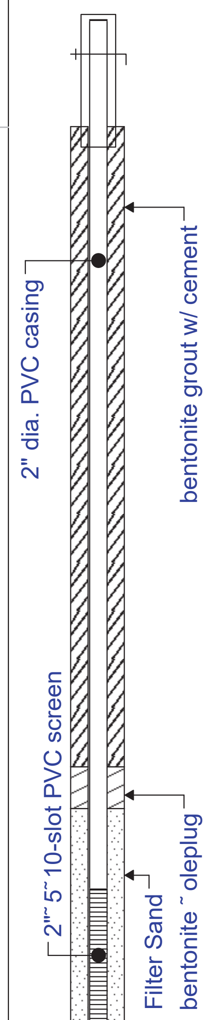
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.
0	Ground Surface	629.6 / 0.0
0-3	0-3.0˜ Dark gray silt si˜e ASH˜ moist˜ dry wit˜ roots @0-0.3˜˜ 1" fine sand si˜e seam at 1.8˜.	626.6 / 3.0
3-12.4	3.0-12.4˜ Dark gray fine sandy silt si˜e ASH˜ moist. Loose˜ wet seams at 5.5-5.7˜and 6.1-6.5˜. Loose˜ wet silt seam at 10.7-11.1˜. Fine sand si˜e seam at 11.1-11.2˜.	618.9 / 10.7; 617.2 / 12.4
12.4-13.2	12.4-13.2˜ Dark gray silty fine sand si˜e ASH˜ moist.	
13.2-16.0	13.2-16.0˜ Dark gray fine sandy silt si˜e ASH˜ moist. Wet silt si˜e seam @ 13.9˜. 1" silty sand si˜e seams at 14.1˜ 14.5˜ and 14.9˜.	613.6 / 16.0
16-22	16.0-22.0˜ Silt si˜e ASH˜ wet. Loose at 17-18˜ and at 21-22˜.	607.6 / 22.0
22-34	22.0-34˜ Brown fine SAND˜ moist. Wet at 29˜.	595.6 / 34.0
34	End of Boring	

SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	1.9	1-1-2-3	3
2	1.9	0-1-0-1	1
2	1.7	1-1-1-1	2
2	2.0	1-1-1-2	2
2	1.6	0-0-0-1	0
2	2.0	0	0
2	2.0	0	0
2	1.7	0	0
2	1.3	3-6-8-7	14
2	1.0	3-4-5-5	9
2	1.1	2-5-7-6	12

Water Content ˜Percent˜: 10 30 50

Well Completion Details



Sheet: 1 of 1

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Log of Borehole: SB-1209

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-8-12
Project Number: 005-12-003	End Date: 6-8-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA	Crew C˜ief: Da˜e Hill
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:
Ground Ele˜ation ˜feet˜: 629.5	Easting: 4057.6
Top of Casing Ele˜ation ˜feet˜: NA	Nort˜ing: -1059.9
Logged By: Kurt Van Appledorn	
Comments:	

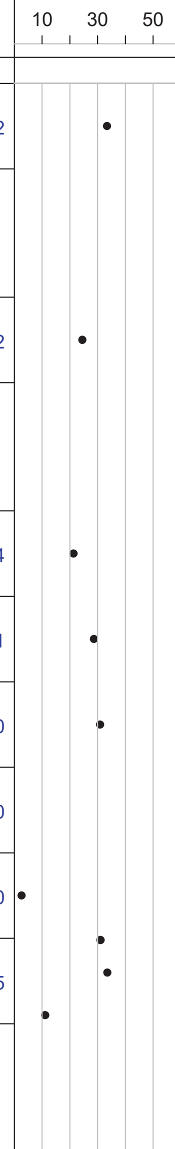
S˜BS˜RFACE PROFILE

Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.
0	Ground Surface	629.5 / 0.0
0–3	0.0-3˜ Dark gray silt si˜e ASH˜ moist˜ top 2"˜ dry wit˜ roots˜ 1" fine sand si˜e as˜ seam at 0.6˜ soft wet seam at 1.5-1.7˜	626.5 / 3.0
3–14	3-14˜ Dark gray fine sand si˜e ASH˜ moist˜ wet silty sand si˜e seam at 7˜	
10	1" to 3" silty si˜e seams between 10 and 14˜ 1/2" wet silt si˜e seam at 12.5˜	619.5 / 10.0
14–16	14.0-16.0˜Dark gray fine sandy silt si˜e ASH˜ moist. brown˜ loose˜ wet˜ silt si˜e seam at 14.5-14.8˜	615.5 / 14.0
16–20.8	16-18˜Dark gray˜ loose˜ silt si˜e ASH˜ wet. 17-17.1˜sandy silt si˜e seam 20-22˜ Dark grayis˜ brown˜ ˜ery soft˜ stiffer 18.7-19.0˜ wet	613.5 / 16.0; 611.5 / 18.0
20.8–22	20.8-22.0˜ Dark brown to black fine SAND˜ moist˜ no black below 21.3˜.	608.7 / 20.8
22	End of Boring	607.5 / 22.0

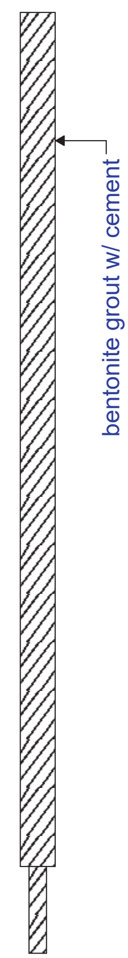
SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	2.0	1-1-1-1	2
2	1.9	2-1-1-1	2
2	2.0	2-2-2-2	4
2	1.1	0-1-0-1	1
2	1.4	0-0-0-1	0
2	2.0	0	0
2	1.7	0	0
2	1.6	0-2-3-3	5

Water Content ˜Percent˜



Well Completion Details



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Log of Borehole: PZ/SB-1210

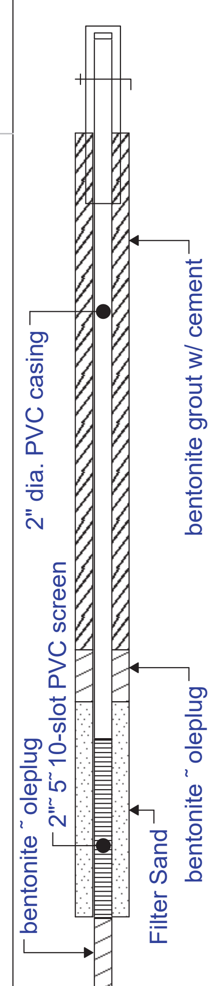
Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜od: 8.25" OD HSA
Sampling Met˜od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 626.9
Top of Casing Ele˜ation ˜feet˜: 629.52
Logged By: Kurt Van Appledorn
Comments:

Start Date: 6-11-12
End Date: 6-12-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ief: Bob
Dept˜ to Water ˜ft BGS during drilling˜: 29
Easting: 3309.1
Nort˜ing: -1383.7

S˜BS˜RFACE PROFILE			SAMPLE				
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜
0	Ground Surface	625.0					
0-3.0	0-3.0˜ Dark gray silt si˜e ASH˜ dry. 1" silty fine sand si˜e seams.	0.0	2	1.5	1-2-3-3	5	
3.0-13.0	3.0-13.0˜ Dark gray silt si˜e ASH˜ moist to wet. Wet seam at 4.6-4.8˜	622.0 / 3.0	2	2.0	1-1-2-2	3	
	Moist˜ sitly fine sand seams at 9.4-9.9˜ 10-10.1˜ 10.2-10.4˜.	615.6 / 9.4	2	2.0	1-2-2-2	4	
13.0-18.0	13.0-18.0˜ Dark gray silt si˜e ASH˜ little fine sand˜ moist. Wet at 14.5-16˜. 1" silty fine sand si˜e seam at 15.3˜. Soft at 15.4-16˜.	612.0 / 13.0	2	2.0	0-0-1-0	1	
	Fine sand si˜e seams at 16.2-16.7˜and 17.0-17.2˜. Wet sandy silt si˜e seam at 17.5-18˜.	608.8 / 16.2	2	1.9	1-1-1-1	2	
18.0-21.0	18.0-21.0˜ Dark gray sandy silt si˜e ASH˜ wet. Little fine sand si˜e at 19-20˜	607.0 / 18.0	2	2.0	1-1-2-1	3	
21.0-22.4	21.0-22.4˜ Dark gray silt si˜e ASH˜ wet.	604.0 / 21.0	2	2.0	0-1-2-1	3	
22.4-24.0	22.4-24.0˜ Brown fine SAND˜ moist. Darker brown 3" below as˜.	602.6 / 22.4	2	1.4	0-2-3-5	5	
24.0	End of Boring	601.0 / 24.0					

Water Content ˜Percent˜ scale: 10, 30, 50

Well Completion Details



Sheet: 1 of 1

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Log of Borehole: SB-1211

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-8-12
Project Number: 005-12-003	End Date: 6-8-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜ od: 8.25" OD HSA	Crew C˜ ief: Da˜e Hill
Sampling Met˜ od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:
Ground Ele˜ation ˜feet˜: 625.0	Easting: 5165.9
Top of Casing Ele˜ation ˜feet˜: NA	Nort˜ ing: -978.5
Logged By: Kurt Van Appledorn	
Comments:	

S˜ BS˜ RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	Well Completion Details
0	Ground Surface	630.5 / 0.0						bentonite grout w/ cement
0–5.6	0.0-26.2˜ Dark gray silt si˜e ASH˜ lig˜ ter gray and black 1" fine sand si˜e as˜ seams˜ roots in upper 2"˜ slig˜ tly moist		2	1.8	0-3-5-8	8		
5.6	5.6-6.3˜ Black fine sand si˜e as˜ 6.4-6.5˜Wet silt si˜e	624.9 / 5.6	2	1.6	2-0-1-1	1		
10.0	Wet silt si˜e @ 10-10.9˜ Soft˜ wet silt si˜e @ 10.9-11.4˜ Fine sand si˜e @11.4-12.0˜	620.5 / 10.0	2	1.8	1-2-2-1	4		
15.0	15-15.2˜sand si˜e˜ moist 15.2-16.1˜silt si˜e˜ loose˜ wet 16.1-16.6˜ fine sand si˜e	615.5 / 15.0	2	1.6	0-1-1-1	2		
21.0	20-22˜ Black to dark gray silt and fine sand si˜e as˜ ˜ grades to fine sand si˜e as˜ at 21-22˜ 22-26.2˜loose˜ silt si˜e˜ wit˜ wet 1" seam of silt si˜e wit˜ little fine sand si˜e as˜ at 25.3˜ 26-26.2˜wet 1/4" brown clay layer at 26.2˜between as˜ and fine sand.	609.5 / 21.0	2	1.6	0-0-0-2	0		
			2	2.0	0	0		
			2	1.8	0	0		
26.2	26.2-28.0˜ Brown fine SAND˜ moist.	604.3 / 26.2	2	1.6	2-5-10-10	15		
28.0	End of Boring	602.5 / 28.0						

Sheet: 1 of 1

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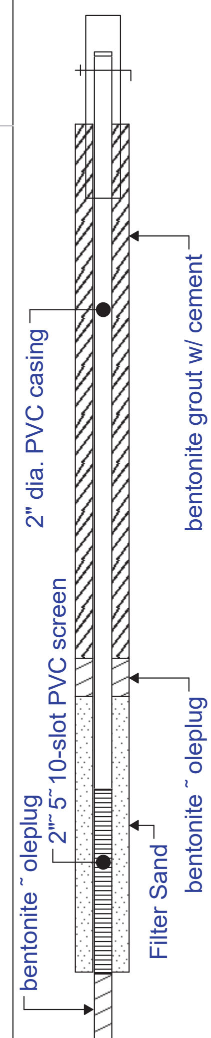
Log of Borehole: PZ/SB-1212

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-11-12
Project Number: 005-12-003	End Date: 6-11-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA	Crew C˜ief: Bob
Sampling Met˜od: 2˜Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:
Ground Ele˜ation ˜feet˜: 627.3	Easting: 2888.7
Top of Casing Ele˜ation ˜feet˜: 629.14	Nort˜ing: -983.0
Logged By: Kurt Van Appledorn	
Comments:	

S˜BS˜RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Symbol	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)
0		Ground Surface	627.3 / 0.0					
0–6.6		0-6.6˜ Dark gray fine sandy silt si˜e ASH˜ dry to 1˜ moist below 1˜. 1/2" fine sand si˜e seams at 0.6˜and 0.7˜ and fine sand si˜e seam at 1.0-1.2˜.		2	2.0	0-4-4-3	8	
		Gray and blackfine sand si˜e as˜ seams at 5.2-5.4˜and 6.0-6.1˜ moist.	622.1 / 5.2	2	2.0	0-1-1-1	2	
6.6–11.8		6.6-11.8˜ Dark gray silt si˜e ASH˜ moist to wet.	620.7 / 6.6	2	2.0	0-1-0-1	1	
11.8–17.0		11.8-17.0˜Black silt si˜e wit˜ t˜in layers of fine sand si˜e ASH˜ moist. Brownis˜ gray at 15-16.9˜.	615.5 / 11.8	2	2.0	0	0	
17.0–20.7		17.0-20.7˜ Sandy silt si˜e ASH˜ wet.	610.3 / 17.0					
		Brownis˜ black silty fine sand si˜e as˜ at 18.1-18.2˜ ˜e ry moist.	609.1 / 18.2	2	1.9	1-3-2-1	5	
		Brownis˜ gray at 18.2-19˜	608.0 / 19.3					
		1/4" Black and gray layers˜ wet˜ at 19.5-20.7˜		2	2.0	0-0-0-1	0	
20.7–22.1		20.7-22.1˜Brownis˜ gray silt si˜e ASH˜ wet˜ soft.	606.6 / 20.7	2	1.1	0-0-0-1	0	
22.1–23.1		23.1-23.1˜ Brownis˜ gray and black layers˜ silty fine sand si˜e ASH˜ wet. 1/8" black sandy silt layer abo˜e natural sand.	605.2 / 22.1					
23.1–25.0		23.1-25.0˜ Grayis˜ brown fine SAND˜ wet.		2	1.1	3-4-5-4	9	
25		End of Boring	602.3 / 25.0					

Well Completion Details



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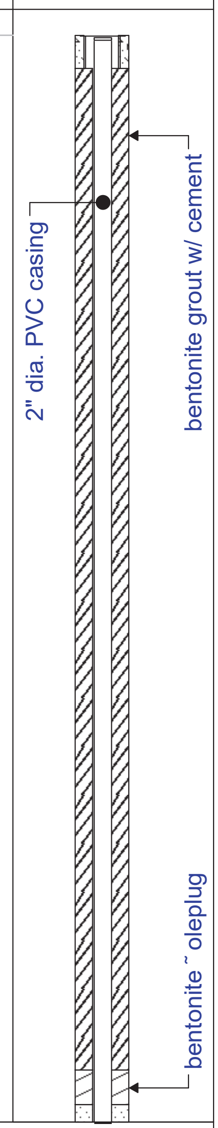
Project Name: RCRA Vertical E˜p. Feasibility	**Log of Borehole: PZ/SB-1213**
Project Number: 005-12-003	Start Date: 6-12-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	End Date: 6-13-12
Drilling Met˜od: 8.25" OD HSA	Driller: Remedial Ser˜ices Di˜ision
Sampling Met˜od: 2˜ Split Spoon	Crew C˜ief: Bob
Ground Ele˜ation ˜feet˜: 628.9	Dept˜ to Water ˜ft BGS during drilling˜: 34
Top of Casing Ele˜ation ˜feet˜: 628.74	Easting: 3288.5
Logged By: Kurt Van Appledorn	Nort˜ ing: -1696.9
Comments:	

S˜ BS˜ RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
	Ground Surface	628.9				
0	0-0.4˜ Brown fine SAND wit˜ organics	0.0				
1	0.4-24.0˜ Yellowis˜ brown ˜10YR5/4˜ fine SAND˜ moist ˜dry 0.4-1.0˜˜		2	1.6	2-2-3-3	5
3			2	1.5	3-5-5-6	10
5			2	1.5	4-5-6-6	11
6	Dark grayis˜ brown ˜10YR4/2˜ silty fine sand seam.	622.8 / 6.1				
7			2	1.5	3-6-8-16	14
9			2	1.7	8-11-16-16	27
11			2	2.0	10-15-16-18	31
13			2	1.5	4-7-8-8	15
15	color darkens to brown˜10YR4/3˜ at 14.8˜.	614.1 / 14.8	2	1.6	6-6-7-8	13
17	Yellowis˜ brown at 16-16.6˜. Dark grayis˜ brown silty sand 16.6-16.7˜. Dark brown seam at 17.4˜.	612.9 / 16.0	2	1.6	6-11-14-16	25
19		609.3 / 19.6	2	1.3	4-8-16-16	24
21	Yellowis˜ brown at 21-21.5˜. Very dark grayis˜ brown at 21.5-22˜. Piece of wood at 21.6˜		2	1.7	4-11-15-15	26
23	Very dark grayis˜ brown at 22-22.8˜. Moist at 22-24˜. 1" dark brown peat seam at 22.8˜.	606.9 / 22.0	2	1.6	4-8-13-15	21
24	24.0-26.2˜ Dark brown to ˜ery dark grayis˜ brown˜ silty fine SAND˜ trace wood and organics˜ moist. Black silty˜ sandy seam at 26-26.2˜.	604.9 / 24.0				
25			2	1.7	6-14-16-20	30
27	26.2-35.0˜ Brownis˜ yellow fine SAND˜ moist.	602.7 / 26.2	2	1.9	8-18-18-17	36
29	Lig˜t yellowis˜ brown at 28-30.5˜	600.9 / 28.0	2	1.5	4-9-12-13	21
31	Brownis˜ yellow˜ some mottles at 30.5-32˜	598.4 / 30.5	2	1.4	3-8-8-8	16

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



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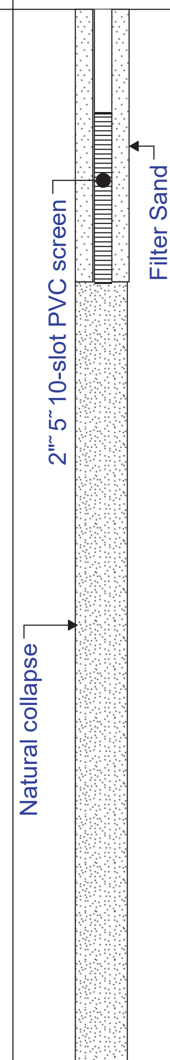
Log of Borehole: PZ/SB-1213

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-12-12
Project Number: 005-12-003	End Date: 6-13-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA	Crew C˜ief: Bob
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 34
Ground Ele˜ation ˜feet˜: 628.9	Easting: 3288.5
Top of Casing Ele˜ation ˜feet˜: 628.74	Nort˜ing: -1696.9
Logged By: Kurt Van Appledorn	
Comments:	

S˜BS˜RFACE PROFILE			SAMPLE				Water Content ˜Percent˜ (10 30 50)
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N	
34	Wet at 34˜	594.9 / 34.0					
35–57	35.0-57.0˜ Brown fine SAND˜ trace medium sand˜ wet		2	1.5	1-3-5-7	8	•
			2	2.0	0-3-11-20	14	•
45	trace coarse sand at 45˜ to 52˜.	583.9 / 45.0	2	1.7	7-11-21-23	33	•
			2	1.0	6-7-11-18	18	•
			2	0	0-8-21-50+	29	
57–63	57.0-63.0˜ Gray silty CLAY˜ moist	571.9 / 57.0	1	1	10-44		•
			1		S˜elby		
63	End of Boring	565.9 / 63.0					

Well Completion Details



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Phone/Fax: (616) 994-6541
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Log of Borehole: PZ/SB-1214

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜od: 8.25" OD HSA
Sampling Met˜od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 633.4
Top of Casing Ele˜ation ˜feet˜: 632.94
Logged By: Kurt Van Appledorn
Comments:

Start Date: 6-13-12
End Date: 6-13-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ief: Bob
Dept˜ to Water ˜ft BGS during drilling˜: 37
Easting: 4573.9
Nort˜ing: -1642.3

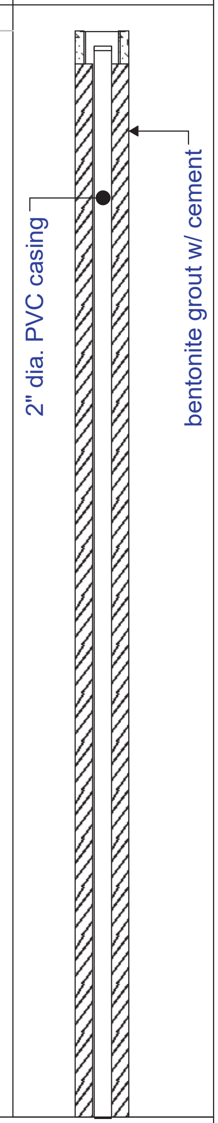
S˜BS˜RFACE PROFILE

Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.
0	Ground Surface	633.4 / 0.0
0	0-0.6˜ Brown fine SAND˜ some organics˜ dry	
0.6	0.6-35.0˜ Yellowis˜ brown fine SAND˜ moist.	
20	trace medium and coarse sand at 20 to 22˜	613.4 / 20.0

SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	1.7	0-2-4-4	6
2	1.4	4-7-9-10	16
2	1.0	4-7-9-11	16
2	1.5	0-3-9-10	12
2	1.5	4-6-9-10	15
2	1.5	3-4-9-12	13
2	1.8	3-6-9-10	15
2	1.5	0-5-10-11	15
2	1.5	3-4-7-10	11
2	1.5	3-8-9-13	17
2	1.5	5-8-16-17	24
2	1.5	8-11-16-14	27
2	1.5	5-8-11-16	19
2	2.0	1-4-16-24	20
2	2.0	4-7-14-19	21
2	1.5	7-7-8-9	15

Water Content ˜Percent˜: 10 30 50



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Phone/Fax: (616) 994-6541
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Log of Borehole: PZ/SB-1214

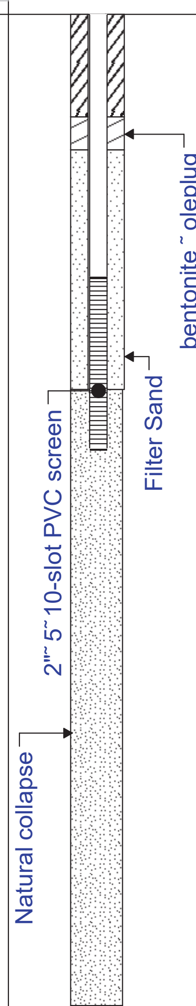
Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 6-13-12
Project Number: 005-12-003	End Date: 6-13-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA	Crew C˜ief: Bob
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 37
Ground Ele˜ation ˜feet˜: 633.4	Easting: 4573.9
Top of Casing Ele˜ation ˜feet˜: 632.94	Nort˜ing: -1642.3
Logged By: Kurt Van Appledorn	
Comments:	

S˜ BS˜ RFACE PROFILE / SAMPLE

Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
35	35.0-41.0˜Yellowis˜ brown fine SAND˜ trace medium and coarse sand˜ ˜ery moist at 35.3˜. Wet at 37˜.	598.4 / 35.0	2	1.5	3-4-5-6	9
40			2	2.0	2-3-3-4	6
41	41.0-55.9˜ Yellowis˜ brown fine SAND˜ wet.	592.4 / 41.0				
45			2	2.0	0-1-1-1	2
50			2	2.0	3-8-12-26	20
54	Dark brown 1/4" seam wit˜ medium and coarse sand just abo˜e clay.	579.4 / 54.0				
55			2	2.0	5-11-21-29	32
56	55.9-61.0˜Brown silty CLAY.	577.5 / 55.9				
58-59			1	0	empty s˜elby	
59-61			2	0	empty s˜elby	
61	End of Boring	572.4 / 61.0				

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



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Log of Borehole: PZ/SB-1215

Project Name:	RCRA Vertical E˜p. Feasibility	Start Date:	8-21-12
Project Number:	005-12-003	End Date:	8-22-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	Driller:	Remedial Ser˜ices Di˜ision
Drilling Met˜od:	8.25" OD HSA/Mud Rotary	Crew C˜ief:	Da˜e Mokma
Sampling Met˜od:	2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜:	43
Ground Ele˜ation ˜feet˜:	631.9	Easting:	6202.4
Top of Casing Ele˜ation ˜feet˜:	631.25	Nort˜ing:	37.0
Logged By:	Kurt Van Appledorn		
Comments:			

S˜ BS˜ RFACE PROFILE

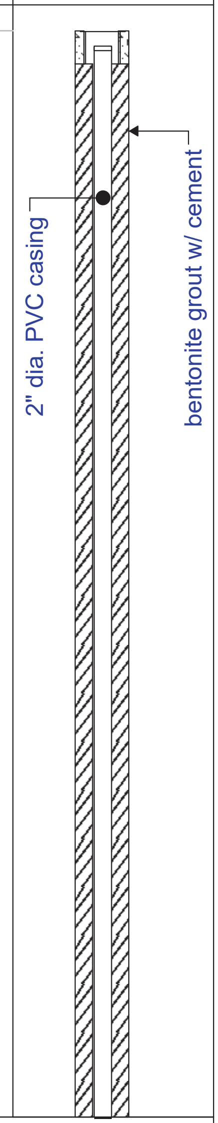
Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜.
0	Ground Surface	633.4 / 0.0
0	0-2.7˜ Gray silty˜ sandy ASH˜ roots in upper 2"˜ trace cinders˜ some seams of dark gray wit˜ some cinders˜ dry.	
2.7	2.7-77.0˜ Brown fine SAND˜ moist.	630.7 / 2.7
12.3	Dark brown silty sand seam	621.1 / 12.3
16.0	Yellowis˜ brown at 16 to 18˜.	617.4 / 16.0
24.0	2" seams of yellowis˜ brown sand wit˜ trace coarse sand between 24 and 25˜.	609.4 / 24.0
29.1	Yellowis˜ brown˜ some medium sand˜ trace coarse sand at 29.1 to 29.4˜.	604.3 / 29.1
30	2" seams wit˜ some medium sand between 30 and 32˜.	

SAMPLE

Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	1.0	0-1-2-2	3
2	1.0	1-2-1-2	3
2	1.0	1-3-4-4	7
2	1.4	2-5-11-11	16
2	1.3	2-6-11-13	17
2	1.5	3-6-9-10	15
2	1.4	2-5-8-9	13
2	1.5	1-3-14-15	17
2	1.4	1-4-14-16	18
2	1.5	1-4-6-7	10
2	1.3	1-3-6-7	9
2	1.4	2-3-5-6	8
2	1.2	2-5-5-6	10
2	1.5	2-3-5-5	8
2	1.4	1-3-3-4	6
2	1.5	2-3-4-5	7

Water Content ˜Percent˜ (10 30 50)

Well Completion Details



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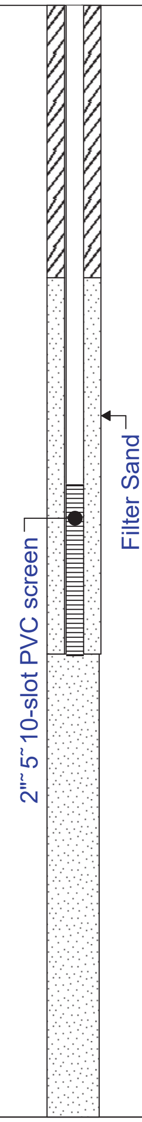
Log of Borehole: PZ/SB-1215

Project Name: RCRA Vertical E˜p. Feasibility	Start Date: 8-21-12
Project Number: 005-12-003	End Date: 8-22-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	Driller: Remedial Ser˜ices Di˜ision
Drilling Met˜od: 8.25" OD HSA/Mud Rotary	Crew C˜ief: Da˜e Mokma
Sampling Met˜od: 2˜ Split Spoon	Dept˜ to Water ˜ft BGS during drilling˜: 43
Ground Ele˜ation ˜feet˜: 631.9	Easting: 6202.4
Top of Casing Ele˜ation ˜feet˜: 631.25	Nort˜ing: 37.0
Logged By: Kurt Van Appledorn	Comments:

S˜BS˜RFACE PROFILE				SAMPLE					
Dept˜ ˜feet BGS˜	Symbol	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	Well Completion Details
35		Lig˜t brown below 35˜	598.4 / 35.0	2	1.3	2-3-4-5	7		
41				2	1.4	1-3-4-5	7		
43		Wet at 43˜	590.4 / 43.0						
45		Little medium sand˜ tracet coarse sand at 45 to 47˜.	588.4 / 45.0	2	0.8	2-4-4-7	8		
48		Switc˜ed to mud rotary							
50		Some medium sand wit˜ 1/2" medium and coarse sand seam at 50.5˜.	583.4 / 50.0	2	1.3	8-11-15-17	26		
55				2	1.7	10-22-30-32	52		
59		3" of ˜ery fine sand at 59.7˜	574.4 / 59.0	2	1.0	13-16-16-20	32		

Depth scale: 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64



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Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜ od: 8.25" OD HSA/Mud Rotary
Sampling Met˜ od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 631.9
Top of Casing Ele˜ation ˜feet˜: 631.25
Logged By: Kurt Van Appledorn
Comments:

Log of Borehole: PZ/SB-1215

Start Date: 8-21-12
End Date: 8-22-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ ief: Da˜e Mokma
Dept˜ to Water ˜ft BGS during drilling˜: 43
Easting: 6202.4
Nort˜ ing: 37.0

S˜ BS˜ RFACE PROFILE				SAMPLE					Well Completion Details
Dept˜ ˜feet BGS˜	Symbol	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	
65				2	1.2	10-15-21-26	36		
70				2	1.5	11-22-22-22	44		
75				2	1.4	13-18-21-31	39		
77		77-79.3˜ Gray silty fine SAND˜ wet.	556.4 77.0						Filter Sand
79.3		79.3-85.0˜ Gray silty CLAY˜ moist.	554.1 79.3						
80				2	1.8	9-10-10-13	20	•	
82				2		S˜ elby			
84				2		S˜ elby			
85		End of Boring	548.4 85.0						

Depth scale: 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

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Log of Borehole: PZ/SB-1216

Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜ od: 8.25" OD HSA
Sampling Met˜ od: 2˜ Split Spoon
Ground Ele˜ation ˜feet˜: 632.3
Top of Casing Ele˜ation ˜feet˜: 631.90
Logged By: Kurt Van Appledorn
Comments:

Start Date: 8-22-12
End Date: 8-23-12
Driller: Remedial Ser˜ices Di˜ision
Crew C˜ ief: Da˜e Mokma
Dept˜ to Water ˜ft BGS during drilling˜: 34
Easting: 4398.8
Nort˜ ing: 132.1

S˜ BS˜ RFACE PROFILE

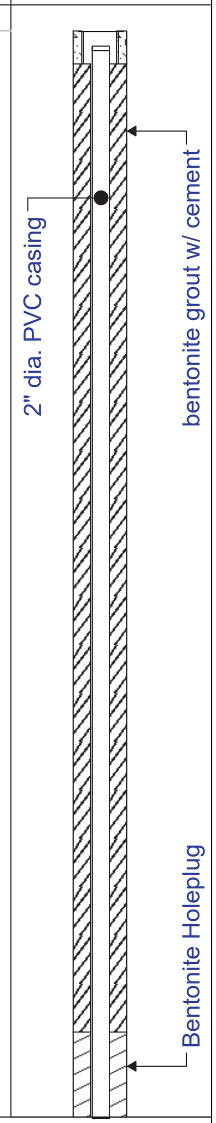
Dept˜ /Ele˜ .	Description
633.4	Ground Surface
0.0	0-0.7˜ Black silty˜ sand si˜e ASH˜ dry.
	0.7-21.1˜ Brown fine SAND˜ slig˜ tly moist˜ dark brown 0.7-1.8˜.
625.4 / 8.0	Dark brown at 8 to 10˜wit˜ 1/2" wood branc˜ at 8.8˜
623.4 / 10.0	Yellowis˜ brown silty fine sand at 10 to 12˜. Wood branc˜ at 11.2˜.
619.4 / 14.0	Yellowis˜ brown at 14 to 14.4˜.
616.9 / 16.5	Dark brown˜ trace silt
612.3 / 21.1	21.1-22.0˜ Dark brown silty fine SAND˜ slig˜ tly moist.
	22.0-65.8˜ Yellowis˜ brown fine SAND˜ slig˜ tly moist.
	Brown below 24˜
607.4 / 26.0	trace medium sand at 26 to 28˜

SAMPLE

Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N
2	2.0	4-6-10-11	16
2	1.4	10-13-17-18	30
2	1.2	4-11-13-13	24
2	1.6	2-5-8-14	13
2	1.7	4-16-26-32	42
2	1.7	2-12-17-17	29
2	1.2	1-2-3-4	5
2	1.7	1-1-2-3	3
2	1.3	0-0-1-2	1
2	1.2	0-1-1-1	2
2	1.4	0-1-1-1	2
2	1.3	1-2-4-4	6
2	1.4	1-2-3-4	5
2	1.3	1-2-3-3	5
2	1.4	2-4-5-5	9

Water Content ˜Percent˜ (10, 30, 50)

Well Completion Details



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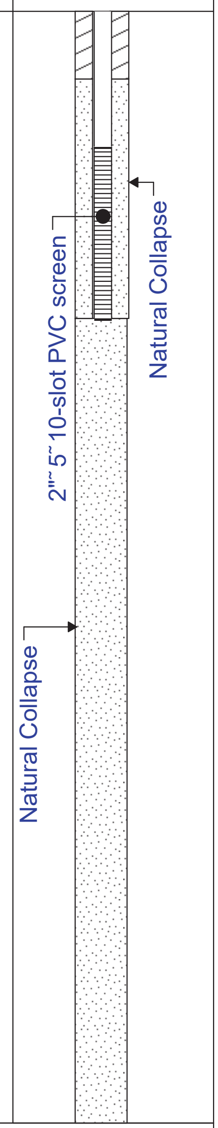
Project Name:	RCRA Vertical E˜p. Feasibility	**Log of Borehole: PZ/SB-1216**	
Project Number:	005-12-003	Start Date:	8-22-12
Site Location:	J.H. Campbell˜ West Oli˜e˜ MI	End Date:	8-23-12
Drilling Met˜od:	8.25" OD HSA	Driller:	Remedial Ser˜ices Di˜ision
Sampling Met˜od:	2˜ Split Spoon	Crew C˜ief:	Da˜e Mokma
Ground Ele˜ation ˜feet˜:	632.3	Dept˜ to Water ˜ft BGS during drilling˜:	34
Top of Casing Ele˜ation ˜feet˜:	631.90	Easting:	4398.8
Logged By:	Kurt Van Appledorn	Nort˜ing:	132.1
Comments:			

S˜BS˜RFACE PROFILE			SAMPLE				Water Content ˜Percent˜ (10 30 50)	Well Completion Details
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N		
33–34	Wet at 34˜	599.4 / 34.0						
35–37	little medium˜ trace coarse sand at 35 to 37˜		2	0.9	2-2-2-3	4		
40–42	trace medium sand at 40 to 47˜	593.4 / 40.0	2	0.6	3-3-6-8	9		
45–47			2	0.3	5-9-19-29	28		
50–52			2	1.4	7-14-26-38	40		
55–57	trace medium and coarse sand	578.4 / 55.0	2	0.7	4-8-16-23	24		
60–62			2	0.4	0-4-7-14	11		



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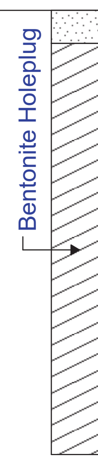
Project Name: RCRA Vertical E˜p. Feasibility
Project Number: 005-12-003
Site Location: J.H. Campbell˜ West Oli˜e˜ MI
Drilling Met˜ od: 8.25" OD HSA
Sampling Met˜ od: 2˜ Split Spoon
Ground Ele˜ ation ˜feet˜: 632.3
Top of Casing Ele˜ ation ˜feet˜: 631.90
Logged By: Kurt Van Appledorn
Comments:

Log of Borehole: PZ/SB-1216

Start Date: 8-22-12
End Date: 8-23-12
Driller: Remedial Ser˜ ices Di˜ ision
Crew C˜ ief: Da˜ e Mokma
Dept˜ to Water ˜ft BGS during drilling˜: 34
Easting: 4398.8
Nort˜ ing: 132.1

S˜ BS˜ RFACE PROFILE			SAMPLE						
Dept˜ ˜feet BGS˜	Description	Dept˜ /Ele˜ .	Sample Lengt˜	Reco˜ ery ˜feet˜	Blow Counts ˜per 6 in˜	N	Water Content ˜Percent˜ (10 30 50)	Well Completion Details
65	Grayis˜ brown	568.4 / 65.0						
66	65.8-77.0˜ Gray silty CLAY˜ slig˜ tly moist.		2	1.1	0-20-45-50+	65		
70–71			1		S˜ elby			
75–77			2		S˜ elby			
77	End of Boring	556.4 / 77.0						



Depth scale: 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

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Phone/Fax: (616) 994-6541
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Project Name: RCRA Vertical E˜p. Feasibility	**Log of Borehole: PZ/SB-1217**
Project Number: 005-12-003	Start Date: 8-23-12
Site Location: J.H. Campbell˜ West Oli˜e˜ MI	End Date: 8-23-12
Drilling Met˜od: 8.25" OD HSA	Driller: Remedial Ser˜ices Di˜ision
Sampling Met˜od: 2˜ Split Spoon	Crew C˜ief: Da˜e Mokma
Ground Ele˜ation ˜feet˜: 626.4	Dept˜ to Water ˜ft BGS during drilling˜:
Top of Casing Ele˜ation ˜feet˜: 629.03	Easting: 2355.5
Logged By: Kurt Van Appledorn	Nort˜ing: -875.9
Comments:	

S˜BS˜RFACE PROFILE

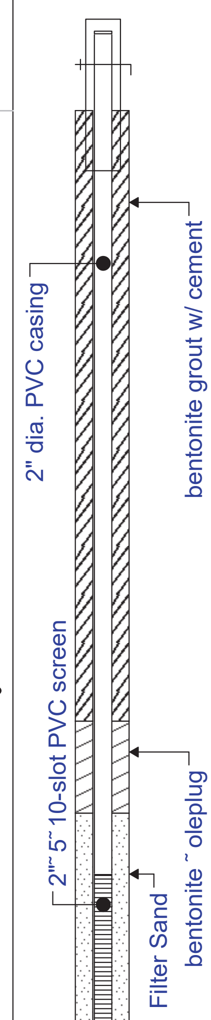
Dept˜ ˜feet BGS˜	Description	Dept˜/Ele˜.
0	Ground Surface	627.3 / 0.0
0	0-0.7˜ Dark gray fine sand si˜e ASH˜ dry	
0.7	0.7-1.2˜ Brownis˜ gray silt si˜e ASH˜ little fine sand si˜e as˜.	
1.2	1.2-3.0˜ Dark gray silt si˜e ASH˜ dry to slig˜tly moist.	624.3 / 3.0
3.0	3.0-4.8˜Dark gray fine sand and sandy silt si˜e ASH˜ slig˜tly moist. Brownis˜ gray at 15-16.9˜.	622.5 / 4.8
4.8	4.8-8.0˜ Dark gray silt si˜e ASH˜ wet.	619.3 / 8.0
8.0	8.0-10.7˜ Dark gray silty fine sand si˜e ASH˜ slig˜tly moist.	616.6 / 10.7
10.7	10.7-11.1˜ Dark gray silt si˜e ASH˜˜ery moist.	615.3 / 12.0
11.1	11.1-12.0˜ Dark gray silty fine sand si˜e ASH˜ slig˜t moist.	
12.0	12.0-16.0˜ Dark brownis˜ gray silt si˜e ASH˜ wet. Slig˜tly moist sand and silt si˜e as˜ seams between 14-14.7˜. Wet˜ soft silt si˜e as˜ at 14.7-15.1˜.	611.3 / 16.0
16.0	16.0-20.0˜ Alternating 1-3" seams of silt si˜e and as˜ si˜e ASH seams˜ slig˜tly moist. Soft˜ wet silt si˜e at 18.1-18.4˜and a 1" seam at 18.7˜.	607.3 / 20.0
20.0	20-23.3˜ Dark gray sandy silty si˜e ASH˜ wet.	604.0 / 23.3
23.3	23.3-30.0˜ Brown fine SAND˜ wet.	597.3 / 30.0
30.0	End of Boring	

SAMPLE

Depth (feet BGS)	Sample Lengt˜	Reco˜ery ˜feet˜	Blow Counts ˜per 6 in˜	N
0-2	2	2.0	3-5-5-6	10
5-7	2	1.8	1-3-2-1	5
10-12	2	1.5	2-1-1-1	2
12-14	2	1.2	1-1-1-1	2
14-16	2	1.1	0-1-0-1	1
16-18	2	1.4	2-1-1-1	2
18-20	2	1.3	0-1-0-0	1
20-22	2	2.0	0-1-0-1	1
22-24	2	1.7	0-0-2-3	2
28-30	2	0.9	1-2-3-4	5

Water Content ˜Percent˜ (10 30 50)

Well Completion Details



Sheet: 1 of 1

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY

LOG OF BORING NUMBER: SB-102

PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION

ARCHITECT-ENGINEER

SITE LOCATION: WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 625.7 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
	1	SS	Sandy topsoil, trace silt, roots and organics - dark brown - medium dense - moist. (SP)		15
	1A	SS	Fine sand, little coal fragments, trace silt, roots and medium sand - brown - dense to very dense - moist. (FILL-SP)		29
		PA			
	2	SS*		110	56
5.0		PA			
	3	SS	Fine sand, little coal fragments, trace silt, brown - extremely dense - moist. (FILL-SP)		84
		RB			
	4	SS*		105	83
10.0		RB			
	5	SS	Fine sand, little coal fragments, trace silt - brown - dense to very dense - moist to saturated (FILL-SP)		44
		RB			
	6	SS*		100	33
15.0		RB			
	7	SS			67
		RB			
	8	SS*		108	69
20.0		RB			
	9	SS	Fine to medium sand, trace silt - brown - very dense - saturated. (FILL-SP)		58
		RB			
25.0			Fine to medium sand, trace silt - brown - medium dense to dense - saturated. (SP)		
	10	SS*		104	20
		RB			
30.0					
	11	SS			31
		RB			
35.0					
	12	SS*		102	24
		RB			
40.0					

... continued

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

STS JOB NO. 72150A   SHEET NO. 1 OF 2

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER: SB-102
PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION	ARCHITECT-ENGINEER
SITE LOCATION: WEST OLIVE, MICHIGAN	

SURFACE ELEVATION 625.7 ft

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} (1, 2, 3, 4, 5)
PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % (10, 20, 30, 40, 50)
STANDARD PENETRATION BLOWS/FT. (10, 20, 30, 40, 50)

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
			Continued from previous page		
40.0	13	SS	Fine to medium sand, trace silt - brown - very dense to extremely dense - saturated. (SP)		52
		RB			
45.0	14	SS*		111	81
		RB			
50.0	15	SS	Fine to medium sand, trace silt - brown - dense - saturated. (SP)		31
		RB			
		RB	Clayey silt, trace fine sand - gray - very dense - saturated. (ML)		
55.0	16	SS*		114	51
		RB			
		RB	Silty clay - gray - stiff to very stiff. (CL)		
60.0	17	SS			17
		RB			
65.0	18	ST		111	
		RB			
		RB	Silty clay, trace silt, gravel and sand - gray - very stiff. (CL)		
70.0	19	ST		117	
		RB			
75.0	20	ST	Fine sand, trace silt - gray - extremely dense - saturated. (SP)		
76.5	21	ST		123	102/6"

END OF BORING : Boring advanced with solid stem augers and washed rotary drilling techniques. Boring backfilled with bentonite chips.

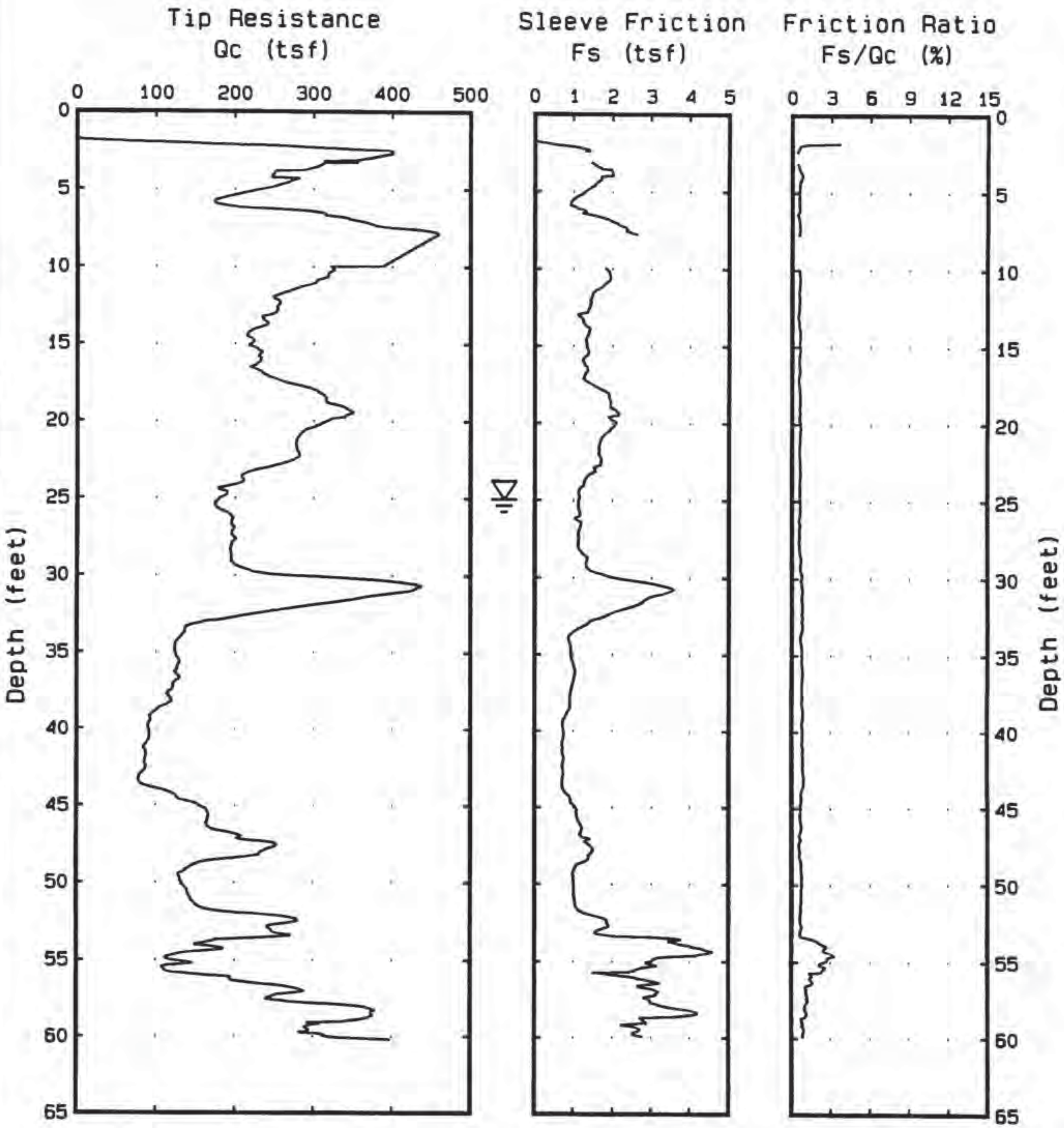
Note: SS* indicates sample collected with plastic liner in split spoon.

* Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 20.0 ft — WS OR WD: WS	BORING STARTED 06/18/92	STS OFFICE Lansing-07	
WL — BCR — ACR	BORING COMPLETED 06/18/92	ENTERED BY DAP	SHEET NO. 2 OF 2
WL 17.0 ft @ 16 hr AB	RIG/FOREMAN DIR-1/BP	APP'D BY JSM	STS JOB NO. 72150A

STS Consultants, Ltd



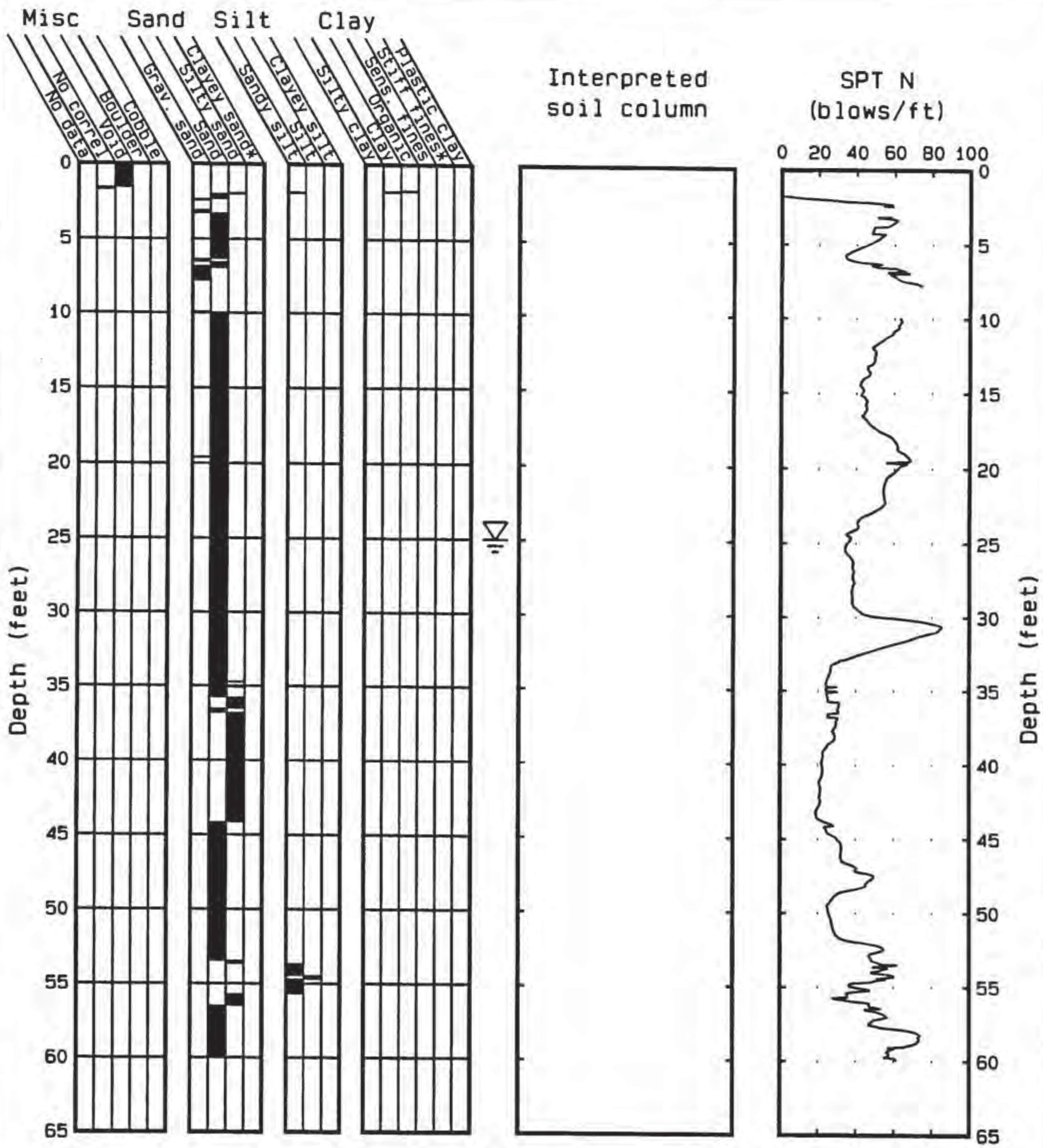
Max depth = 60.2 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER TEST DATA

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP103A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I30-H10
Site:	CREST OF DIKE, LOCATION SB-103	Sounding:	CPT-103A (RE
Date:	06-11-1992 17:24	Proj. no:	72150-A

STS Consultants, Ltd



Max depth = 60.2 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER SOIL STRATIGRAPHY

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP103A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I30-H10
Site:	CREST OF DIKE, LOCATION SB-103	Sounding:	CPT-103A (RE
Date:	06-11-1992 17:24	Proj. no:	72150-A

STS Consultants, Ltd

Database filename: CAMP103A.CPT
Client: CONSUMERS POWER COMPANY
Project name: CAMPBELL ASH STORAGE
Project number: 72150-A
Site: CREST OF DIKE, LOCATION SB-103
Sounding number: CPT-103A (RE)
Test date: 06-11-1992 17:24
Cone ID: I30-H10
Water table: 25 FT (ASSUMED)
Soil unit weight: 120 PCF (ASSUMED)
Test engineer: DEON, D.A.D.
Dissipation: NONE
Comment: HOLE PRE-DRILLED TO 2 FT
Comment: HOLE ENDED AT REQUIRED DEPTH OF 60.1 FT
Comment:
Comment:
Comment:

STANDARD CONE PENETROMETER ANALYSIS REPORT

Depth ...... Depth to tip of cone
Tip .... Tip resistance
Sleeve ..... Local sleeve friction
Incl .... Deviation from vertical
ore .... Induced dynamic pore pressure (zero for standard cone)
Ratio ...... Friction ratio (Sleeve / Tip) * 100%
Mat. type .. Soil classification (Robertson & Campanella, 1983)
SPT N ...... Standard Penetration Test N value (Robertson 1985)
SPT N1 ..... N value corrected for overburden (Marcuson & Bieganousky, 1977)
Sigv' ...... Effective vertical overburden
Phi .... Drained friction angle for sands (Robertson & Campanella, 1983)
Dr .... Relative density of sands (Baldi 1982)
Su .... Undrained shear strength of clays (Tip - Sigvtot) / Nk (Nk = cone factor) (R & C, 83)

All values are averaged and reported at an interval of .5 feet

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
0.25	22.8	0.00	2.1	0.00	0.0	Silty sand to sandy silt	7	13	0.02	--	51	1.34
0.75	0.0	0.00	1.7	0.00	---	Void	0	0	0.04	--	--	----
1.25	0.0	0.00	1.3	0.00	---	Void	0	0	0.07	--	--	----
1.75	15.7	0.16	1.0	0.00	1.0	Sandy silt to clayey silt	6	11	0.11	43	43	0.92
2.25	259.5	1.22	0.9	0.00	0.5	Sand	51	91	0.13	> 48	> 90	----
3.25	327.2	1.57	1.1	0.00	0.5	Gravelly sand to sand	53	96	0.19	> 48	> 90	----
3.75	280.5	1.96	1.1	0.00	0.7	Sand	55	99	0.22	> 48	> 90	----
4.25	261.7	1.66	1.1	0.00	0.6	Sand	51	92	0.25	> 48	> 90	----

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Database filename: CAMP103A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
4.75	253.8	1.44	1.1	0.00	0.6	Sand	50	89	0.29	> 48	> 90	----
5.25	211.7	1.15	1.1	0.00	0.5	Sand	41	74	0.31	> 48	> 90	----
5.75	177.8	0.96	1.1	0.00	0.5	Sand	35	62	0.34	48	> 90	----
6.25	239.9	1.23	1.1	0.00	0.5	Sand	47	81	0.38	> 48	> 90	----
6.75	332.1	1.82	1.1	0.00	0.5	Sand	65	105	0.40	> 48	> 90	----
7.25	376.6	2.27	1.2	0.00	0.6	Gravelly sand to sand	61	95	0.44	> 48	> 90	----
7.75	437.9	2.47	1.2	0.00	0.6	Gravelly sand to sand	71	106	0.46	> 48	> 90	----
9.75	388.1	1.81	1.8	0.00	0.5	Gravelly sand to sand	63	84	0.58	> 48	> 90	----
10.25	323.1	1.91	1.9	0.00	0.6	Sand	63	82	0.61	48	> 90	----
10.75	311.3	1.89	2.0	0.00	0.6	Sand	61	77	0.64	48	> 90	----
11.25	288.4	1.66	2.1	0.00	0.6	Sand	56	70	0.68	47	> 90	----
11.75	259.5	1.47	2.3	0.00	0.6	Sand	51	61	0.70	47	> 90	----
12.25	255.0	1.43	2.3	0.00	0.6	Sand	50	59	0.73	46	> 90	----
12.75	253.4	1.32	2.5	0.00	0.5	Sand	49	57	0.76	46	> 90	----
13.25	239.5	1.21	2.6	0.00	0.5	Sand	47	53	0.80	46	> 90	----
13.75	238.6	1.35	2.7	0.00	0.6	Sand	47	52	0.82	46	> 90	----
14.25	219.4	1.37	2.9	0.00	0.6	Sand	43	47	0.85	45	> 90	----
14.75	221.6	1.33	3.0	0.00	0.6	Sand	43	47	0.89	45	> 90	----
15.25	225.0	1.36	3.1	0.00	0.6	Sand	44	47	0.92	45	> 90	----
15.75	232.3	1.29	3.2	0.00	0.6	Sand	45	47	0.94	45	> 90	----
16.25	229.0	1.30	3.4	0.00	0.6	Sand	45	46	0.97	45	> 90	----
16.75	229.7	1.32	3.6	0.00	0.6	Sand	45	45	1.00	45	> 90	----
17.25	251.4	1.33	3.8	0.00	0.5	Sand	49	49	1.04	45	> 90	----
17.75	285.3	1.66	4.0	0.00	0.6	Sand	56	55	1.06	45	> 90	----
18.25	310.0	1.90	4.2	0.00	0.6	Sand	61	59	1.10	45	> 90	----
18.75	320.7	1.95	4.4	0.00	0.6	Sand	63	61	1.13	46	> 90	----
19.25	345.3	2.11	4.6	0.00	0.6	Sand	67	64	1.15	46	> 90	----
19.75	333.1	1.99	4.7	0.00	0.6	Sand	65	62	1.19	45	> 90	----
20.25	306.3	2.01	4.8	0.00	0.7	Sand	60	56	1.22	45	> 90	----
20.75	285.8	1.80	4.9	0.00	0.6	Sand	56	52	1.24	45	> 90	----
21.25	278.5	1.67	5.0	0.00	0.6	Sand	54	50	1.27	44	> 90	----
21.75	278.8	1.65	5.1	0.00	0.6	Sand	54	49	1.30	44	> 90	----
22.25	280.2	1.69	5.2	0.00	0.6	Sand	55	49	1.33	44	> 90	----
22.75	258.7	1.62	5.4	0.00	0.6	Sand	51	45	1.37	44	89	----
23.25	221.3	1.45	5.6	0.00	0.7	Sand	43	38	1.39	43	82	----
23.75	209.3	1.28	5.7	0.00	0.6	Sand	41	35	1.42	43	80	----
24.25	189.3	1.18	5.7	0.00	0.6	Sand	37	32	1.46	42	75	----
24.75	186.8	1.14	5.9	0.00	0.6	Sand	36	31	1.48	42	74	----
25.25	175.9	1.13	6.0	0.00	0.6	Sand	34	29	1.51	42	71	----
25.75	182.1	1.15	6.1	0.00	0.6	Sand	36	30	1.52	42	72	----
26.25	195.1	1.13	6.2	0.00	0.6	Sand	38	32	1.54	42	75	----
26.75	196.6	1.17	6.4	0.00	0.6	Sand	38	32	1.55	42	75	----
27.25	196.2	1.13	6.5	0.00	0.6	Sand	38	32	1.56	42	74	----
27.75	197.8	1.13	6.7	0.00	0.6	Sand	39	32	1.58	42	75	----
28.25	193.8	1.18	6.8	0.00	0.6	Sand	38	31	1.59	42	73	----
28.75	194.6	1.33	6.9	0.00	0.7	Sand	38	31	1.61	42	73	----

Depth (ft) | Tip (tsf) | Sleeve (tsf) | Incl (deg) | Pore (tsf) | Ratio (%) | Material Type | SPT N (bpf) | SPT N1 (bpf) | Sigv' (tsf) | Phi (deg) | Dr (%) | Su (tsf)

Database filename: CAMP103A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
29.25	199.7	1.34	7.0	0.00	0.7	Sand	39	32	1.62	42	74	----
29.75	226.3	1.69	7.2	0.00	0.7	Sand	44	36	1.64	42	80	----
30.25	359.7	2.67	7.3	0.00	0.7	Sand	70	56	1.65	44	> 90	----
30.75	431.7	3.49	7.4	0.00	0.8	Sand	84	67	1.67	45	> 90	----
31.25	388.3	3.05	7.5	0.00	0.8	Sand	76	60	1.68	45	> 90	----
31.75	319.3	2.60	7.6	0.00	0.8	Sand	62	49	1.69	44	> 90	----
32.25	253.5	2.03	7.7	0.00	0.8	Sand	50	39	1.71	43	83	----
32.75	194.1	1.54	7.8	0.00	0.8	Sand	38	30	1.72	41	72	----
33.25	143.5	1.17	7.9	0.00	0.8	Sand	28	22	1.74	40	59	----
33.75	134.4	0.91	8.1	0.00	0.7	Sand	26	20	1.75	40	55	----
34.25	126.6	0.91	8.2	0.00	0.7	Sand	25	19	1.77	39	53	----
34.75	123.8	0.94	8.4	0.00	0.8	Sand	24	19	1.78	39	51	----
35.25	125.7	0.96	8.5	0.00	0.8	Sand	25	19	1.80	39	52	----
35.75	128.1	1.02	8.6	0.00	0.8	Sand to silty sand	31	24	1.81	39	52	----
36.25	125.2	1.04	8.7	0.00	0.8	Sand to silty sand	31	23	1.82	39	51	----
36.75	126.9	1.00	8.9	0.00	0.8	Sand to silty sand	31	24	1.84	39	51	----
37.25	120.3	0.94	9.0	0.00	0.8	Sand to silty sand	29	22	1.85	39	49	----
37.75	115.3	0.92	9.2	0.00	0.8	Sand to silty sand	28	21	1.87	39	47	----
38.25	116.6	0.92	9.3	0.00	0.8	Sand to silty sand	28	21	1.88	39	47	----
38.75	101.7	0.86	9.4	0.00	0.8	Sand to silty sand	25	19	1.90	38	42	----
39.25	93.2	0.76	9.6	0.00	0.8	Sand to silty sand	23	17	1.91	37	< 40	----
39.75	90.6	0.73	9.7	0.00	0.8	Sand to silty sand	22	16	1.92	37	< 40	----
40.25	91.6	0.75	9.9	0.00	0.8	Sand to silty sand	22	16	1.94	37	< 40	----
40.75	90.1	0.72	10.0	0.00	0.8	Sand to silty sand	22	16	1.95	37	< 40	----
41.25	85.4	0.72	10.1	0.00	0.8	Sand to silty sand	21	15	1.97	37	< 40	----
41.75	86.9	0.75	10.3	0.00	0.9	Sand to silty sand	21	15	1.98	37	< 40	----
42.25	86.2	0.73	10.4	0.00	0.8	Sand to silty sand	21	15	2.00	37	< 40	----
42.75	84.4	0.74	10.5	0.00	0.9	Sand to silty sand	21	15	2.01	37	< 40	----
43.25	78.6	0.72	10.6	0.00	0.9	Sand to silty sand	19	14	2.03	36	< 40	----
43.75	91.1	0.74	10.8	0.00	0.8	Sand to silty sand	22	16	2.04	37	< 40	----
44.25	120.5	0.88	10.9	0.00	0.7	Sand	24	17	2.05	38	46	----
44.75	140.2	0.98	11.1	0.00	0.7	Sand	27	19	2.07	39	52	----
45.25	161.4	1.08	11.2	0.00	0.7	Sand	32	22	2.08	40	58	----
45.75	165.5	1.11	11.4	0.00	0.7	Sand	32	23	2.10	40	59	----
46.25	164.9	1.20	11.5	0.00	0.7	Sand	32	23	2.11	40	59	----
46.75	190.6	1.19	11.7	0.00	0.6	Sand	37	26	2.13	40	65	----
47.25	221.3	1.36	11.8	0.00	0.6	Sand	43	30	2.14	41	71	----
47.75	244.0	1.48	12.0	0.00	0.6	Sand	48	33	2.15	41	75	----
48.25	218.7	1.38	12.1	0.00	0.6	Sand	43	30	2.17	41	70	----
48.75	156.2	1.13	12.2	0.00	0.7	Sand	31	21	2.18	39	55	----
49.25	135.3	1.00	12.3	0.00	0.7	Sand	26	18	2.20	39	49	----
49.75	129.8	1.00	12.5	0.00	0.8	Sand	25	17	2.21	38	47	----
50.25	135.7	1.01	12.6	0.00	0.7	Sand	27	18	2.23	39	49	----
50.75	140.9	1.02	12.7	0.00	0.7	Sand	28	19	2.24	39	50	----
51.25	146.8	1.05	12.8	0.00	0.7	Sand	29	20	2.26	39	52	----
51.75	171.9	1.20	13.0	0.00	0.7	Sand	34	23	2.27	40	59	----

Depth ft) | Tip (tsf) | Sleeve (tsf) | Incl (deg) | Pore (tsf) | Ratio (%) | Material Type | SPT N (bpf) | SPT N1 (bpf) | Sigv' (tsf) | Phi (deg) | Dr (%) | Su (tsf)

Database filename: CAMP103A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
52.25	260.5	1.73	13.1	0.00	0.7	Sand	51	34	2.28	42	77	----
52.75	252.7	1.81	13.2	0.00	0.7	Sand	49	33	2.30	41	75	----
53.25	255.7	1.90	13.3	0.00	0.7	Sand	50	34	2.31	41	76	----
53.75	187.9	3.69	13.4	0.00	2.0	Sand to silty sand	46	31	2.33	40	62	----
54.25	166.8	4.37	13.6	0.00	2.6	Silty sand to sandy silt	54	36	2.34	39	56	9.62
54.75	119.4	3.48	13.8	0.00	2.9	Sandy silt to clayey silt	47	31	2.36	38	42	6.83
55.25	125.4	2.93	14.1	0.00	2.3	Silty sand to sandy silt	41	27	2.37	38	44	7.18
55.75	120.8	2.14	14.2	0.00	1.8	Silty sand to sandy silt	39	26	2.39	38	43	6.91
56.25	194.2	2.87	14.4	0.00	1.5	Sand to silty sand	47	31	2.40	40	62	----
56.75	265.9	2.94	14.6	0.00	1.1	Sand	52	34	2.41	41	76	----
57.25	260.4	3.01	14.8	0.00	1.2	Sand	51	33	2.43	41	75	----
57.75	289.2	3.11	15.0	0.00	1.1	Sand	56	37	2.44	42	80	----
58.25	373.0	4.00	15.2	0.00	1.1	Sand	73	48	2.46	43	> 90	----
58.75	365.3	3.06	15.4	0.00	0.8	Sand	71	47	2.47	43	> 90	----
59.25	299.9	2.59	15.6	0.00	0.9	Sand	59	38	2.49	42	81	----
59.72	298.7	2.62	15.8	0.00	0.9	Sand	58	38	2.50	42	81	----
Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Maximum test depth = 59.94 feet

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER SB-104
PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION	ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % × — WATER CONTENT % ● — LIQUID LIMIT % △ 10 20 30 40 50

⊗ STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

DEPTH (FT) | ELEVATION (FT) | SAMPLE NO. | SAMPLE TYPE | SAMPLE DISTANCE | RECOVERY | DESCRIPTION OF MATERIAL | UNIT DRY WT. LBS./FT.^{3}

SURFACE ELEVATION 633.1 ft

Depth (ft)	Sample No.	Sample Type	Unit Dry Wt. (lbs/ft³)	Standard Penetration (blows/ft)
	1	SS		20
		PA		
	2	SS*	101	38
5.0		PA		
	3	SS		33
		PA		
	4	SS*	104	21
10.0		PA		
	5	SS		20
		PA		
	6	SS*	105	13
15.0		PA		
	7	SS		18
	7A	SS		33
		PA		
	8	SS*	106	32
20.0		PA		
	9	SS		35
		RB		
25.0				
	10	SS*	111	41
		RB		
30.0		RB		
	11	SS		14
		RB		
35.0				
	12	SS*	110	13
		RB		
40.0				

Sandy fill, trace coal fragments - black - medium dense - desicated. (FILL - FLY ASH)

Fine sand fill, trace silt and medium sand - brown - medium dense to dense - moist. (FILL-SP)

Sandy topsoil, trace silt, roots and organics - dark brown - medium dense - moist. (FILL-SP)

Fine sand, trace silt roots and medium sand - brown - dense - moist to saturated. (FILL-SP)

Note: Black wood cuttings noted between 25 to 29 ft. depth.

Fine to medium sand, trace silt - brown - medium dense to dense - saturated. (SP)

.... continued

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

STS JOB NO. 72150A | SHEET NO. 1 OF 2

STS Consultants Ltd.

CLIENT	LOG OF BORING NUMBER
CONSUMERS POWER COMPANY	SB-104
PROJECT NAME	ARCHITECT-ENGINEER
CAMPBELL ASH STORAGE FACILITY EXPANSION	

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 633.1 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
			Continued from previous page		
40.0	13	SS	Fine to medium sand, trace silt - brown - medium dense to dense - saturated. (SP)		16
		RB			
45.0	14	SS*		106	31
		RB			
50.0	15	SS			34
52.0					

END OF BORING

Boring advanced with solid stem augers and washed rotary drilling techniques.
Boring backfilled with bentonite chips.

Note: SS* indicates sample collected with plastic liner in split spoon.

Note: 50% water loss between 25 and 50 ft depth.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 26.5 ft	WS OR WD WS	BORING STARTED 06/16/92	STS OFFICE Lansing-07	
WL BCR	ACR 7.0 ft	BORING COMPLETED 06/16/92	ENTERED BY DAP	SHEET NO. 2 OF 2
WL		RIG/FOREMAN DIR-1/BP	APP'D BY JSM	STS JOB NO. 72150A

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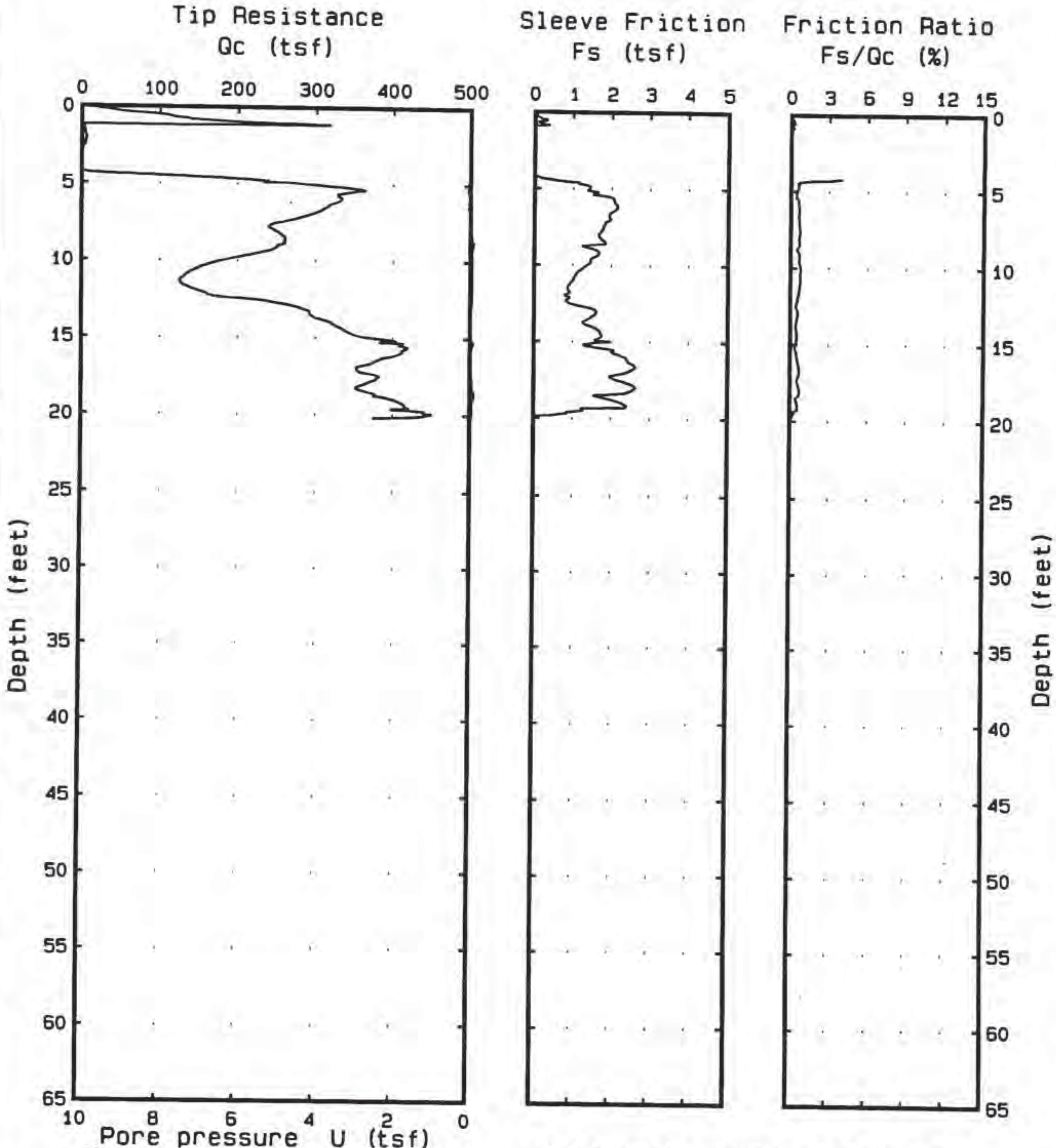


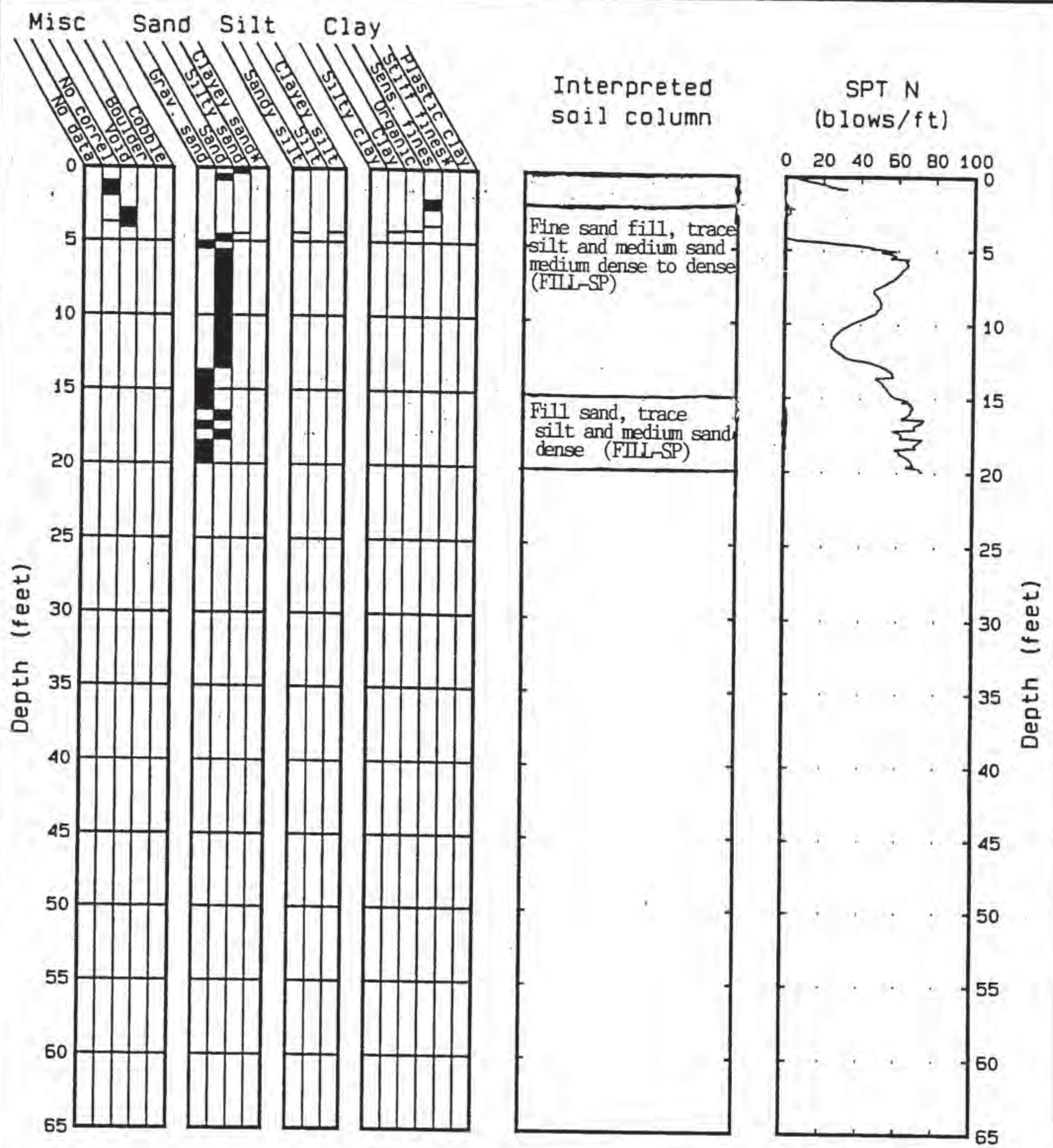
Max depth = 20.21 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER TEST DATA

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP104A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I26-P15
Site:	CREST OF DIKE, LOCATION SB-104 A	Sounding:	CPTU-104A
Date:	06-11-1992 12:47	Proj. no:	72150-A

STS Consultants, Ltd



Max depth = 20.21 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER SOIL STRATIGRAPHY

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP104A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I26-P15
Site:	CREST OF DIKE, LOCATION SB-104 A	Sounding:	CPTU-104A
Date:	06-11-1992 12:47	Proj. no:	72150-A

STS Consultants, Ltd

Database filename: CAMP104A.CPT
Client: CONSUMERS POWER COMPANY
Project name: CAMPBELL ASH STORAGE
Project number: 72150-A
Site: CREST OF DIKE, LOCATION SB-104A
Sounding number: CPTU-104A
Test date: 06-11-1992 12:47
Cone ID: I26-P15
Water table: NONE
Soil unit weight: 120 PCF (ASSUMED)
Test engineer: T.K., D.T.
Dissipation: NONE
Comment: OFFSET 20 FT NORTH OF SB-104
Comment: HOLE PRE-DRILLED FROM 1 TO 5 FT
Comment: REFUSAL AT 20.2 FT DUE TO EXCESSIVE TIP LOAD
Comment:
Comment:

STANDARD CONE PENETROMETER ANALYSIS REPORT

Depth ...... Depth to tip of cone
Tip .... Tip resistance
Sleeve ..... Local sleeve friction
Incl .... Deviation from vertical
Pore .... Induced dynamic pore pressure (zero for standard cone)
Ratio ...... Friction ratio (Sleeve / Tip) * 100%
Mat. type .. Soil classification (Robertson & Campanella, 1983)
SPT N ...... Standard Penetration Test N value (Robertson 1985)
SPT N1 ..... N value corrected for overburden (Marcuson & Bieganousky, 1977)
Sigv' ...... Effective vertical overburden
Phi .... Drained friction angle for sands (Robertson & Campanella, 1983)
Dr .... Relative density of sands (Baldi 1982)
Su .... Undrained shear strength of clays (Tip - Sigvtot) / Nk (Nk = cone factor) (R & C, 83)

All values are averaged and reported at an interval of .5 feet

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
0.25	59.1	0.07	0.7	0.00	0.1	Sand to silty sand	14	26	0.02	> 48	72	----
0.75	148.0	0.18	1.3	0.00	0.1	Sand	29	52	0.04	> 48	> 90	----
1.25	87.0	-0.01	0.9	0.00	-0.0	-- No soil correlation --	--	--	0.07	--	--	----
1.75	5.0	-0.01	0.3	0.00	-0.2	-- No soil correlation --	--	--	0.11	--	--	----
2.25	5.5	0.00	0.3	0.00	0.0	Sensitive fine grained	3	5	0.13	--	--	0.36
2.75	1.3	0.00	0.3	0.00	0.0	Sensitive fine grained	1	1	0.16	--	--	0.08
3.25	0.0	0.00	0.3	0.00	---	Void	0	0	0.19	--	--	----
3.75	0.3	-0.01	0.5	0.00	-2.0	Void	0	0	0.22	--	--	----

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Database filename: CAMP104A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
4.25	18.9	0.15	0.7	0.00	0.8	Sandy silt to clayey silt	7	13	0.25	40	40	1.10
4.75	218.9	1.26	1.2	0.01	0.6	Sand	43	77	0.29	> 48	> 90	----
5.25	338.2	1.55	1.3	0.04	0.5	Gravelly sand to sand	55	99	0.31	> 48	> 90	----
5.75	332.7	2.05	1.4	0.01	0.6	Sand	65	117	0.34	> 48	> 90	----
6.25	321.8	2.12	1.4	0.02	0.7	Sand	63	109	0.38	> 48	> 90	----
6.75	303.0	1.96	1.5	0.00	0.6	Sand	59	96	0.40	> 48	> 90	----
7.25	272.9	1.86	1.5	0.00	0.7	Sand	53	83	0.44	> 48	> 90	----
7.75	243.6	1.74	1.5	0.00	0.7	Sand	48	71	0.46	48	> 90	----
8.25	254.6	1.73	1.5	-0.02	0.7	Sand	50	71	0.50	48	> 90	----
8.75	258.8	1.54	1.6	-0.07	0.6	Sand	51	70	0.53	48	> 90	----
9.25	242.9	1.65	1.6	-0.05	0.7	Sand	47	64	0.56	47	> 90	----
9.75	201.9	1.46	1.7	-0.05	0.7	Sand	39	52	0.58	46	> 90	----
10.25	160.9	1.22	1.6	-0.05	0.8	Sand	31	41	0.61	45	85	----
10.75	137.8	1.05	1.6	-0.05	0.8	Sand	27	34	0.64	44	79	----
11.25	127.0	0.92	1.6	-0.05	0.7	Sand	25	31	0.68	44	75	----
11.75	137.5	0.87	1.6	-0.05	0.6	Sand	27	33	0.70	44	77	----
12.25	170.3	0.86	1.6	-0.05	0.5	Sand	33	39	0.73	45	84	----
12.75	251.9	1.33	1.7	-0.03	0.5	Sand	49	57	0.76	46	> 90	----
13.25	288.2	1.55	1.7	0.00	0.5	Sand	56	64	0.80	47	> 90	----
13.75	304.3	1.35	1.7	0.00	0.4	Gravelly sand to sand	50	55	0.82	47	> 90	----
14.25	327.3	1.64	1.7	0.00	0.5	Gravelly sand to sand	53	59	0.85	47	> 90	----
14.75	347.4	1.69	1.7	0.00	0.5	Gravelly sand to sand	57	61	0.89	47	> 90	----
15.25	397.6	1.59	1.7	-0.04	0.4	Gravelly sand to sand	65	69	0.92	47	> 90	----
15.75	414.5	2.12	1.7	-0.01	0.5	Gravelly sand to sand	67	71	0.94	47	> 90	----
16.25	394.4	2.44	1.7	0.00	0.6	Gravelly sand to sand	64	66	0.97	47	> 90	----
16.75	363.4	2.56	1.6	0.00	0.7	Sand	71	72	1.00	47	> 90	----
17.25	364.0	2.09	1.7	0.00	0.6	Gravelly sand to sand	59	59	1.04	46	> 90	----
17.75	373.9	2.45	1.7	-0.04	0.7	Sand	73	72	1.06	46	> 90	----
18.25	355.9	2.42	1.7	-0.06	0.7	Sand	70	68	1.10	46	> 90	----
18.75	379.2	1.89	1.7	-0.10	0.5	Gravelly sand to sand	62	60	1.13	46	> 90	----
19.25	410.8	1.95	1.7	-0.05	0.5	Gravelly sand to sand	67	64	1.15	46	> 90	----
19.72	430.4	0.56	1.7	-0.05	0.1	Gravelly sand to sand	70	66	1.18	47	> 90	----
Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Maximum test depth = 19.95 feet

STS Consultants Ltd.

CLIENT	CONSUMERS POWER COMPANY
PROJECT NAME	CAMPBELL ASH STORAGE FACILITY EXPANSION
LOG OF BORING NUMBER	SB-105
ARCHITECT-ENGINEER	
SITE LOCATION	WEST OLIVE, MICHIGAN

SURFACE ELEVATION 632.6 ft

Legend: UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} (1, 2, 3, 4, 5); PLASTIC LIMIT % ×, WATER CONTENT % ●, LIQUID LIMIT % △ (10, 20, 30, 40, 50); ⊗ STANDARD PENETRATION BLOWS/FT. (10, 20, 30, 40, 50)

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
	1	SS	Sandy fill, trace silt - black - loose - desicated. (FILL - FLY ASH)		6
	1A	SS	Fine sand, trace silt - brown - medium dense - moist to saturated. (FILL-SP)		14
		RB			
	2	SS*		104	16
5.0		RB			
	3	SS			17
		RB			
	4	SS*		105	26
10.0		RB			
	5	SS			27
		RB			
	6	SS*	Fine sand, trace silt - brown - dense to very dense - moist to saturated. (FILL-SP)	107	79
15.0		RB			
	7	SS			43
		RB			
	8	SS*		105	40
20.0		RB			
	9	SS			54
		RB			
		RB	Fine sand, trace medium sand, silt and roots - brown - medium dense to dense - moist to saturated. (SP)		
25.0	10	SS*		104	31
		RB			
30.0	11	SS			31
		RB			
35.0	12	SS*		103	48
		RB			
		RB	Fine to medium sand, trace silt - brown - medium dense - saturated. (SP)		
40.0					

... continued

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

STS JOB NO. 72150A | SHEET NO. 1 OF 2

STS Consultants Ltd.

CLIENT	CONSUMERS POWER COMPANY
LOG OF BORING NUMBER	SB-105
PROJECT NAME	CAMPBELL ASH STORAGE FACILITY EXPANSION
ARCHITECT-ENGINEER	
SITE LOCATION	WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 632.6 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION
			Continued from previous page		
40.0	13	SS	Fine to medium sand, trace silt - brown - medium dense - saturated. (SP)		22
		RB			
45.0	14	SS*	Fine to medium sand, trace silt - brown - extremely dense - saturated. (SP)	112	87
		RB			
50.0	15	SS			89
52.0					

END OF BORING

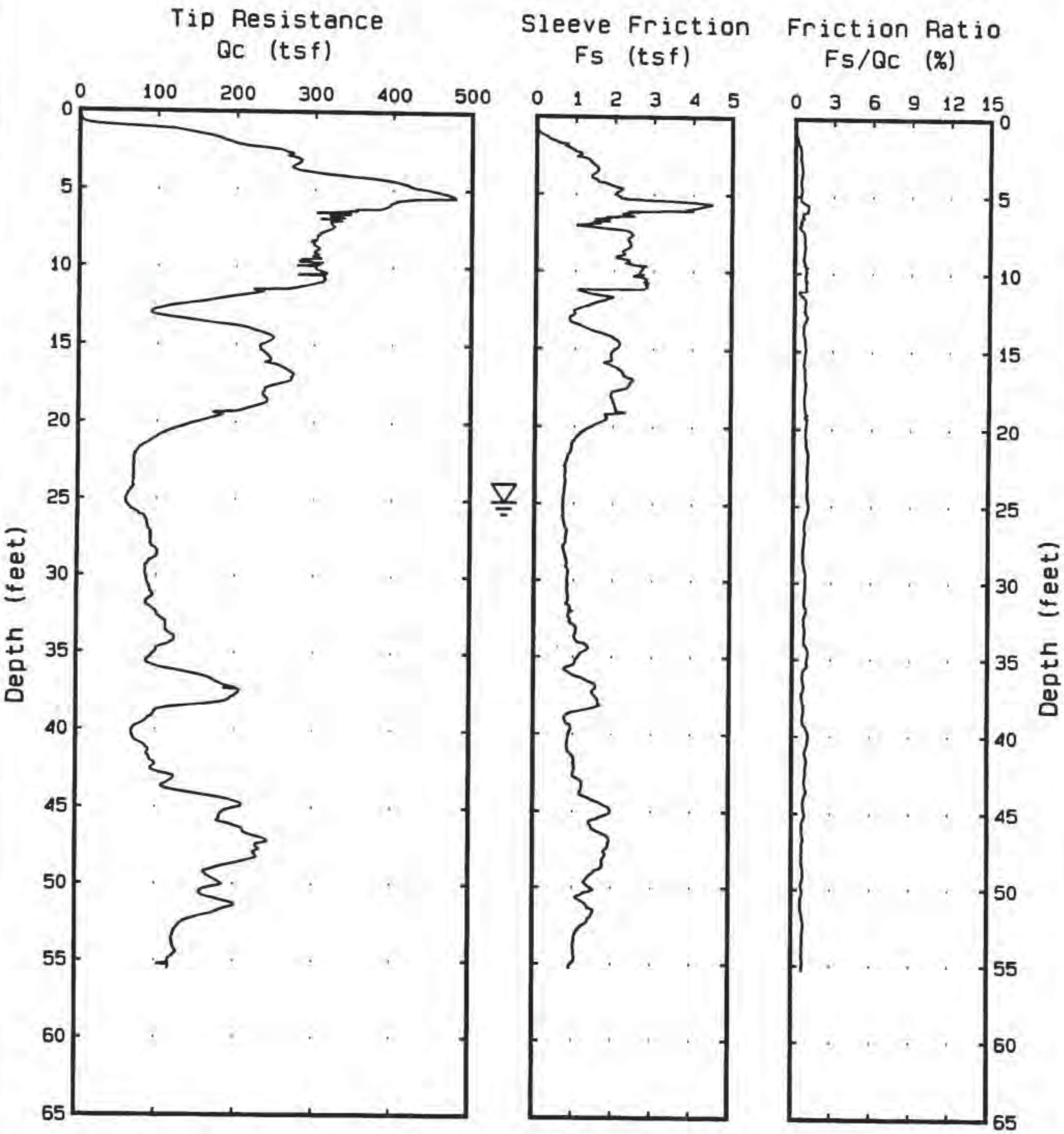
Boring advanced with washed rotary drilling techniques.
Boring backfilled with bentonite chips.

Note: SS* indicates sample collected with plastic liner in split spoon.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 26.5 ft WS OR WD WD	BORING STARTED 06/18/92	STS OFFICE Lansing-07
WL BCR ACR 7.0 ft	BORING COMPLETED 06/18/92	ENTERED BY DAP; SHEET NO. 2 OF 2
WL	RIG/FOREMAN DR-1/BP	APP'D BY JSM; STS JOB NO. 72150A

STS Consultants, Ltd



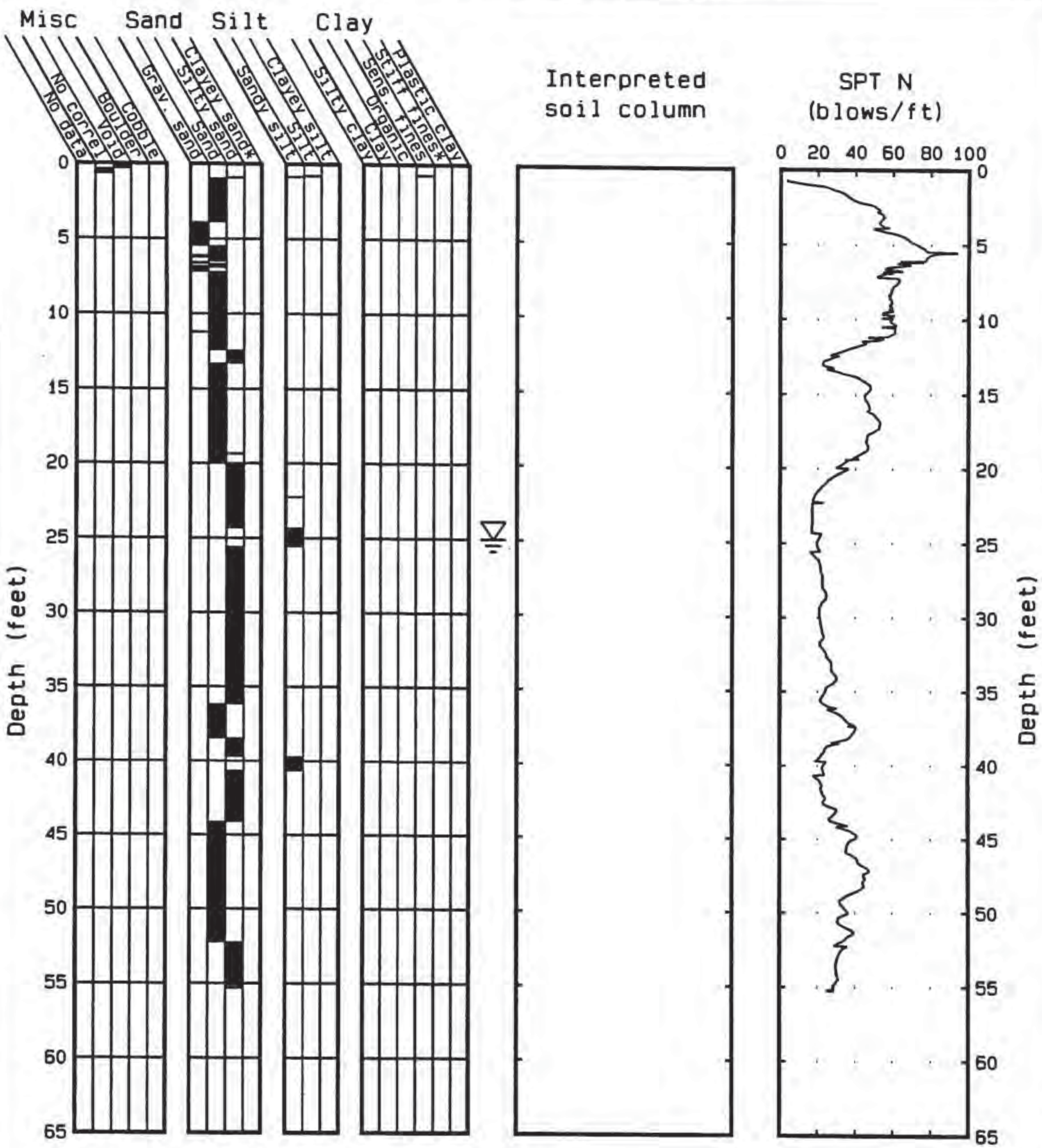
Max depth = 55.58 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER TEST DATA

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP106A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I30-H10
Site:	CREST OF DIKE, LOCATION SB-106A	Sounding:	CPTU-106A (R
Date:	06-11-1992 14:55	Proj. no:	72150-A

STS Consultants, Ltd



Max depth = 55.58 feet

Soil unit weight = 120 pcf

STANDARD CONE PENETROMETER SOIL STRATIGRAPHY

Client:	CONSUMERS POWER COMPANY	Filename:	CAMP106A.CPT
Project:	CAMPBELL ASH STORAGE	Cone id:	I30-H10
Site:	CREST OF DIKE, LOCATION SB-106 A	Sounding:	CPTU-106A (R
Date:	06-11-1992 14:55	Proj. no:	72150-A

STS Consultants, Ltd

Database filename: CAMP106A.CPT
Client: CONSUMERS POWER COMPANY
Project name: CAMPBELL ASH STORAGE
Project number: 72150-A
Site: CREST OF DIKE, LOCATION SB-106 A
Sounding number: CPTU-106A (RE)
Test date: 06-11-1992 14:55
Cone ID: I30-H10
Water table: 25 FT (ASSUMED)
Soil unit weight: 120 PCF (ASSUMED)
Test engineer: DEON, D.A.D.
Dissipation: NONE
Comment: HOLE PRE-DRILLED TO 1 FT
Comment: TEST ENDED AT 55.6 FT DUE TO INCLINATION
Comment:
Comment:
Comment:

STANDARD CONE PENETROMETER ANALYSIS REPORT

Depth ...... Depth to tip of cone
Tip .... Tip resistance
Sleeve ..... Local sleeve friction
Incl .... Deviation from vertical
Pore .... Induced dynamic pore pressure (zero for standard cone)
Ratio ...... Friction ratio (Sleeve / Tip) * 100%
Mat. type .. Soil classification (Robertson & Campanella, 1983)
SPT N ...... Standard Penetration Test N value (Robertson 1985)
SPT N1 ..... N value corrected for overburden (Marcuson & Bieganousky, 1977)
Sigv' ...... Effective vertical overburden
Phi .... Drained friction angle for sands (Robertson & Campanella, 1983)
Dr .... Relative density of sands (Baldi 1982)
Su .... Undrained shear strength of clays (Tip - Sigvtot) / Nk (Nk = cone factor) (R & C, 83)

All values are averaged and reported at an interval of .5 feet

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
0.25	0.4	-0.01	1.0	0.00	-1.7	Void	0	0	0.02	--	--	----
0.75	20.5	0.01	0.3	0.00	0.0	Silty sand to sandy silt	7	12	0.04	--	48	1.20
1.25	131.7	0.22	0.3	0.00	0.2	Sand	26	46	0.07	> 48	> 90	----
1.75	180.6	0.64	0.5	0.00	0.4	Sand	35	63	0.11	> 48	> 90	----
2.25	231.3	1.04	0.6	0.00	0.4	Sand	45	81	0.13	> 48	> 90	----
2.75	269.8	1.29	0.6	-0.01	0.5	Sand	53	95	0.16	> 48	> 90	----
3.25	278.8	1.53	0.8	-0.03	0.6	Sand	54	98	0.19	> 48	> 90	----
3.75	284.0	1.46	0.8	-0.04	0.5	Sand	55	100	0.22	> 48	> 90	----

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Database filename: CAMP106A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
4.25	364.6	1.72	0.9	-0.05	0.5	Gravelly sand to sand	59	107	0.25	> 48	> 90	----
4.75	425.1	2.11	0.9	-0.05	0.5	Gravelly sand to sand	69	125	0.29	> 48	> 90	----
5.25	466.5	2.49	0.9	-0.05	0.5	Gravelly sand to sand	76	137	0.31	> 48	> 90	----
5.75	415.9	4.19	0.4	-0.01	1.0	Sand	81	146	0.34	> 48	> 90	----
6.25	362.5	2.50	0.5	0.00	0.7	Sand	71	123	0.38	> 48	> 90	----
6.75	330.9	1.62	0.6	0.00	0.5	Gravelly sand to sand	54	87	0.40	> 48	> 90	----
7.25	323.7	1.85	0.7	0.00	0.6	Sand	63	98	0.44	> 48	> 90	----
7.75	311.9	2.41	0.8	0.00	0.8	Sand	61	91	0.46	> 48	> 90	----
8.25	300.8	2.39	1.0	0.00	0.8	Sand	59	84	0.50	> 48	> 90	----
8.75	302.0	2.25	1.1	0.00	0.7	Sand	59	82	0.53	> 48	> 90	----
9.25	302.5	2.24	1.3	0.00	0.7	Sand	59	80	0.56	48	> 90	----
9.75	293.5	2.65	1.4	0.00	0.9	Sand	57	76	0.58	48	> 90	----
10.25	303.5	2.67	1.6	0.00	0.9	Sand	59	77	0.61	48	> 90	----
10.75	312.1	2.81	1.7	0.00	0.9	Sand	61	77	0.64	48	> 90	----
11.25	279.3	1.82	1.9	0.00	0.7	Sand	55	68	0.68	47	> 90	----
11.75	216.4	1.79	2.0	0.00	0.8	Sand	42	51	0.70	46	> 90	----
12.25	156.7	1.30	2.1	0.00	0.8	Sand	31	36	0.73	44	81	----
12.75	102.2	0.95	2.4	0.00	0.9	Sand to silty sand	25	29	0.76	42	66	----
13.25	118.9	0.94	2.6	0.00	0.8	Sand to silty sand	29	33	0.80	43	70	----
13.75	190.0	1.38	2.6	0.00	0.7	Sand	37	41	0.82	45	86	----
14.25	233.9	1.93	2.7	0.00	0.8	Sand	46	50	0.85	45	> 90	----
14.75	242.5	2.12	2.8	0.00	0.9	Sand	47	51	0.89	45	> 90	----
15.25	232.1	1.96	2.9	0.00	0.8	Sand	45	48	0.92	45	> 90	----
15.75	241.1	1.88	3.0	0.00	0.8	Sand	47	49	0.94	45	> 90	----
16.25	248.5	2.07	3.2	0.00	0.8	Sand	49	50	0.97	45	> 90	----
16.75	269.1	2.32	3.3	0.00	0.9	Sand	53	53	1.00	45	> 90	----
17.25	268.0	2.41	3.4	0.00	0.9	Sand	52	52	1.04	45	> 90	----
17.75	242.7	2.08	3.6	0.00	0.9	Sand	47	47	1.06	45	> 90	----
18.25	235.7	1.96	3.7	0.00	0.8	Sand	46	45	1.10	44	90	----
18.75	235.2	2.04	3.8	0.00	0.9	Sand	46	44	1.13	44	89	----
19.25	198.0	1.93	4.0	0.00	1.0	Sand	39	37	1.15	43	82	----
19.75	166.6	1.63	4.1	0.00	1.0	Sand	33	31	1.19	42	74	----
20.25	134.2	1.25	4.2	0.00	0.9	Sand to silty sand	33	31	1.22	41	65	----
20.75	106.4	1.03	4.4	0.00	1.0	Sand to silty sand	26	24	1.24	40	56	----
21.25	89.8	0.93	4.6	0.00	1.0	Sand to silty sand	22	20	1.27	39	48	----
21.75	76.9	0.87	4.7	0.00	1.1	Sand to silty sand	19	17	1.30	38	42	----
22.25	71.1	0.80	4.9	0.00	1.1	Sand to silty sand	17	16	1.33	38	< 40	----
22.75	70.7	0.77	5.0	0.00	1.1	Sand to silty sand	17	15	1.37	38	< 40	----
23.25	70.7	0.76	5.2	0.00	1.1	Sand to silty sand	17	15	1.39	38	< 40	----
23.75	70.1	0.77	5.3	0.00	1.1	Sand to silty sand	17	15	1.42	37	< 40	----
24.25	68.7	0.75	5.4	0.00	1.1	Sand to silty sand	17	14	1.46	37	< 40	----
24.75	62.5	0.72	5.5	0.00	1.2	Silty sand to sandy silt	20	17	1.48	37	< 40	3.59
25.25	62.0	0.72	5.7	0.00	1.2	Silty sand to sandy silt	20	17	1.51	37	< 40	3.56
25.75	71.8	0.72	5.9	0.00	1.0	Sand to silty sand	18	15	1.52	37	< 40	----
26.25	85.3	0.75	5.9	0.00	0.9	Sand to silty sand	21	17	1.54	38	42	----
26.75	88.5	0.80	6.1	0.00	0.9	Sand to silty sand	22	18	1.55	38	43	----

Depth (ft) Tip (tsf) Sleeve (tsf) Incl (deg) Pore (tsf) Ratio (%) Material Type SPT N (bpf) SPT N1 (bpf) Sigv' (tsf) Phi (deg) Dr (%) Su (tsf)

Database filename: CAMP106A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
27.25	92.3	0.79	6.2	0.00	0.9	Sand to silty sand	23	19	1.56	38	44	----
27.75	92.3	0.74	6.4	0.00	0.8	Sand to silty sand	23	18	1.58	38	44	----
28.25	98.1	0.76	6.5	0.00	0.8	Sand to silty sand	24	20	1.59	39	45	----
28.75	99.2	0.82	6.7	0.00	0.8	Sand to silty sand	24	20	1.61	39	46	----
29.25	88.5	0.83	6.8	0.00	0.9	Sand to silty sand	22	17	1.62	38	41	----
29.75	86.0	0.84	6.9	0.00	1.0	Sand to silty sand	21	17	1.64	38	40	----
30.25	87.8	0.84	7.1	0.00	1.0	Sand to silty sand	21	17	1.65	38	41	----
30.75	90.8	0.84	7.2	0.00	0.9	Sand to silty sand	22	18	1.67	38	42	----
31.25	94.2	0.85	7.4	0.00	0.9	Sand to silty sand	23	18	1.68	38	43	----
31.75	88.2	0.88	7.5	0.00	1.0	Sand to silty sand	22	17	1.69	38	40	----
32.25	96.8	0.89	7.7	0.00	0.9	Sand to silty sand	24	19	1.71	38	43	----
32.75	105.3	0.93	7.8	0.00	0.9	Sand to silty sand	26	20	1.72	39	46	----
33.25	112.5	1.06	7.9	0.00	0.9	Sand to silty sand	27	22	1.74	39	48	----
33.75	117.3	1.04	8.1	0.00	0.9	Sand to silty sand	29	22	1.75	39	50	----
34.25	121.3	1.31	8.3	0.00	1.1	Sand to silty sand	30	23	1.77	39	51	----
34.75	103.4	1.22	8.4	0.00	1.2	Sand to silty sand	25	20	1.78	38	44	----
35.25	93.4	1.05	8.6	0.00	1.1	Sand to silty sand	23	18	1.80	38	41	----
35.75	93.5	0.84	8.7	0.00	0.9	Sand to silty sand	23	17	1.81	38	40	----
36.25	133.4	1.10	8.9	0.00	0.8	Sand	26	20	1.82	39	54	----
36.75	171.5	1.51	9.0	0.00	0.9	Sand	33	25	1.84	41	64	----
37.25	193.9	1.52	9.2	0.00	0.8	Sand	38	29	1.85	41	70	----
37.75	200.0	1.62	9.4	0.00	0.8	Sand	39	29	1.87	41	71	----
38.25	171.8	1.52	9.5	0.00	0.9	Sand	34	25	1.88	41	64	----
38.75	106.6	0.89	9.6	0.00	0.8	Sand to silty sand	26	19	1.90	38	44	----
39.25	92.2	0.84	9.8	0.00	0.9	Sand to silty sand	23	17	1.91	37	< 40	----
39.75	77.8	0.93	10.0	0.00	1.2	Sand to silty sand	19	14	1.92	36	< 40	----
40.25	70.4	0.87	10.1	0.00	1.2	Silty sand to sandy silt	23	17	1.94	36	< 40	4.00
40.75	76.7	0.85	10.3	0.00	1.1	Sand to silty sand	19	14	1.95	36	< 40	----
41.25	89.2	0.93	10.4	0.00	1.0	Sand to silty sand	22	16	1.97	37	< 40	----
41.75	91.3	1.02	10.5	0.00	1.1	Sand to silty sand	22	16	1.98	37	< 40	----
42.25	97.4	1.04	10.7	0.00	1.1	Sand to silty sand	24	17	2.00	37	< 40	----
42.75	106.1	1.07	10.8	0.00	1.0	Sand to silty sand	26	19	2.01	38	42	----
43.25	120.1	1.23	11.0	0.00	1.0	Sand to silty sand	29	21	2.03	38	46	----
43.75	114.7	1.21	11.1	0.00	1.1	Sand to silty sand	28	20	2.04	38	44	----
44.25	167.4	1.52	11.3	0.00	0.9	Sand	33	23	2.05	40	60	----
44.75	205.7	1.90	11.5	0.00	0.9	Sand	40	28	2.07	41	69	----
45.25	189.5	1.83	11.6	0.00	1.0	Sand	37	26	2.08	41	65	----
45.75	181.5	1.46	11.7	0.00	0.8	Sand	35	25	2.10	40	63	----
46.25	203.9	1.61	11.9	0.00	0.8	Sand	40	28	2.11	41	68	----
46.75	221.8	1.92	12.0	0.00	0.9	Sand	43	30	2.13	41	71	----
47.25	237.1	1.91	12.2	0.00	0.8	Sand	46	32	2.14	41	74	----
47.75	228.6	1.83	12.4	0.00	0.8	Sand	45	31	2.15	41	72	----
48.25	224.1	1.77	12.6	0.00	0.8	Sand	44	30	2.17	41	71	----
48.75	192.1	1.69	12.8	0.00	0.9	Sand	38	26	2.18	40	64	----
49.25	166.3	1.44	12.9	0.00	0.9	Sand	32	22	2.20	40	58	----
49.75	177.9	1.36	13.0	0.00	0.8	Sand	35	24	2.21	40	61	----

Depth ft) | Tip (tsf) | Sleeve (tsf) | Incl (deg) | Pore (tsf) | Ratio (%) | Material Type | SPT N (bpf) | SPT N1 (bpf) | Sigv' (tsf) | Phi (deg) | Dr (%) | Su (tsf)

Database filename: CAMP106A.CPT

Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)
50.25	168.8	1.40	13.2	0.00	0.8	Sand	33	23	2.23	40	58	----
50.75	164.2	1.18	13.4	0.00	0.7	Sand	32	22	2.24	40	57	----
51.25	194.4	1.40	13.6	0.00	0.7	Sand	38	26	2.26	40	64	----
51.75	181.5	1.51	13.7	0.00	0.8	Sand	35	24	2.27	40	61	----
52.25	148.1	1.36	13.9	0.00	0.9	Sand	29	20	2.28	39	52	----
52.75	130.2	1.16	14.1	0.00	0.9	Sand to silty sand	32	21	2.30	38	46	----
53.25	124.2	1.06	14.2	0.00	0.9	Sand to silty sand	30	20	2.31	38	44	----
53.75	122.5	1.04	14.4	0.00	0.8	Sand to silty sand	30	20	2.33	38	44	----
54.25	125.1	1.05	14.5	0.00	0.8	Sand to silty sand	31	20	2.34	38	44	----
54.75	121.5	1.04	14.7	0.00	0.9	Sand to silty sand	30	20	2.36	38	43	----
55.16	114.5	0.94	14.8	0.00	0.8	Sand to silty sand	28	19	2.37	37	41	----
Depth (ft)	Tip (tsf)	Sleeve (tsf)	Incl (deg)	Pore (tsf)	Ratio (%)	Material Type	SPT N (bpf)	SPT N1 (bpf)	Sigv' (tsf)	Phi (deg)	Dr (%)	Su (tsf)

Maximum test depth = 55.31 feet

STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER SB-107
PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION	ARCHITECT-ENGINEER
SITE LOCATION: WEST OLIVE, MICHIGAN	

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 632.2 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
	1	SS	Sandy fill, trace silt - black - loose - desicated. (FLY ASH)		9
	1A	SS	Fine sand fill, trace silt and coal fragments - brown - medium dense to dense - moist. (FLY ASH - SP)		15
		PA			
	2	SS*		99	24
5.0		PA			
	3	SS			46
		PA			
	4	SS*		102	11/6"
	4A	SS*	Silty sand, trace roots - black - medium dense to dense - saturated. (FLY ASH - SM)	107	31
10.0		PA			
	5	SS			14
		RB			
	6	SS*	Sandy silt - black - medium dense - saturated. (FLY ASH - ML)	87	12
15.0		RB			
	7	SS	Silty sand, little coal fragments - medium dense - moist (FLY ASH - SM)		15
		RB			
	8	SS*	Sandy silt - black - loose - saturated. (FLY ASH - ML)	84	8
20.0		RB			
	9	SS			5
		RB			
		RB	Fine sand, trace medium sand, silt and roots - brown - medium dense to dense - wet to saturated (SP)		
25.0					
	10	SS*		126	11
		RB			
30.0					
	11	SS			11
		RB			
35.0					
	12	SS*		108	13
		RB			
40.0					

.... continued

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

STS JOB NO. 72150A SHEET NO. 1 OF 2

STS Consultants Ltd.

CLIENT
CONSUMERS POWER COMPANY

LOG OF BORING NUMBER SB-107

PROJECT NAME
CAMPBELL ASH STORAGE FACILITY EXPANSION

ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

UNCONFINED COMPRESSIVE STRENGTH TONS/FT.[2] 1 2 3 4 5

PLASTIC LIMIT % — WATER CONTENT % — LIQUID LIMIT % 10 20 30 40 50

STANDARD PENETRATION - BLOWS/FT. 10 20 30 40 50

SURFACE ELEVATION 632.2 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.³	STANDARD PENETRATION BLOWS/FT.
			Continued from previous page		
40.0	13	SS	Fine sand, trace medium sand, silt and roots - brown - medium dense to dense - wet to saturated (SP)		30
		RB			
45.0	14	SS*		111	36
		RB			
50.0	15	SS	Silt, trace fine sand - gray - very dense - saturated. (ML)		53
52.0	15A	SS			78

END OF BORING

Boring advanced with solid stem augers and washed rotary drilling techniques.
Boring backfilled with bentonite chips.

Note: SS* indicates sample collected with plastic liner in split spoon.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL 16 ft WS OR WD WS	BORING STARTED 06/17/92	STS OFFICE Lansing-07
WL BCR ACR	BORING COMPLETED 06/17/92	ENTERED BY DAP — SHEET NO. 2 OF 2
WL	RIG/FOREMAN CME550/BP	APP'D BY JSM — STS JOB NO. 72150A

STS Consultants Ltd.

CLIENT	CONSUMERS POWER COMPANY
PROJECT NAME	CAMPBELL ASH STORAGE FACILITY EXPANSION
LOG OF BORING NUMBER	SB-108
ARCHITECT-ENGINEER	
SITE LOCATION	WEST OLIVE, MICHIGAN

SURFACE ELEVATION 628.9 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}	STANDARD PENETRATION BLOWS/FT.
	1	SS*	Fine sand, little silt, trace roots - black - very loose - moist. (FLY ASH - SM)	53	2
		PA			
	2	SS			2
5.0		PA			
	3	SS*		65	2
		PA			
	4	SS	Sandy silt - black - very loose - saturated. (FLY ASH - ML)		4
10.0		PA			
	5	SS*	Fine sand, little silt - black - very loose - moist. (FLY ASH - SP)	62	3
		PA	Note: Attempted to obtain shelby tube sample at 20 ft. - Sampler dropped 7 ft. under weight of rods - no sample recovered.		
15.0	6	SS			2
		PA			
20.0	7	ST			
25.0		PA			
30.0	8	SS*			
32.0	BA	SS*	Fine to coarse sand, trace silt - brown to grayish brown - medium dense - wet. (SW)	120	28

END OF BORING

Boring advanced with solid stem augers.
Boring backfilled with bentonite chips and soil cuttings.

Note: SS* indicates sample collected with plastic liner in split spoon.

Chart scales: UNCONFINED COMPRESSIVE STRENGTH TONS/FT.^{2} 1 2 3 4 5; PLASTIC LIMIT % × — WATER CONTENT % ● — LIQUID LIMIT % △ 10 20 30 40 50; ⊗ STANDARD PENETRATION BLOWS/FT. 10 20 30 40 50

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL WS OR WD	BORING STARTED 06/18/92	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 06/18/92	ENTERED BY DAP	SHEET NO. 1 OF 1
WL 18 ft AB	RIG/FOREMAN CME550/BP	APP'D BY JSM	STS JOB NO. 72150A

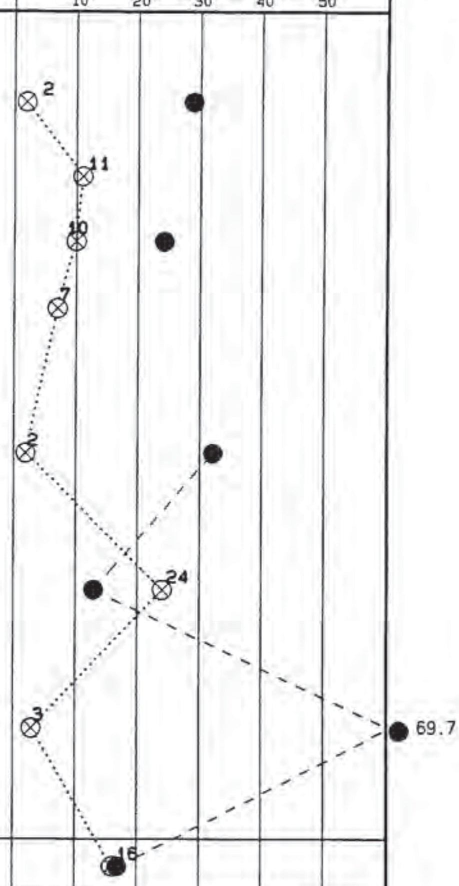
STS Consultants Ltd.

CLIENT: CONSUMERS POWER COMPANY	LOG OF BORING NUMBER: SB-109
PROJECT NAME: CAMPBELL ASH STORAGE FACILITY EXPANSION	ARCHITECT-ENGINEER

SITE LOCATION
WEST OLIVE, MICHIGAN

SURFACE ELEVATION 631.1 ft

DEPTH (FT)	SAMPLE NO.	SAMPLE TYPE	DESCRIPTION OF MATERIAL	UNIT DRY WT. LBS./FT.^{3}
	1	SS	Sandy silt, trace roots - black - very loose to medium dense - moist to saturated. (FLY ASH - ML)	
		PA		
	2	SS*		71
5.0		PA		
	3	SS		
		PA		
	4	SS*		84
10.0		PA		
	5	SS		
		PA		
15.0	6	SS*		85
		PA		
20.0	7	SS*		90
		PA		
25.0	8	SS*		64
		PA		
30.0	9	SS*	Fine sand, trace medium sand, silt and coal fragments - brown - medium dense - wet. (SP)	107
32.0				



END OF BORING

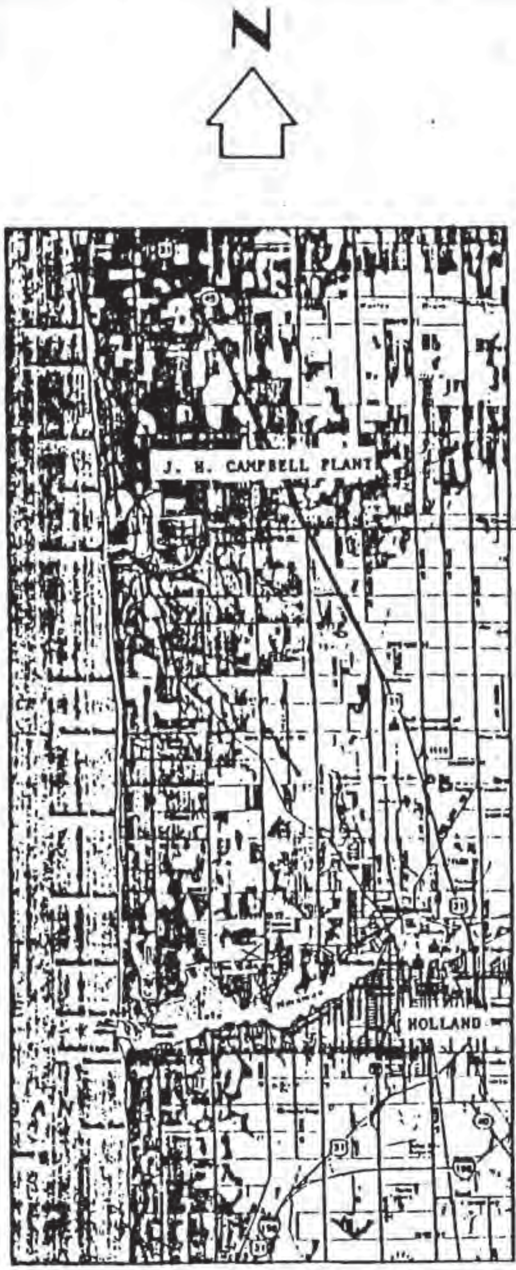
Boring advanced with solid stem augers.
Boring backfilled with bentonite chips and soil cuttings.

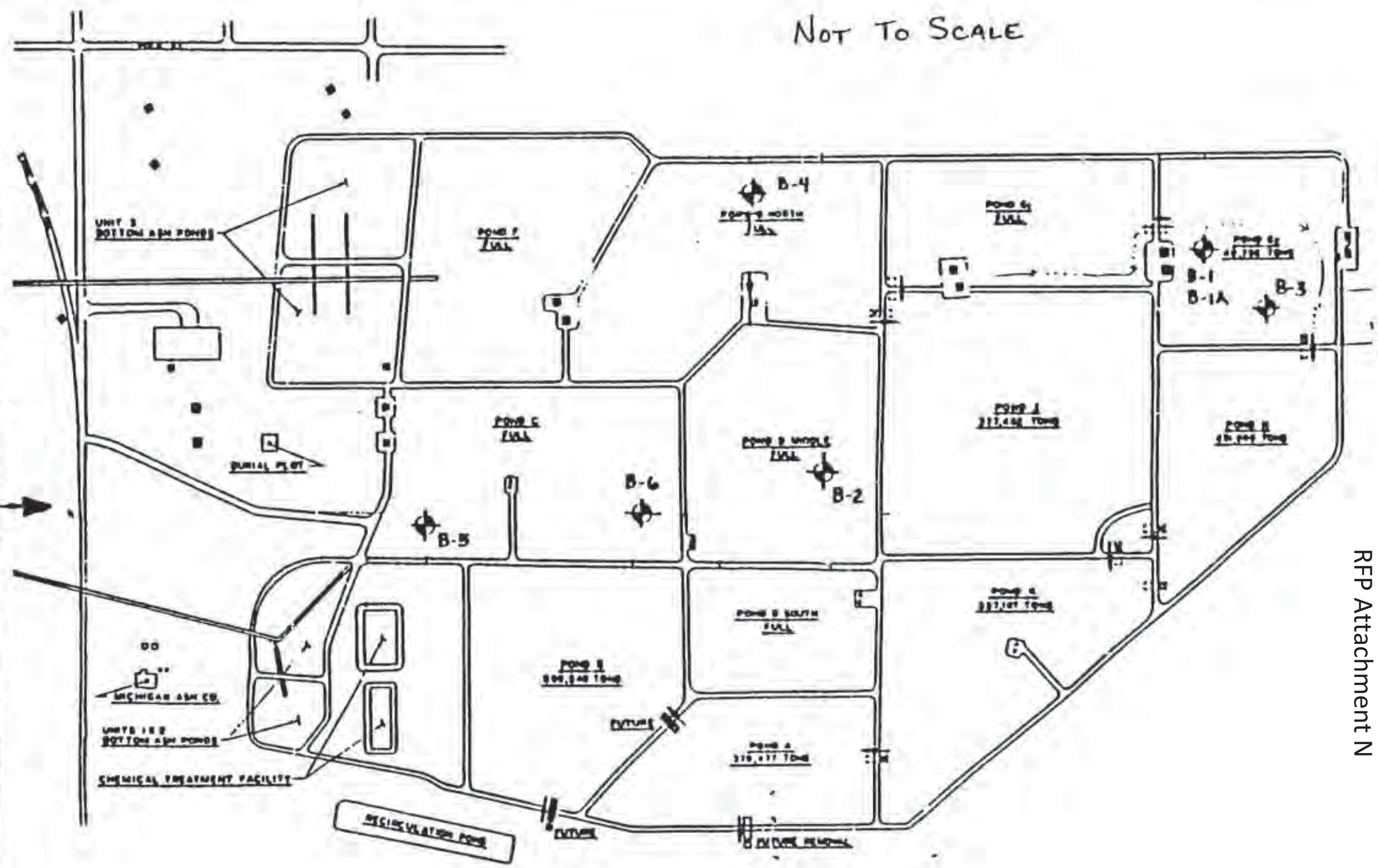
Note: SS* indicates sample collected with plastic liner in split spoon.

The stratification lines represent the approximate boundary lines between soil types: in-situ, the transition may be gradual.

WL WS OR WD	BORING STARTED 06/18/92	STS OFFICE Lansing-07	
WL BCR ACR	BORING COMPLETED 06/18/92	ENTERED BY DAP	SHEET NO. 1 OF 1
WL 25 ft @ 17 hr AB	RIG/FOREMAN CME550/BP	APP'D BY JSM	STS JOB NO. 72150A

MATERIAL TESTING CONSULTANTS BORING LOGS AND TEST RESULTS (1991)





BORING LOCATIONS

B-1	235'S, 120'E OF NW Corner of Pond G_2
B-1A	6'S of B-1
B-2	400'S, 220'W of NE Corner of Pond D (Middle)
B-3	120'S, 240'W of SE Corner of Pond G_2
B-4	140'S, 340'E of NW Corner of Pond D (North)
B-5	200'N, 135'E of SW Corner of Pond C
B-6	175'N, 150'W of SE Corner of Pond C

TITLE: BORING LOCATION PLAN			PROJECT: CPC CAMPBELL ASH PONDS
SCALE: NTS	DATE: 8-9-91	JOB NO: 261Q	Materials Testing Consultants Inc.
FIG. NO: 1	DR. BY: SMT	REV. BY: SE	

TABLE NO. 1
SUMMARY OF MOISTURE/DENSITY TEST DATA

Bor No.	Sample Type	Depth Ft.	Mst Pct	Dry Unit Wt., PCF	Spec Grav	Void Ratio	* Max Dry Dens, PCF	* Opt Mst Pct.	* Pct. Comp.
B-1	Sand Cone	0-1	22.4	60.5					
B-1	3" SBS	0-2	24.6	60.0	2.35	1.44			
B-1	3" SBS	0-2	26.6	53.6					
B-1	3" SBS	5-7	16.5	60.3					
B-1	3" SBS	10.5-11	34.8	58.1	2.13	1.29	78.5	23.9	74
B-1	3" SBS	11-11.5	39.8	70.2					
B-1	3" SBS	12-14	11.1	72.4					
B-1	3" SBS	15-17	29.8	56.8					
B-1	3" SBS	22-24	51.9	61.9	2.22	1.24			
			avg	61.5	2.23	1.32			
B-1A	3" Shelby	10-12	35.1	65.3					
B-1A	3" SBS	23-25	44.0	68.4					
B-1A	2" SBS	25-27	43.0	71.3					
B-1A	3" SBS	28-30	44.1	66.6					
			avg	67.9					
B-2	Sand Cone	0-1	20.7	78.1					
B-2	3" SBS	0-2	30.3	77.4	2.29	0.85			
B-2	3" Shelby	5-7	21.8	24.0					
B-2	3" SBS	8-10	26.7	86.0	2.49	0.81			
B-2	3" Shelby	13-15	24.1	77.5					
B-2	3" SBS	17-19	27.8	88.3					
B-2	3" SBS	20-22	26.8	89.8	2.57	0.79			
			avg	74.4	2.45	0.82			
B-3	2" SBS	0-2	23.6	43.2					
B-3	3" Shelby	0-2	27.0	56.5	2.27	1.51			
B-3	3" SBS	0-2	29.3	53.4					
B-3	3" SBS	4-6	40.5	61.8					
B-3	3" SBS	9-11	37.5	66.4	2.23	1.10	82.5	23.2	80
B-3	3" SBS	13-15	38.6	71.6					
B-3	2" SBS	21-23	49.7	60.9					
B-3	2" SBS	24-26	42.3	79.0	2.40	0.90			
B-3	2" SBS	29-31	46.0	69.0					
			avg	62.4	2.30	1.17			

* Based on Standard Proctor Test, ASTM D 698

TABLE NO. 1 (Cont'd)
SUMMARY OF MOISTURE/DENSITY TEST DATA

Bor No.	Sample Type	Depth Ft.	Mst Pct	Dry Unit Wt., PCF	Spec Grav	Void Ratio	* Max Dry Dens, PCF	* Opt Mst Pct.	* Pct. Comp.
B-4	Sand Cone	0-1	1.9	81.1					
B-4	3" SBS	0-2	3.9	75.6	2.49	1.06			
B-4	3" Shelby	4-6	5.2	76.7					
B-4	3" SBS	6-8	32.7	72.8					
B-4	3" SBS	9-11	15.7	76.5	2.49	1.03			
B-4	3" Shelby	13-15	19.7	83.6					
B-4	3" SBS	17-19	28.7	89.1					
B-4	2" SBS	19-21	36.9	79.0	2.49	0.97			
B-4	2" SBS	24-26	41.98	74.6					
			avg	78.8	2.49	1.02			
B-5	Sand Cone	0-1	5.3	87.0					
B-5	3" SBS	3-5	21.8	73.3	2.36	1.01			
B-5	3" SBS	9-11	7.9	90.7	2.74	0.89	102.8	14.3	88
B-5	3" SBS	19-21	16.4	96.7	2.67	0.72			
B-5	3" SBS	23-25	30.2	81.6					
			avg	85.9	2.59	0.87			
B-6	Sand Cone	0-1	16.6	84.2					
B-6	3" SBS	0-2	3.7	76.7	2.54	1.07			
B-6	3" Shelby	3-5	15.0	68.3					
B-6	3" SBS	5-7	13.7	68.2					
B-6	3" SBS	9-11	15.7	84.7	2.50	0.84			
B-6	3" SBS	15-17	33.9	80.4					
B-6	3" SBS	20-22	29.7	88.3	2.59	0.83			
B-6	2" SBS	24-26	32.9	84.7					
			avg	79.4	2.54	0.91			

* Based on Standard Proctor Test, ASTM D 698

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LOG OF BORING

Project No. 2610
Boring No. B-1
Sheet 1 of 1

Project: CPC Campbell Ash Ponds
Contractor: Mateco Drilling Company
Client: Consumers Power Company
Date Begin: 6-25-91 Date End: 6-25-91
Location: Pond G2, NW Corner
Crew Chief: S. Miller
Drill Type: CME 850
Inspector: S. Thompson
Plugging Record: Backfilled with excavated soil.
Reviewed By:
Elevation:
Datum:
Depth Drilled: 24.0'
Notes: 235'N, 120'E of SW corner of Pond

	TYPE	DIA.	NO.
Casing	HSA	4½"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	20'
End	NA
Seepage	10.5
Date	Depth

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12")
Cobbles (12" to 3")
Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4)
Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive)
Silt PI < 1
Clayey Silt 1 < PI < 5
Silt and Clay 5 < PI < 10
Clay and Silt 10 < PI < 20
Silty Clay 20 < PI < 40
Clay PI > 40

Minor Component: Trace 1-10%. Little 10-20%. Some 20-35%. And 35-50%
QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	S-1 3"	2.0	WOH-1-1	ML	Gray to dark gray SILT, some fine sand, moist (fly ash)		53.6
5	S-2 3"	2.0	2-2-2-2	ML	grades with occasional thin clayey silt seams with perched water		60.3
10	S-3 3"	1.9	2-½-½-2	ML	wet seam at 11'		58.1
							70.2
	S-4 3"	2.0	Pushed	ML			72.4
15						Pushed sample from 12' to 14'.	
	S-5 3"	1.5	3-4-2-2	ML	Gray to dark gray SILT, some fine sand, moist (Fly Ash)		56.8
20	S-6 3"	0.0	1-½-1½-1	ML	grades wet	Did not use screen in sampler from 0' to 20' No recovery with S-6.	
	S-7 3"	1.5	WOR/24"	ML	grades to trace fine sand	Put screen in sampler at sampled from 22'-24'	61.9
25					End of Boring at 24.0'	Cave in at 19'	
30							
35						γ_D = Dry Density (pcf)	

* Visual estimate unless laboratory testing has been performed.

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LOG OF BORING

Project No. 261Q
Boring No. B-1A
Sheet 1 of 1

Project: CPC Campbell Ash Ponds
Contractor: Mateco Drilling Company
Client: Consumers Power Company
Date Begin: 6-26-91
Date End: 6-26-91
Location: Pond G2, NW Corner
Crew Chief: S. Miller
Drill Type: CME 850
Inspector: S. Thompson
Plugging Record: Backfilled with excavated soil
Reviewed By:
Elevation:
Datum:
Depth Drilled: 35.0'
Notes: 6' south of B-1

	TYPE	DIA.	NO.
Casing	HSA	4½"	
Sampler	SPT	2"	
Core			
Tube			

GROUNDWATER	
During	20'
End	20.1 BAR
Seepage	
Date	Depth
AAR	21.0
6/28	20.5 WCI

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12") Cobbles (12" to 3")
Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4)
Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive)
Silt PI < 1; Clayey Silt 1 < PI < 5; Silt and Clay 5 < PI < 10; Clay and Silt 10 < PI < 20; Silty Clay 20 < PI < 40; Clay PI > 40

Minor Component: Trace 1-10%, Little 10-20%, Some 20-35%, And 35-50%
QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
5				ML	Gray Fly Ash		
10						Proctor sample taken from auger cuttings.	
	U-1	2.0	Shelby Tube	ML	Gray SILT, some fine sand, moist (Fly Ash) with occasional thin clayey silt seams with perched water		65.3
15							
20	U-2	0.0	Shelby Tube	ML			
25	S-3 3"	1.5	3/24"	ML	Gray SILT, trace fine sand, wet (Fly Ash)		68.4
	S-4 2"	1.5	2-½-½-2			Washed augers before sampling S-4	71.3
				ML			66.6
30	S-5 3"	1.2	3-3-4-5	SP	Dark brown medium to fine SAND, wet with trace organic to brown		
35	S-6 3"	0.7	10-14-14-14	SP			
					End of Boring at 35.0'	WCI = Wet Cave-in	
						γ_D = Dry Density (pcf)	

* *Visual estimate unless laboratory testing has been performed.*

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LOG OF BORING

Project No. 261Q
Boring No. B-2
Sheet 1 of 1

Project: CPC Campbell Ash Ponds
Contractor: Mateco Drilling Company
Client: Consumers Power Company
Date Begin: 6-26-91
Date End: 6-26-91
Location: Pond D, Middle
Crew Chief: S. Miller
Drill Type: CME 850
Inspector: S. Thompson
Plugging Record: Backfilled with excavated soil.
Reviewed By:
Elevation:
Datum:
Depth Drilled: 31.0'
Notes: 400'S, 220'W, of NE corner of pond

	TYPE	DIA.	NO.
Casing	HSA	4¼"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	17.7 BAR
End	24.3 BAR
Seepage	
Date	Depth
1.0 hr	21.5' BAR
1.5 hr	14.7' AAR
6/28	15.2 WCI

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12") — Cobbles (12" to 3") — Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4) — Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive)
Silt PI < 1 — Clayey Silt 1 < PI < 5 — Silt and Clay 5 < PI < 10 — Clay and Silt 10 < PI < 20 — Silty Clay 20 < PI < 40 — Clay PI > 40

Minor Component: Trace 1-10%, Little 10-20%, Some 20-35%, And 35-50%
QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	S-1 3"	1.8	1-1-1-1	ML	Gray SILT, tracefine sand, moist with trace organics wet seam at 1.5', occasional thin seams of black medium to fine sand (coarse ash)		77.4
5	U-2 3"	1.5	Shelby Tube	ML	Occasional seams or lenses of clayey silt with perched water		24.0
							86.0
10	S-3 3"	2.0	3-1-1-2	ML			
15	U-4	1.8	Shelby Tube	ML			77.5
	S-5 3"	0.0	4-1-1-1	ML	grades wet	No recovery on S-5, put screen back in sampler to get better recovery.	
	S-6 3"	2.0	3-2-2-2	ML	Gray SILT, little fine sand, wet (Fly Ash)		88.3
20	S-7 3"	1.8	4-3-2-2	ML			89.3
25	S-8 3"	1.4	1-5-6-7	SP	Light brown medium to fine SAND, wet		
30	S-9 3"	1.5	3-3-4	SP			
35					End of Boring at 31.0'	6/26 dry cave in at 15.2'	
						WCI = Wet Cave-in	
						γ_D = Dry Density (pcf)	

* Visual estimate unless laboratory testing has been performed.

RFP Attachment N

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LOG OF BORING

Project No. 2610
Boring No. B-3
Sheet 1 of 1

Project: CPC Campbell Ash Ponds
Contractor: Mateco Drilling Company
Client: Consumers Company
Date Begin: 6-26-91 Date End: 6-26-91
Location: Pond G2, SE corner
Crew Chief: S. Miller
Drill Type: CME 850
Inspector: S. Thompson
Plugging Record: Backfilled with excavated soil. Cave in at 9.3' (6/27)
Reviewed By:
Elevation:
Datum:
Depth Drilled: 36.0'
Notes: 120'N, 240'W of SE corner of Pond

	TYPE	DIA.	NO.
Casing	HSA	4¼"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	13.7 BAR
End	12.5 AAR
Seepage	
Date	Depth
6/27	9.3 Cave-in

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12") Cobbles (12" to 3")
Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4)
Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive)
Silt PI < 1; Clayey Silt 1 < PI < 5; Silt and Clay 5< PI < 10; Clay and Silt 10 < PI < 20; Silty Clay 20 < PI < 40; Clay PI > 40

Minor Component: Trace 1-10%, Little 10-20%, Some 20-35%, And 35-50%
QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	U-1	1.0	Shelby Tube	ML	Gray SILT, trace fine sand, moist with frequent very thin black fine sand seams (coarse ash)		56.5
5	S-2 3"	1.5	1-1-1-1	ML	grades with occasional thin clayey silt seams with perched water		61.8
10	S-3 3"	2.0	1-WOH-1-1	ML	wet from 10', grades with little fine sand	Bottom ft of S-3 ran out of sampler.	66.4
15	S-4 3"	0.9	1-1-WOH-½	ML			71.6
	U-5	0.0	Shelby tube			Pushed shelby tube, no recovery.	
20	S-6 3"	1.5	2-2-1-1	ML	Gray to dark gray SILT, trace fine sand, wet (Fly Ash) with frequent thin black fine sand seams (coarse ash)	Sampler ran out of 3" spoon unable to get density liner sampler switched to 2" spoon.	
	S-7 2"	2.0	WOH	ML			60.9
25	S-8 2"	2.0	WOH	ML			79.0
30	S-9 2"	2.0	WOH	ML			69.0
						33'±	
					Dark gray grading to		
35	S-10 2"	1.5	6-13-21	SP	Light brown medium to fine SAND, wet		
					End of Boring at 36.0'	γ_D = Dry Density (pcf)	

* Visual estimate unless laboratory testing has been performed.

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LOG OF BORING

Project No. 2610
Boring No. B-4
Sheet 1 of 1

Project	CPC Campbell Ash Ponds	Contractor	Mateco Drilling Company
Client	Consumers Power Company	Date Begin	6-27-91
Location	Ponds D, North	Date End	6-27-91
Crew Chief	S. Miller	Drill Type	CME 850
Inspector	S. Thompson	Plugging Record:	Backfilled with excavated soil
Reviewed By			
Elevation			
Datum		Depth Drilled	31.0'
Notes:	140'S, 340'E of the NW corner of Pond		

	TYPE	DIA.	NO.
Casing	HSA	4¼"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	16.0'
End	26' BAR
Seepage	
Date	Depth
4 hr.	23.3'
6/28	23.0'

SOIL TYPE: Coarse Grained (Cohesionless) Boulder (> 12") Cobbles (12" to 3") Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4) Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive) Silt PI < 1; Clayey Silt 1 < PI < 5; Silt and Clay 5 < PI < 10; Clay and Silt 10 < PI < 20; Silty Clay 20 < PI < 40; Clay PI > 40

Minor Component: Trace 1-10%. Little 10-20%. Some 20-35%. And 35-50%   QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	S-1 3"	1.7	WOH -1-2 12	ML	Gray SILT, and fine sand, moist with frequent thin seams of black fine sand (coarse ash)		75.6
5	U-2	0.5	Shelby tube	ML	Fly Ash		76.7
	S-3 3"	2.0	2-3-4-4	ML	grades wet 7' to 8'		72.8
10	S-4 3"	2.0	4-3-4-6	ML	Gray SILT, little fine sand, moist with frequent thin black fine sand seams (coarse ash)		76.5
15	U-5	0.4	Shelby tube	ML			83.6
	S-6 3"	2.0	6-1-1-1	ML	grades wet	No liner sample taken for S-6.	
	S-7 3"	2.0	7-4-4-4	ML		Put screen in 3" SBS after S-6.	89.1
20	S-8 2"	2.0	4-1-1-1	ML		Switch to 2" spoon from S-8	79.0
25	S-9 2"	2.0	2-1/18"	ML	Gray clayey SILT, wet (Fly Ash)		74.6
27'						Driller noted change	
30	S-10 2"	1.6	6-6-7-6	SP	Light brown medium to fine SAND, wet		
					End of Boring at 31.0'		
35							

γ_D = Dry Density (pcf)

* Visual estimate unless laboratory testing has been performed.

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LOG OF BORING

Project No. 2610
Boring No. B-5
Sheet 1 of 1

Project	CPC Campbell Ash Ponds	Contractor	Mateco Drilling Company
Client	Consumers Power Company	Date Begin	6-27-91 Date End 6-27-91
Location	Ponds C, SE corner		
Crew Chief	S. Miller	Drill Type	CME 850
Inspector	S. Thompson	Plugging Record:	Backfilled with excavated soil
Reviewed By			
Elevation			
Datum		Depth Drilled	30.0'
Notes:	200'N, 135'E of the SW corner of the Pond		

	TYPE	DIA.	NO.
Casing	HSA	4½"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	17.5'
End	23.7 AAR
Seepage	
Date	Depth
6/28	24.3 WCI

SOIL TYPE: Coarse Grained (Cohesionless): Boulder (> 12"), Cobbles (12" to 3"), Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4), Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)

Fine-Grained (Cohesive): Silt PI < 1, Clayey Silt 1 < PI < 5, Silt and Clay 5 < PI < 10, Clay and Silt 10 < PI < 20, Silty Clay 20 < PI < 40, Clay PI > 40

Minor Component: Trace 1-10%, Little 10-20%, Some 20-35%, And 35-50%   QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	S-1 3"	0.5	1-1-1-1	ML	Gray SILT, little fine sand, moist (fly ash) with trace organics	No sample taken	
5	S-2	1.9	4-4-4-4	ML			73.3
	U-3	1.5	Shelby tube	ML	grades with wet seam at 7', occasional wet seams	No density sample, tube dented.	
				ML			
10	S-4 3"	1.9	13-8-5-4	SM	Gray medium to fine SAND, some silt, moist (fly ash) with coarse ash and coal fragments		90.7
15	U-5	1.0	Shelby tube	SM		Damaged shelby tube, disturbed sample (bagged)	
	S-6 3"	0.2	4-3-1-1	SM		Added screen to 3" sampler after S-6	
	S-7 3"	1.5	4-3-4-11	ML	Gray SILT, and medium to fine+ sand, wet with trace slag 4" of black fine SAND, some silt with large wood fragment	3/4" ply wood in S-7 sample	
20	S-8 3"	1.8	6-7-10-15	ML	trace brown medium to fine sand mixed in ash, trace- roots		96.7
25	S-9 3"	2.0	7-4-3-2	ML	Gray SILT, and medium to fine+ sand, moist (fly ash) with occasional seams with coal fragments	Driller noted change	81.6
30	S-10 3"	1.9	6-8-22-36	SP	Light brown medium to fine, wet		
35					End of Boring at 30.0'	Frequent wet seams in samples, no standing water in augers during drilling. WCI = Wet Cave-in γ_D = Dry Density (pcf)	

* Visual estimate unless laboratory testing has been performed.

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LOG OF BORING

Project No. 2610
Boring No. B-6
Sheet 1 of 1

Project: CPC Campbell Ash Ponds
Client: Consumers Power Company
Location: Pond C, SE corner
Crew Chief: S. Miller
Inspector: S. Thompson
Reviewed By:
Elevation:
Datum:
Notes: 175'N, 150'W of SE corner of Pond

Contractor: Mateco Drilling Company
Date Begin: 6-28-91 Date End: 6-28-91
Drill Type: CME 850
Plugging Record: Backfilled with excavated soil
Depth Drilled: 30.0'

	TYPE	DIA.	NO.
Casing	HSA	4¼"	
Sampler	SPT	2"	
Core			
Tube	Shelby	3"	
Sampler	SBS	3"	

GROUNDWATER	
During	15'±
End	23.9 BAR
Seepage	
Date	Depth
6/28	6.6 Cave-in

SOIL TYPE: Coarse Grained (Cohesionless)
Boulder (> 12") Cobbles (12" to 3")
Gravel - Coarse (3" to ¾") - Fine (¾" to No. 4)
Sand - Coarse (No. 4 to No. 10) - Medium (No. 10 to No. 40) - Fine (No. 40 to No. 200)
Fine-Grained (Cohesive)
Silt PI < 1; Clayey Silt 1 < PI < 5; Silt and Clay 5< PI < 10; Clay and Silt 10 < PI < 20; Silty Clay 20 < PI < 40; Clay PI > 40

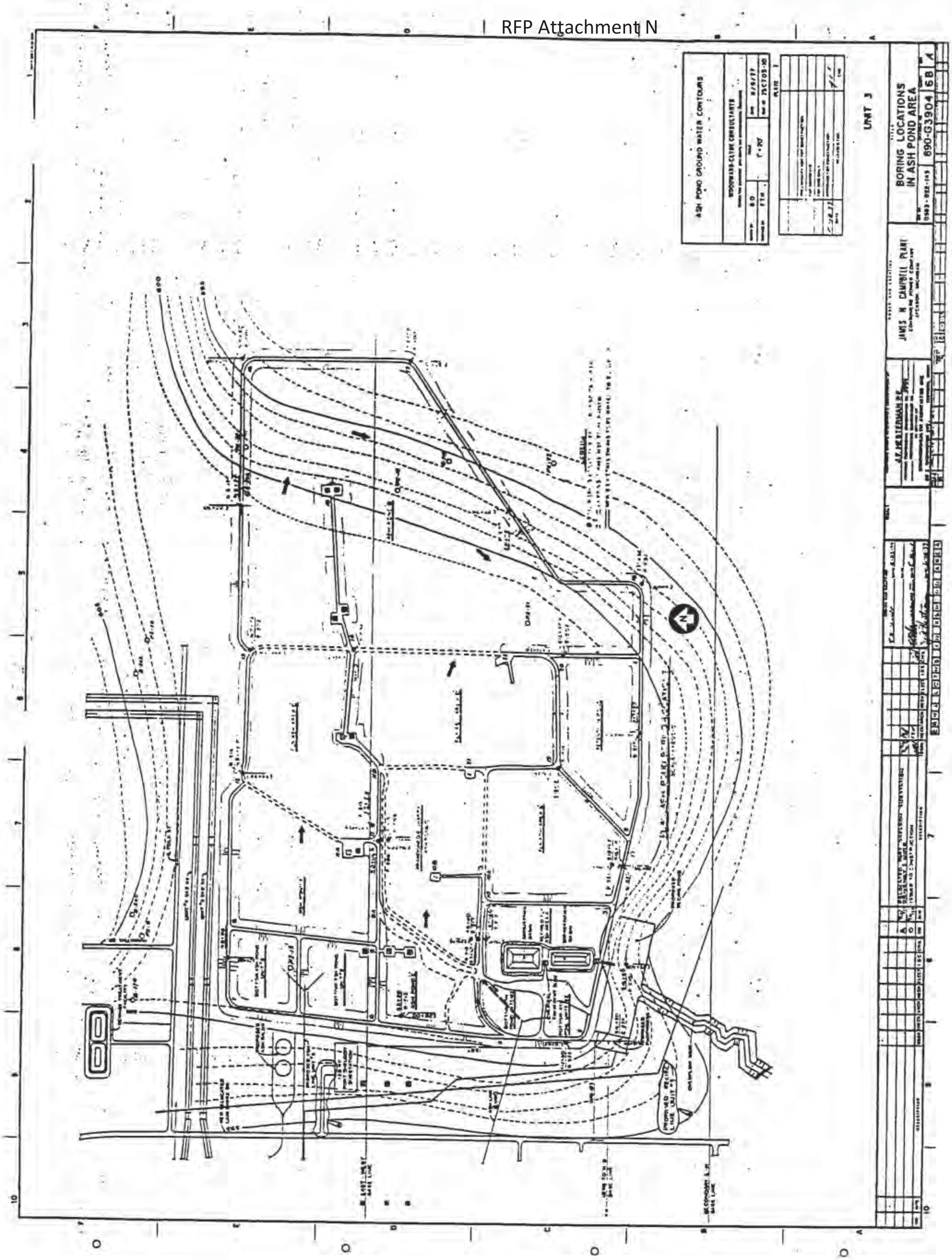
Minor Component: Trace 1-10%. Little 10-20%. Some 20-35%. And 35-50%   QP = Calibrated Penetrometer Reading (Tons/Sq.Ft.)

Depth FT.	Sample NO.	REC. FT.	PENETRATION (Blows Per 6") ASTM D 1586	*UNIF. SOIL CLASS.	*DESCRIPTION	REMARKS	γ_D
	S-1 3"	2.0	2-2-2-2	ML	Gray SILT, trace fine sand, moist (Fly Ash) with frequent thin black fine sand seams and occasional wet seams		76.7
5	U-2	2.0	Shelby tube	ML			68.3 / 68.2
	S-3 3"	1.0	4-3-2-2	ML	wet at 7'	1.0' of sample fell out bottom of sampler.	
10	S-4 3"	1.0	8-7-7-7	ML	Gray SILT, some fine sand, moist (fly ash)	1.0' of sample fell out bottom of sampler	84.7
15	U-5 3"	0.0	Shelby tube	ML		No recovery	
	S-6 3"	2.0	2-1-1-1	ML	wet at 16'		80.4
20	U-7	0.0	Shelby tube	ML	Gray SILT, little fine sand, wet (fly ash)	No recovery	
	S-8 3"	1.5	2-2-2-2	ML		Sample disturbed	88.3
25	S-9 2"	2.0	2-1-1-1	ML		Switch to 2" split spoon Driller noted change	84.7
30	S-10 2"	1.9	11-14-16-15	SP	Light brown medium to fine SAND, wet		
35					End of Boring at 30.0'		

γ_D = Dry Density (pcf)

* Visual estimate unless laboratory testing has been performed.

WOODWARD-CLYDE & ASSOCIATES BORING LOGS



ASH POND GROUND WATER CONTOURS
WOODWARD-CLYDE CONSULTANTS
UNIT 3
BORING LOCATIONS
IN ASH POND AREA
JAMES H. CAMPBELL PLANT
890-G3904 6B A

A-1

LOG of BORING No. B-500

DATE 6/20/77 SURFACE ELEV. 611.8 LOCATION S 2+25 E 62+10

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			Brown silty sand with vegetation	611.2				
		5						
5		8						
		8						
10		6	Medium dense tan medium to fine sand; (SP)					
15		6		593.8				
20		16						
25		9	Medium dense tan coarse to fine sand with trace fine gravel; (SW)					
30		12						
35		16		573.8				
40		15	Medium dense to dense tan fine sand; (SP)					
45		23	(continued)					

COMPLETION DEPTH 56.5 Water Depth 20.0' (el. 591.8) Date 6-20-77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

LOG of BORING No. B-500

DATE 6/20/77 SURFACE ELEV. 611.8 LOCATION S 2+25 E 62+10

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		23						
50		26	See Page 1 of Boring Logs					
55		48	Very dense gray coarse to fine sand trace silt; (SW)	556.3 555.3				
			End of Boring					
60								

COMPLETION DEPTH 56.5 Water Depth 20.0' (el. 591.8) Date 6/20/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 1 of 2

LOG of BORING No. B-501

DATE 6/17/77 SURFACE ELEV. 617.00 LOCATION N 8+58 E 62+10

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
			Tan fine sand with vegetation	616.00				
		6	Medium dense tan fine sand ; (SP)					
5		8						
		8						
10		9						
15		10						
20		15						
25		21						
30		20		582.0				
35		19	Medium dense tan medium to fine sand; (SP)					
40		24		572.0				
45		37	Dense tan-gray fine sand; (SP) (continued)					

COMPLETION DEPTH 56.5' Water Depth 23.0' (el. 599.0) Date 6/17/77
SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 2 of 2

LOG of BORING No. B-501

DATE 6/17/77 SURFACE ELEV. 617.00 LOCATION N 8+58 E 62+10

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		37						
50		21	See Page 1 of Boring Log.					
55		81	Very dense gray clayey silty medium to fine sand; (SM)	561.5				
			End of Boring	562.5				
60								

COMPLETION DEPTH 56.5' Water Depth 23.0' (el. 574.0) Date 6/17/77
SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

A-2

LOG of BORING No. B-502

DATE 6/20/77 SURFACE ELEV. 611.5 LOCATION N 8+16 E 53+52

Sampling Resistance	Description	Elevation	Water Content, %	Liquid Limit, %	Plastic Limit, %	Other Tests
	Brown silty sand with vegetation					
5, 6, 6, 11, 5, 5	Medium dense tan fine sand (SP)	589.5				
30, 30, 22, 20	Dense tan-gray medium to fine sand, trace coarse sand and fine gravel; (SW)	569.5				
57	Very dense gray fine sand trace silt; (SP)	565.0				

Depth, feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45

COMPLETION DEPTH 46.5' Water Depth 15.0' (el. 596.5) Date 6/20/77

SAMPLER: 2" O.D SPLIT BARREL SAMPLER

LOG of BORING No. B-503

DATE 6/23/77 - 6/24/77 SURFACE ELEV. 624.1 LOCATION N 7+66 E 43+38

Sampling Resistance	Description	Elevation	Water Content, %	Liquid Limit, %	Plastic Limit, %	Other Tests
	Black coarse to fine sand and gravel	623.6				
10, 6, 2, 4	Very loose to medium dense tan fine sand; (SP)	611.1				
17, 16, 9, 11, 30	Medium dense to dense brown to tan fine sand; (SP)	586.1				
56	Very dense tan-gray coarse to fine sand ; (SP)	582.6				
	End of Boring					

Depth, feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45

COMPLETION DEPTH 41.5' Water Depth 22.0' (el. 602.1) Date 6/23/77

SAMPLER: 2" O.D SPLIT BARREL SAMPLER

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LOG of BORING No. B-504

DATE 6/23/77 SURFACE ELEV. 623.6 LOCATION N 00+92 E 43+74

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		14	Black coarse to fine gravelly coarse to fine sand. Trace silt (Bottom Ash)	621.6				
5		9	Medium dense brown and tan fine sand ; (SP)					
		8						
10		10						
15		12						
20		6						
25		11						
30		8		590.6				
35		25	Medium dense to dense tan-gray medium to fine sand; (SP)					
40		13						
45		36	(continued)					

COMPLETION DEPTH 56.5' Water Depth 19.0' (el. 604.6) Date 6/23/77

SAMPLER: 2" O.D SPLIT BARREL SAMPLER

LOG of BORING No. B-504

DATE 6/23/77 SURFACE ELEV. 623.6 LOCATION N 00+92 E 43+74

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		36	See page 1 of boring log	575.6				
50		17	Medium dense to very dense medium to fine sand, trace silt; (SP)					
55		54		567.1				
60			End of Boring					

COMPLETION DEPTH 56.5' Water Depth 19.0' (el. 604.6) Date 6/23/77

SAMPLER: 2" O.D SPLIT BARREL SAMPLER

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LOG of BORING No. B-505

DATE 6/23/77 SURFACE ELEV. 625.1 LOCATION S 12+21 E 42+97

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		Black coarse to fine sand and gravel	624.1				
	7						
5	4						
	2						
10	5						
15	5	Very loose to medium dense brown to tan fine sand; (SP)					
20	8						
25	6						
30	6						
35	9		586.1				
40	68	Very dense tan-gray fine sandy clayey silt; (ML)	583.6				
		End of Boring					
45							

COMPLETION DEPTH 41.5 Water Depth 19.0' (el. 606.1) Date 6/23/77

SAMPLER: 3" O.D SPLIT BARREL SAMPLER

LOG of BORING No. B-506

DATE 6/20/77 SURFACE ELEV. 605.2 LOCATION S 17+30 E 49+06

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0	9						
5	7						
10	8						
15	4	Medium dense to tan medium to fine sand; (SP)					
20	9		580.7				
25	22						
30	12	Dense tan fine sand; (SP)					
35	31		569.2				
		Very dense gray fine clayey silt, trace medium to fine sand; (ML)					
40	68		563.7				
		End of Boring					
45							

COMPLETION DEPTH 41.5' Water Depth 12.0' (el. 593.2) Date 6/20/77

SAMPLER: 3" O.D SPLIT BARREL SAMPLER

LOG of BORING No. B-507

DATE 6/20/77 SURFACE ELEV. 603.0 LOCATION S 11+01 E 52+75

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0							
	6						
5	8						
	8	Medium dense tan fine sand ; (SP)					
10	7						
15	10		585.0				
20	26	Very dense tan medium to fine sand ; (SP)	580.0				
25	32	Very dense gray clayey silt; (ML)					
30	88		571.5				
35		End of Boring					

COMPLETION DEPTH 31.5 Water Depth 6.5' (el. 596.5) Date 6/20/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Page 1 of 2

LOG of BORING No. B508

DATE 6/24/77 SURFACE ELEV. 626.4 LOCATION S 00+52 E 31+00

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0	38	Dense to very dense black coarse to fine sand and gravel (bottom ash)					
5	14		618.4				
10	27						
15	22	Dense to very dense tan fine sand ; (SP)					
20	40						
25	16		598.4				
30	7	Loose tan medium to fine sand ; (SP)					
35	8		588.4				
40	29	Dense tan-gray fine sand ; (SP)					
45	26	(continued)					

COMPLETION DEPTH 56.5' Water Depth 21.0' (el. 605.4) Date 6/24/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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Page 2 of 2

LOG of BORING No. B-508

DATE 6/24/77 SURFACE ELEV. 626.4 LOCATION S 00+52 E 31+00

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		26	See page 1 of boring log					
50		21		573.4				
55		40	Very dense gray fine sand; (SP)	567.9				
60			End of Boring					

COMPLETION DEPTH 56.5' Water Depth 21.0' (el. 605.4) Date 6/24/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 1 of 2

LOG of BORING No. B-509

DATE 6/24/77 SURFACE ELEV. 623.2 LOCATION S 1+17 E 31+57

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		2						
5		3						
		2	Very loose black fine sand some silt (Fly Ash)					
10		WOH						
15		WOH						
20		2		601.2				
25		14	Medium dense tan-gray fine sand, trace medium sand; (SP)					
30		10		593.2				
35		30	Medium dense to dense tan fine sand; (SP)					
40		19						
45		33	(continued)					

COMPLETION DEPTH 56.5 Water Depth 15.0' (el. 608.2) Date 6/27/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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Sheet 2 of 2

LOG of BORING No. B-509

DATE 6/24/77 SURFACE ELEV. 623.2 LOCATION S 1+17 E 31+57

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		33	See page 1 of Boring Log					
50		27		569.2				
55		100	Very dense gray silt and fine sand; (ML)	566.7				
			End of Boring					
60								

COMPLETION DEPTH 56.5 Water Depth 15.0' (el. 608.2) Date 6/27/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

LOG of BORING No. B-510

DATE 6/27/77 SURFACE ELEV. 605.9 LOCATION S 16+32 E 23+78

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		6						
5		7						
		8						
10		6	Loose to medium dense brown to tan fine sand; (SP)					
15		5		585.9				
20		27	Medium dense to dense brown to tan fine sand; (SP)					
25		14		577.8				
30		21	Medium dense gray fine sand. Trace medium sand; (SP)					
35		12		567.8				
40		49	Very dense gray fine sand and silt; (SM)	564.3				
			End of Boring					
45								

COMPLETION DEPTH 41.5 Water Depth 10.0' (el. 595.9) Date 6/27/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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LOG of BORING No. B-511

DATE 6/17/77 SURFACE ELEV. 606.0 LOCATION N 8+80 E 24+00

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0–10	7, 7, 5	Medium dense tan fine sand; (SP)	596.0				
10–18	15, 23	Medium dense to dense tan medium to fine sand. Trace coarse sand and fine gravel; (SP)	588.0				
18–28	23, 28	Dense tan medium to fine sand; (SP)	578.0				
28–39	13, 45	Medium dense to very dense gray to tan-gray fine sand; (SP)	567.0				
39–46.5	33, 62	Very dense gray fine sand and silt; (SM)	559.5				

COMPLETION DEPTH 46.5 Water Depth 6.0' (el. 600.0) Date 6/17/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

LOG of BORING No. B-512

DATE 6/27/77 SURFACE ELEV. 602.7 LOCATION S 2+20 E 20+00

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0–1		Brown silty sand with vegetation	601.7				
1–13	9, 11, 8, 4	Loose to medium dense brown to tan fine sand; (SP)	589.7				
13–27	9, 17, 19	Medium dense gray fine sand; (SP)	575.7				
27–31.5	139	Very dense gray silt and fine sand; (ML)	571.2				
		End of Boring					

COMPLETION DEPTH 31.5 Water Depth 5.0' (el. 597.7) Date 6/27/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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LOG of BORING No. B-513

DATE 6/24/77 SURFACE ELEV. 625.5 LOCATION S 00+16 / 3 32+54

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0	5	Very loose to loose gray fine sand, some silt. (Fly Ash)					
5	3						
	5						
10	4						
15	2						
20			605.5				
	2	Very loose to medium dense brown to tan fine sand; (SP)					
25	12						
30	9						
35	6						
			587.5				
40	45	Very dense tan-gray fine sand; (SP)					
45	42		579.0				

COMPLETION DEPTH 46.5 Water Depth 15.0' (el. 610.5) Date 6/24/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

LOG of BORING No. B-514

DATE 6/22/77 SURFACE ELEV. 623.9 LOCATION S 11+97 / E 36+52

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		Black gravelly coarse to fine sand. Trace silt (Bottom Ash)	622.9				
	15	Medium dense to dense brown to tan fine sand. Trace medium sand; (SP)					
5	17						
	16						
10	13						
15	6						
20	9						
25	13						
30	8						
35	23						
40	18	Medium dense gray silt and fine sand; (ML)	583.4 / 582.4				
		End of Boring					
45							

COMPLETION DEPTH 41.5 Water Depth 15.0' (el. 608.9) Date 6/22/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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LOG of BORING No. B-515

DATE 6/28/77 SURFACE ELEV. 607.4 LOCATION S 17+30 E 38+30

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
		5						
5		5						
		9						
10		6	Very loose to medium dense brown to tan fine sand; (SP)					
15		2						
20		5		584.4				
25		26	Dense tan fine sand; (SP)	576.9				
30		54	Very dense gray fine sand; (SP)	575.9				
			End of Boring					
35								

COMPLETION DEPTH 31.5 Water Depth 5.0' (el. 602.4) Date 6/28/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 1 of 2

LOG of BORING No. B-516

DATE 6/24/77 SURFACE ELEV. 624.6 LOCATION N 8+-1 E 35+39

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0			Black coarse to fine sand and gravel (Bottom Ash)	623.6				
		16						
5		8						
		2						
10		3						
15		2	Very loose to medium dense tan and brown fine sand; (SP)					
20		7		599.6				
25		11						
30		8						
35		21	Medium dense tan-gray coarse to fine sand; (SP)					
40		29						
45		18	(continued)					

COMPLETION DEPTH 51.5 Water Depth 21.5' (el. 603.1) Date 6/24/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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Sheet 2 of 2

LOG of BORING No. B-516

DATE 6/24/77 SURFACE ELEV. 624.6 LOCATION N 8+01 E 35+39

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		18	See Page 1 of Boring Log	577.6				
50		52	Very dense gray fine sand; (SP)	573.1				
55			End of Boring					

COMPLETION DEPTH 51.5 Water Depth 21.5' (el. 603.1) Date 6/24/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 1 of 2

LOG of BORING No. B-517

DATE 6/22/77 SURFACE ELEV. 624.8 LOCATION S 7+10 E 25+30

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		14	Medium dense to dense black coarse to fine sand, little coarse to fine gravel, trace of silt; (SP)					
5		31						
		10						
10		17						
15		21		606.8				
20		9	Medium dense tan fine sand; (SP)					
25		8						
30		8		591.8				
35		22	Medium dense tan fine sand, trace medium sand; (SP)					
40		24						
45		24	(continued)					

COMPLETION DEPTH 91.5 Water Depth 27.5' (el. 597.3) Date 6/21/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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Sheet 1 of 2

LOG of BORING No. B518

DATE 6/22/77 SURFACE ELEV. 622.0 LOCATION S 6+60 E 25+35

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0							
	12						
5	5	Black silty fine sand. Trace fine gravel (Fly Ash-Bottom Ash)					
	2						
10	13						
15	2						
20			602.0				
	22						
25	8	Loose to dense tan fine sand; (SP)					
30	4						
35	29						
40	24						
45	13	(continued)					

COMPLETION DEPTH 56.5 Water Depth 16.0' (el. 606.0) Date 6/22/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 2 of 2

LOG of BORING No. B-517

DATE 6/22/77 SURFACE ELEV. 624.8 LOCATION S 7+10 E 25+30

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45	24	See Page 1 of Boring Log	576.8				
50	37	Dense gray fine sand and silt; (SM)	569.8				
55	22						
60	20	Gray silt some fine sand; (ML)					
65	19						
70	18		549.8				
75	21						
80	24	Gray clayey silt, trace fine sand; (ML)					
85	33						
90	26		533.3				

COMPLETION DEPTH 91.5 Water Depth 22.5' (el. 597.3) Date 6/21/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Sheet 2 of 2

LOG of BORING No. B-518

DATE 6/22/77 SURFACE ELEV. 622.0 LOCATION S 6+60 E 25+35

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45	13	See Page 1 of Boring Log					
50	32		570.0				
55	81	Very dense gray silt and fine sand; (ML)	565.5				
60		End of Boring					

COMPLETION DEPTH 56.5 Water Depth 16.0' (el. 606.0) Date 6/22/77
SAMPLER: 2" O.D SPLIT BARREL SAMPLER

LOG of BORING No. B519

DATE 6/22/77 SURFACE ELEV. 617.4 LOCATION S 7+60 N 25+35

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0	1	Very loose gray silt and fine sand (Fly Ash)					
5	3		611.4				
	5	Loose tan fine sand and black fine gravelly coarse to fine sand (Bottom Ash)					
10	5		605.4				
15	5						
20	8						
25	2	Very loose to medium dense tan fine sand; (SP)					
30	16						
35	15		580.4				
		Dense tan fine sand; (SP)					
40	23		575.4				
		Very dense gray silt and fine sand; (ML)					
45	87		570.9				

COMPLETION DEPTH 46.5 Water Depth 12.5' (el. 604.9) Date 6/22/77
SAMPLER: 2" O.D SPLIT BARREL SAMPLER

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Sheet 1 of 2

LOG of BORING No. B-520

DATE 6/22/77 SURFACE ELEV. 623.1 LOCATION S 16+15 E 29+70

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
	27	Black coarse to fine sand some coarse to fine gravel (Fly Ash)					
5	32		616.1				
	18	Medium dense brown fine sand; (SP)					
10	17						
15	9		608.1				
20	7	Medium dense tan fine sand; (SP)					
25	11						
30	11						
35	7						
40	16						
45	21	(continued)					

COMPLETION DEPTH 56.5 Water Depth 20.0' (el. 603.1) Date 6/22/77
SAMPLER 2" O.D SPLIT BARREL SAMPLER

Sheet 2 of 2

LOG of BORING No. B-520

DATE 6/22/77 SURFACE ELEV. 623.1 LOCATION S 16+15 E 29+70

DEPTH, FEET	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45	21	See Page 1 of Boring Log	575.1				
50	34	Dense tan-gray fine sand; (SP)	571.1				
55	20	Gray clayey silt; (ML)	566.5				
		End of Boring					
60							

COMPLETION DEPTH 56.5 Water Depth 20.0' (el. 603.1) Date 6/22/77
SAMPLER: 2" O.D SPLIT BARREL SAMPLER

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Sheet 1 of 2

LOG of BORING No. B-522

DATE 6/23/77 SURFACE ELEV. 625.3 LOCATION S 12+80 E 19+01

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		16	Medium dense to very dense black fine gravelly coarse to fine sand. Trace silt (Bottom Ash)					
5		21						
		22						
10		11						
15		8	Medium dense brown to tan fine sand. Trace medium sand; (SP)	609.8				
20		11						
25		11						
30		10						
35		5						
40		13		582.3				
45		33	(continued)					

COMPLETION DEPTH 56.5 Water Depth 24.0' (el. 601.3) Date 6/23/77

SAMPLER 2" O.D. SPLIT BARREL SAMPLER

Sheet 2 of 2

LOG of BORING No. B-522

DATE 6/23/77 SURFACE ELEV. 625.3 LOCATION S 12+80 E 19+01

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		33	Dense tan fine sand. Trace medium sand; (SP)					
50		23		572.3				
55		77	Very dense gray fine sand and silt; (SM)	567.8				
60			End of Boring					

COMPLETION DEPTH 56.5 Water Depth 24.0' (el. 601.3) Date 6/23/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

LOG of BORING No. B-524

DATE 6/27/77 SURFACE ELEV. 608.7 LOCATION S 16+20 E 18+98

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
		10						
5		7						
		10						
10		9	Medium dense tan fine sand. Trace medium sand; (SP)					
15		6						
20		12						
25		14						
30		10						
35		14	Medium dense gray fine sand. Trace medium sand; (SP)					
40		59	Very dense gray fine sand and silt; (SM)					
			End of Boring					
45								

COMPLETION DEPTH 41.5 Water Depth 10.0' (el. 598.7) Date 6/27/77

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

Page 1 of 2

LOG of BORING No. 176

DATE 11/1/73 SURFACE ELEV. 610.5 LOCATION See Plate 2

DEPTH, FEET	SAMPLES	SAMPLING RESISTANCE	DESCRIPTION	ELEVATION	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0								
		10	Brown loose fine sand	607.5				
5		27						
		11	Brown medium dense medium to fine sand					
10		14						
15		14		593.5				
20		55						
25		62						
30		46	Light gray and tan very dense coarse to fine sand, trace gravel and silt					
35		46						
40		30						
45		33	(cont'd)					

COMPLETION DEPTH 61' Water Depth 8.9' Date 11/1/73

SAMPLER: 2" O.D. SPLIT BARREL SAMPLER

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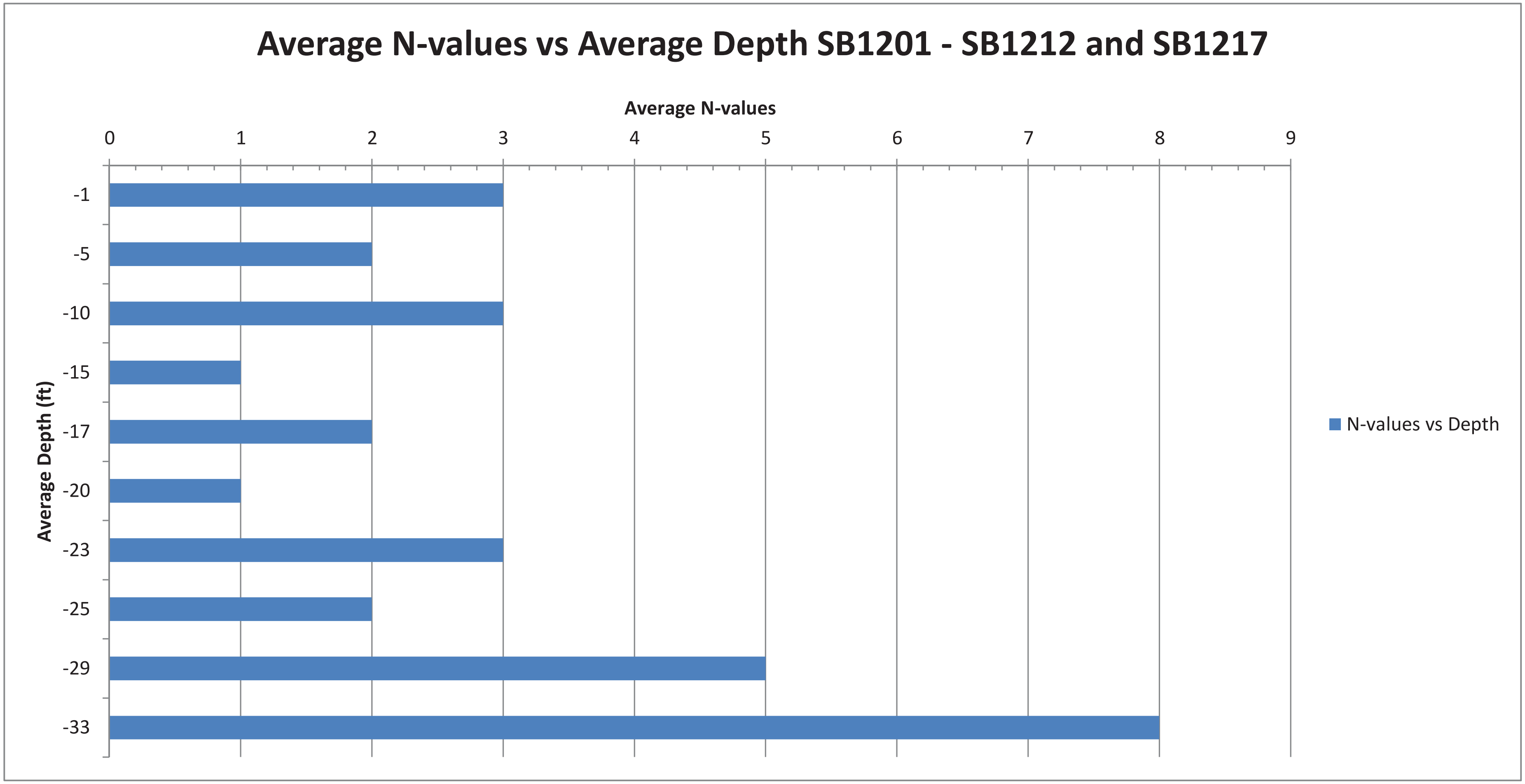
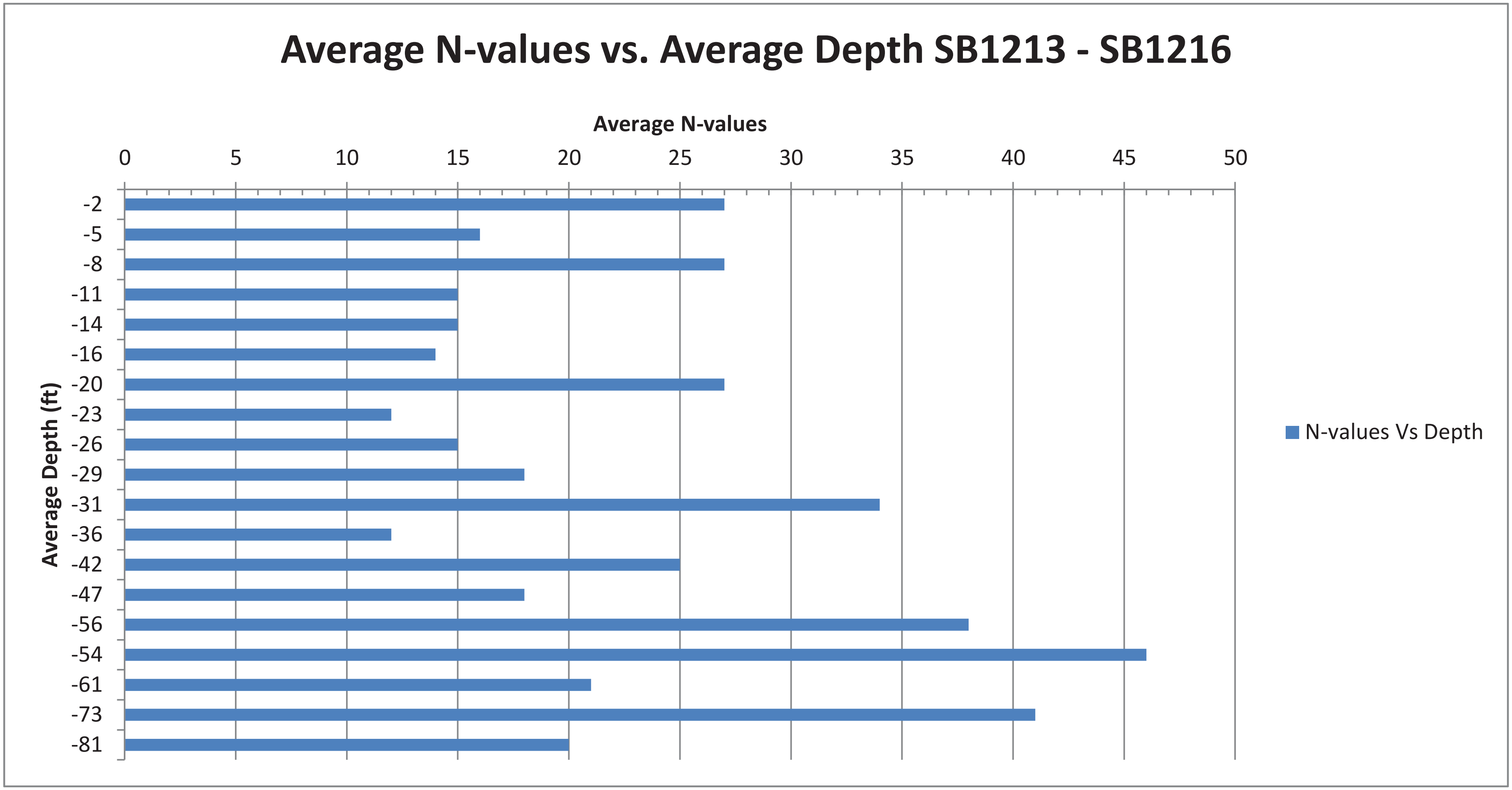
APPENDIX D

Moisture & N-value vs. Depth Plots

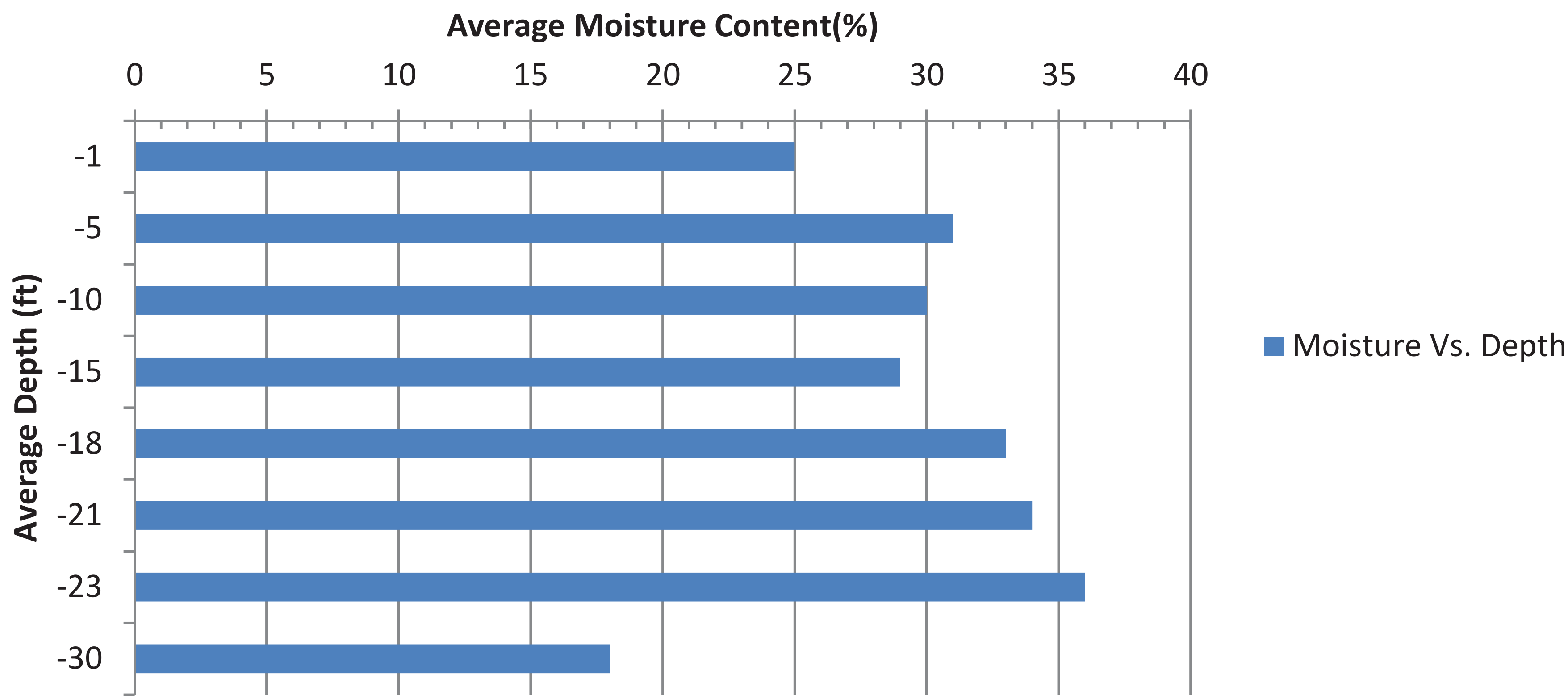


Golder Associates

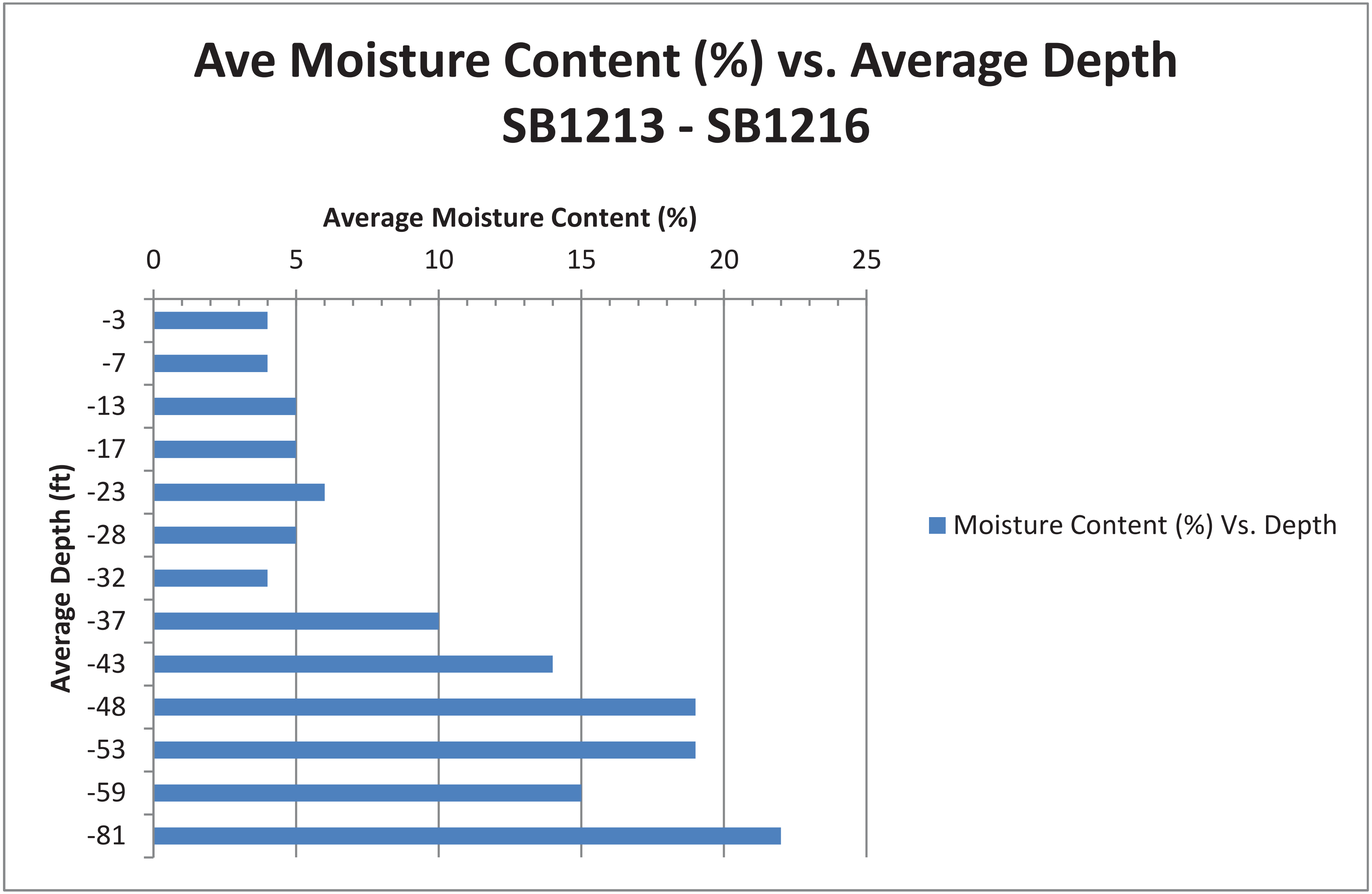


Average N-values vs. Average Depth SB1213 - SB1216
Average N-values
0
5
10
15
20
25
30
35
40
45
50
Average Depth (ft)
-2
-5
-8
-11
-14
-16
-20
-23
-26
-29
-31
-36
-42
-47
-56
-54
-61
-73
-81
N-values Vs Depth

Ave Moisture Content (%) vs. Average Depth
SB1201 - SB1212 and SB1217



Golder Associates



Golder Associates

APPENDIX E

Soils Laboratory Results

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896

SAMPLE ID:	SB-1201
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	5.0'-7.0'

DESCRIPTION:	Dark grayish brown, Silt, some sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	34.97
Weight of Dry Soil & Tare	32.26
Weight of Tare	14.34
Weight of Water	2.71
Weight of Dry Soil	17.92
Water Content	15.12%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	RS
REVIEW	BSJ

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1201
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	5.0'-7.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	34.97
Wt. Dry Soil & Tare (gm)	(W2)	32.26
Weight of Tare (gm)	(W3)	14.34
Weight of Water (gm)	(W4=W1-W2)	2.71
Weight of Dry Soil (gm)	(W5=W2-W3)	17.92
Moisture Content (%)	(W4/W5)*100	15.12%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	34.26
Dry Soil & Tare (gm)	34.19
Tare Weight (gm)	14.01
Moisture Content (%)	0.35

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	712.50	
Tare Weight (gm)	215.50	
Total Weight (gm)	495.28	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.16
Calculated Dry Wt. used in test (gm)	49.99
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 97.23

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	97.23	0.00	**100.0**	#10	medium sand
#20	97.25	0.02	**100.0**	#20	medium sand
#40	97.49	0.26	**99.5**	#40	fine sand
#60	97.80	0.57	**98.9**	#60	fine sand
#100	98.88	1.65	**96.7**	#100	fine sand
#200	103.72	6.49	**87.0**	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 12:29	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	12:31	2.00	38.0	21.00	0.013	5.83	32.17	10.1	1.00
6/22/2012	12:34	5.00	31.0	21.00	0.013	5.83	25.17	11.2	1.00
6/22/2012	12:44	15.00	24.0	21.00	0.013	5.83	18.17	12.4	1.00
6/22/2012	12:59	30.00	20.0	21.00	0.013	5.83	14.17	13.0	1.00
6/22/2012	13:29	60.00	16.0	21.00	0.013	5.83	10.17	13.7	1.00
6/22/2012	16:39	250.00	11.0	21.00	0.013	5.83	5.17	14.5	1.00
6/23/2012	12:29	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0303	64.4	% COARSE GRAVEL	0.00	
0.0202	50.3	% FINE GRAVEL	0.00	0.00
0.0123	36.3	% COARSE SAND	0.00	
0.0089	28.3	% MEDIUM SAND	0.52	
0.0064	20.3	% FINE SAND	12.46	12.98
0.0032	10.3	% FINES	87.02	
0.0014	2.3	% TOTAL SAMPLE	100.00	

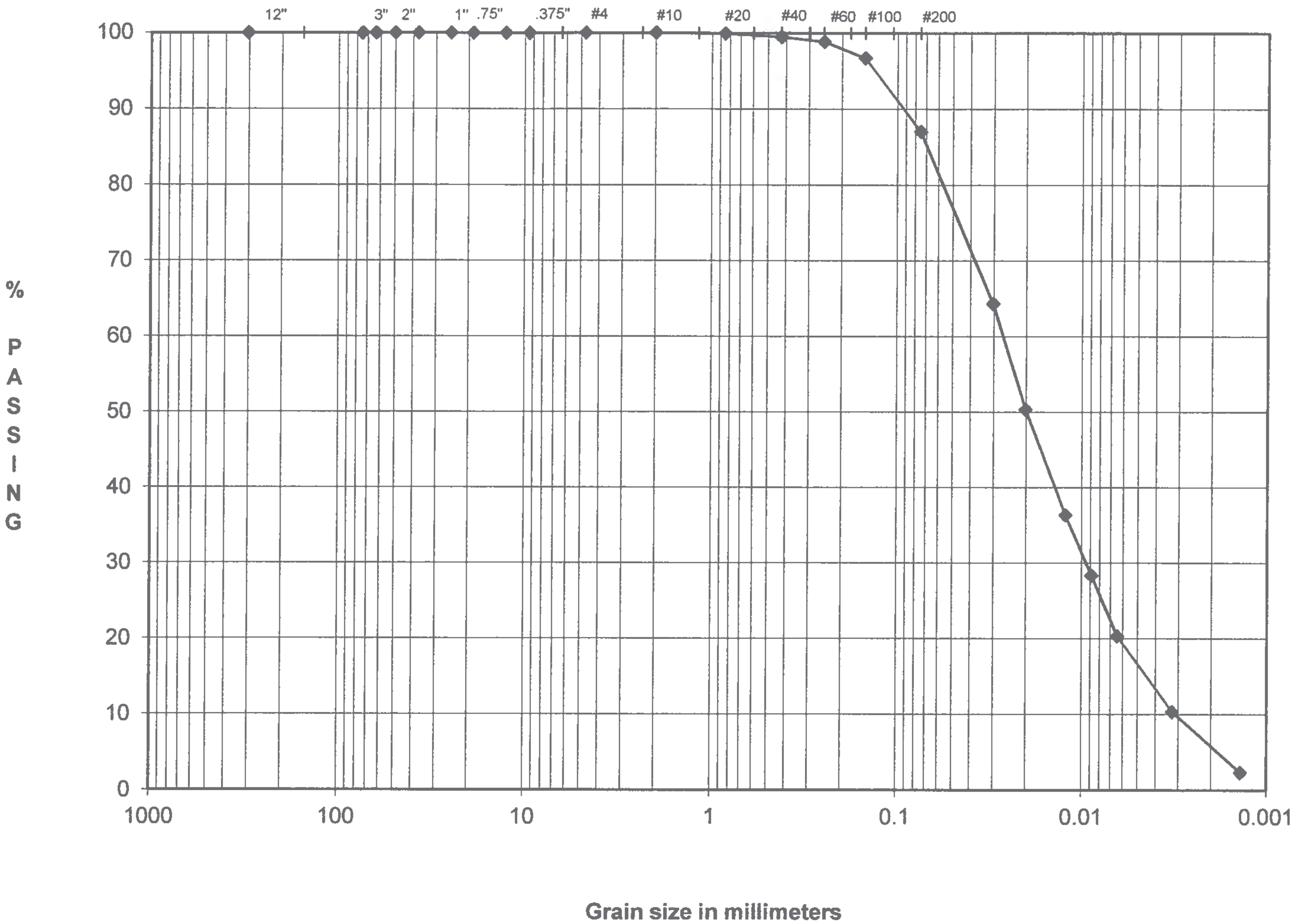
Description Dark grayish brown, Silt, some sand

USCS FLY ASH/ML

-	LL
-	PL
-	PI

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BSJ

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		SAND			FINES
		0.00		12.98			87.02

SAMPLE ID	SB-1201
SAMPLE TYPE	Jar
SAMPLE DEPTH	5.0'-7.0'

LL	-
PL	-
PI	-

DESCRIPTION	Dark grayish brown, Silt, some sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	ESU

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:	PROJECT NAME:	Consumers Campbell Ash Impoundment
	PROJECT NUMBER:	123-88896
	SAMPLE ID:	SB-1202
	SAMPLE TYPE:	Jar
	SAMPLE DEPTH:	23.0'-25.0'
	DESCRIPTION:	Greenish gray, SILT, trace sand
	USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:		
	Weight of Wet Soil & Tare	36.16
	Weight of Dry Soil & Tare	29.73
	Weight of Tare	14.16
	Weight of Water	6.43
	Weight of Dry Soil	15.57
	Water Content	41.30%

TITLE BLOCK:		
	TECH	CB
	DATE	06/19/12
	CHECK	PS
	REVIEW	BST

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1202
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	23.0'-25.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	36.16
Wt. Dry Soil & Tare (gm)	(W2)	29.73
Weight of Tare (gm)	(W3)	14.16
Weight of Water (gm)	(W4=W1-W2)	6.43
Weight of Dry Soil (gm)	(W5=W2-W3)	15.57
Moisture Content (%)	(W4/W5)*100	41.30%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	34.46
Dry Soil & Tare (gm)	33.53
Tare Weight (gm)	13.88
Moisture Content (%)	4.73

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	883.10	
Tare Weight (gm)	219.40	
Total Weight (gm)	633.71	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.41
Calculated Dry Wt. used in test (gm)	48.13
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.48

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.52	0.04	99.9	#10	medium sand
#20	30.62	0.14	99.7	#20	medium sand
#40	30.72	0.24	99.5	#40	fine sand
#60	30.83	0.35	99.3	#60	fine sand
#100	31.08	0.60	98.8	#100	fine sand
#200	32.23	1.75	96.4	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 12:27	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	12:29	2.00	48.0	21.00	0.013	5.83	42.17	8.4	1.00
6/22/2012	12:32	5.00	43.0	21.00	0.013	5.83	37.17	9.2	1.00
6/22/2012	12:42	15.00	33.0	21.00	0.013	5.83	27.17	10.9	1.00
6/22/2012	12:57	30.00	27.0	21.00	0.013	5.83	21.17	11.9	1.00
6/22/2012	13:27	60.00	22.0	21.00	0.013	5.83	16.17	12.7	1.00
6/22/2012	16:37	250.00	15.0	21.00	0.013	5.83	9.17	13.8	1.00
6/23/2012	12:27	1440.00	9.0	21.00	0.013	5.83	3.17	14.8	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0276	87.6	% COARSE GRAVEL	0.00	
0.0183	77.2	% FINE GRAVEL	0.00	0.00
0.0115	56.4	% COARSE SAND	0.08	
0.0085	44.0	% MEDIUM SAND	0.42	
0.0062	33.6	% FINE SAND	3.14	3.64
0.0032	19.0	% FINES	96.36	
0.0014	6.6	% TOTAL SAMPLE	100.00	

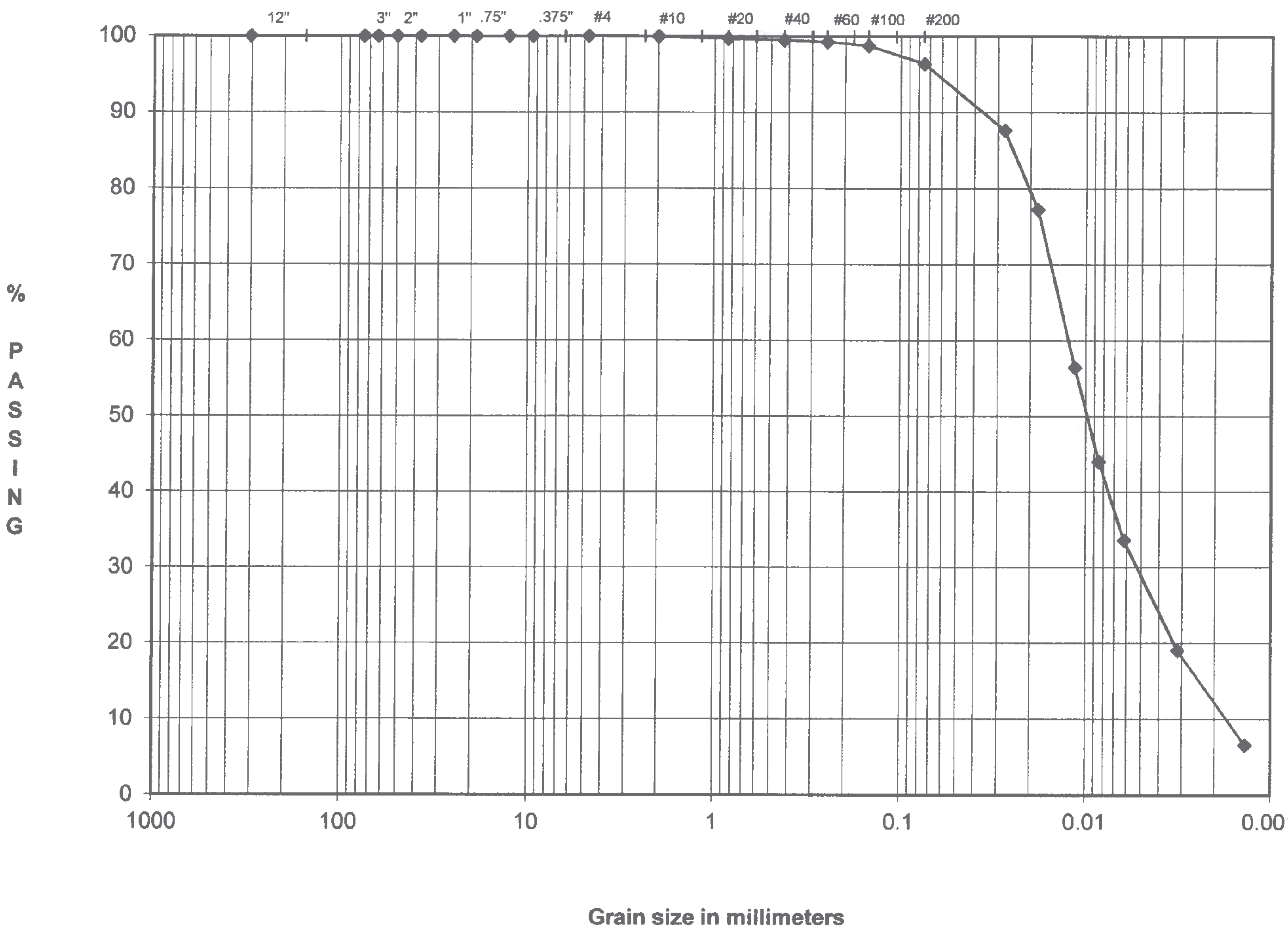
Description Greenish gray, SILT, trace sand

USCS FLY ASH/ML

-	LL
-	PL
-	PI

TECH	CB
DATE	6/19/2012
CHECK	TD
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	GRAVEL		SAND			FINES
		0.00		3.64			96.36

SAMPLE ID	SB-1202
SAMPLE TYPE	Jar
SAMPLE DEPTH	23.0'-25.0'

LL	-
PL	-
PI	-

DESCRIPTION	Greenish gray, SILT, trace sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BST

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896

SAMPLE ID:	SB-1203
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	22.0'-24.0'

DESCRIPTION:	Greenish gray, SILT, some sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	36.03
Weight of Dry Soil & Tare	29.21
Weight of Tare	13.79
Weight of Water	6.82
Weight of Dry Soil	15.42
Water Content	44.23%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	TDS
REVIEW	BJT

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1203
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	22.0'-24.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	36.03
Wt. Dry Soil & Tare (gm)	(W2)	29.21
Weight of Tare (gm)	(W3)	13.79
Weight of Water (gm)	(W4=W1-W2)	6.82
Weight of Dry Soil (gm)	(W5=W2-W3)	15.42
Moisture Content (%)	(W4/W5)*100	44.23%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	37.03
Dry Soil & Tare (gm)	36.96
Tare Weight (gm)	13.79
Moisture Content (%)	0.30

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	813.60	
Tare Weight (gm)	217.40	
Total Weight (gm)	594.40	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.67
Calculated Dry Wt. used in test (gm)	50.52
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 96.09

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	96.20	0.11	99.8	#10	medium sand
#20	96.32	0.23	99.5	#20	medium sand
#40	96.39	0.30	99.4	#40	fine sand
#60	96.65	0.56	98.9	#60	fine sand
#100	97.78	1.69	96.7	#100	fine sand
#200	102.69	6.60	86.9	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 11:41	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	11:43	2.00	33.0	21.00	0.013	5.83	27.17	10.9	1.00
6/22/2012	11:46	5.00	19.0	21.00	0.013	5.83	13.17	13.2	1.00
6/22/2012	11:56	15.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/22/2012	12:11	30.00	11.0	21.00	0.013	5.83	5.17	14.5	1.00
6/22/2012	12:41	60.00	11.0	21.00	0.013	5.83	5.17	14.5	1.00
6/22/2012	15:51	250.00	9.0	21.00	0.013	5.83	3.17	14.8	1.00
6/23/2012	11:41	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0315	53.8	% COARSE GRAVEL	0.00	
0.0219	26.1	% FINE GRAVEL	0.00	0.00
0.0132	12.2	% COARSE SAND	0.22	
0.0094	10.2	% MEDIUM SAND	0.38	
0.0066	10.2	% FINE SAND	12.47	13.06
0.0033	6.3	% FINES	86.94	
0.0014	2.3	% TOTAL SAMPLE	100.00	

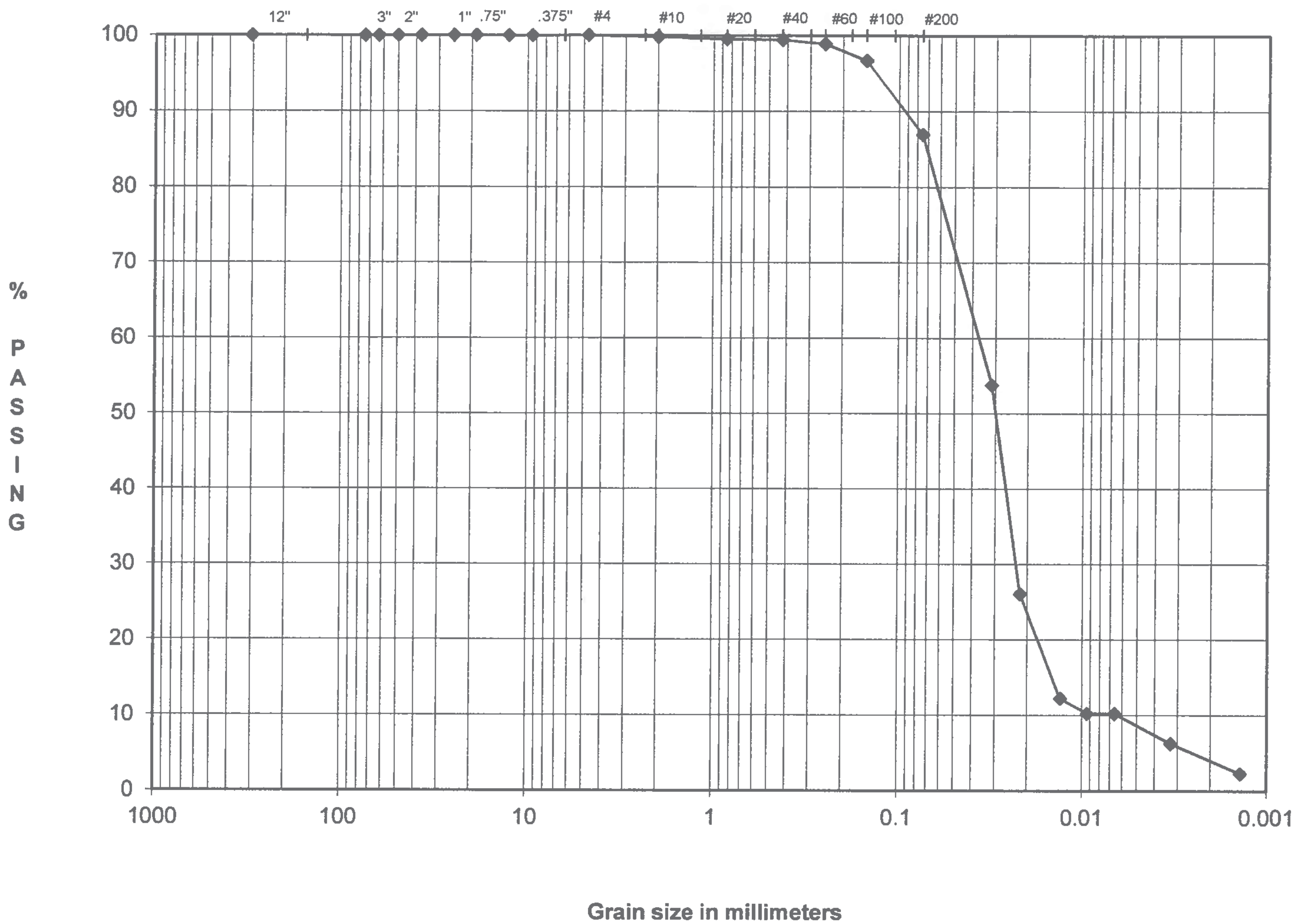
Description Greenish gray, SILT, some sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BH

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		0.00		13.06			86.94

SAMPLE ID	SB-1203
SAMPLE TYPE	Jar
SAMPLE DEPTH	22.0'-24.0'

LL	-
PL	-
PI	-

DESCRIPTION	Greenish gray, SILT, some sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BSW

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1204
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	15.0'-17.0'
DESCRIPTION:	Bluish gray, SILT, little sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	32.54
Weight of Dry Soil & Tare	27.84
Weight of Tare	13.36
Weight of Water	4.70
Weight of Dry Soil	14.48
Water Content	32.46%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	PJ
REVIEW	BSJ

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1204
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	15.0'-17.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	32.54
Wt. Dry Soil & Tare (gm)	(W2)	27.84
Weight of Tare (gm)	(W3)	13.36
Weight of Water (gm)	(W4=W1-W2)	4.70
Weight of Dry Soil (gm)	(W5=W2-W3)	14.48
Moisture Content (%)	(W4/W5)*100	32.46%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	32.60
Dry Soil & Tare (gm)	32.27
Tare Weight (gm)	13.99
Moisture Content (%)	1.81

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	734.60	
Tare Weight (gm)	216.40	
Total Weight (gm)	509.01	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.45
Calculated Dry Wt. used in test (gm)	49.56
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.81

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.87	0.06	99.9	#10	medium sand
#20	31.15	0.34	99.3	#20	medium sand
#40	31.62	0.81	98.4	#40	fine sand
#60	32.11	1.30	97.4	#60	fine sand
#100	32.98	2.17	95.6	#100	fine sand
#200	35.54	4.73	90.5	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 11:39	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	11:41	2.00	38.0	21.00	0.013	5.83	32.17	10.1	1.00
6/22/2012	11:44	5.00	32.0	21.00	0.013	5.83	26.17	11.1	1.00
6/22/2012	11:54	15.00	23.0	21.00	0.013	5.83	17.17	12.5	1.00
6/22/2012	12:09	30.00	18.0	21.00	0.013	5.83	12.17	13.3	1.00
6/22/2012	12:39	60.00	15.0	21.00	0.013	5.83	9.17	13.8	1.00
6/22/2012	15:49	250.00	10.0	21.00	0.013	5.83	4.17	14.7	1.00
6/23/2012	11:39	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
0.0303	64.9	% COBBLES	0.00	
0.0201	52.8	% COARSE GRAVEL	0.00	
0.0123	34.6	% FINE GRAVEL	0.00	0.00
0.0090	24.6	% COARSE SAND	0.12	
0.0065	18.5	% MEDIUM SAND	1.51	
0.0033	8.4	% FINE SAND	7.91	9.54
0.0014	2.4	% FINES	90.46	
		% TOTAL SAMPLE	100.00	

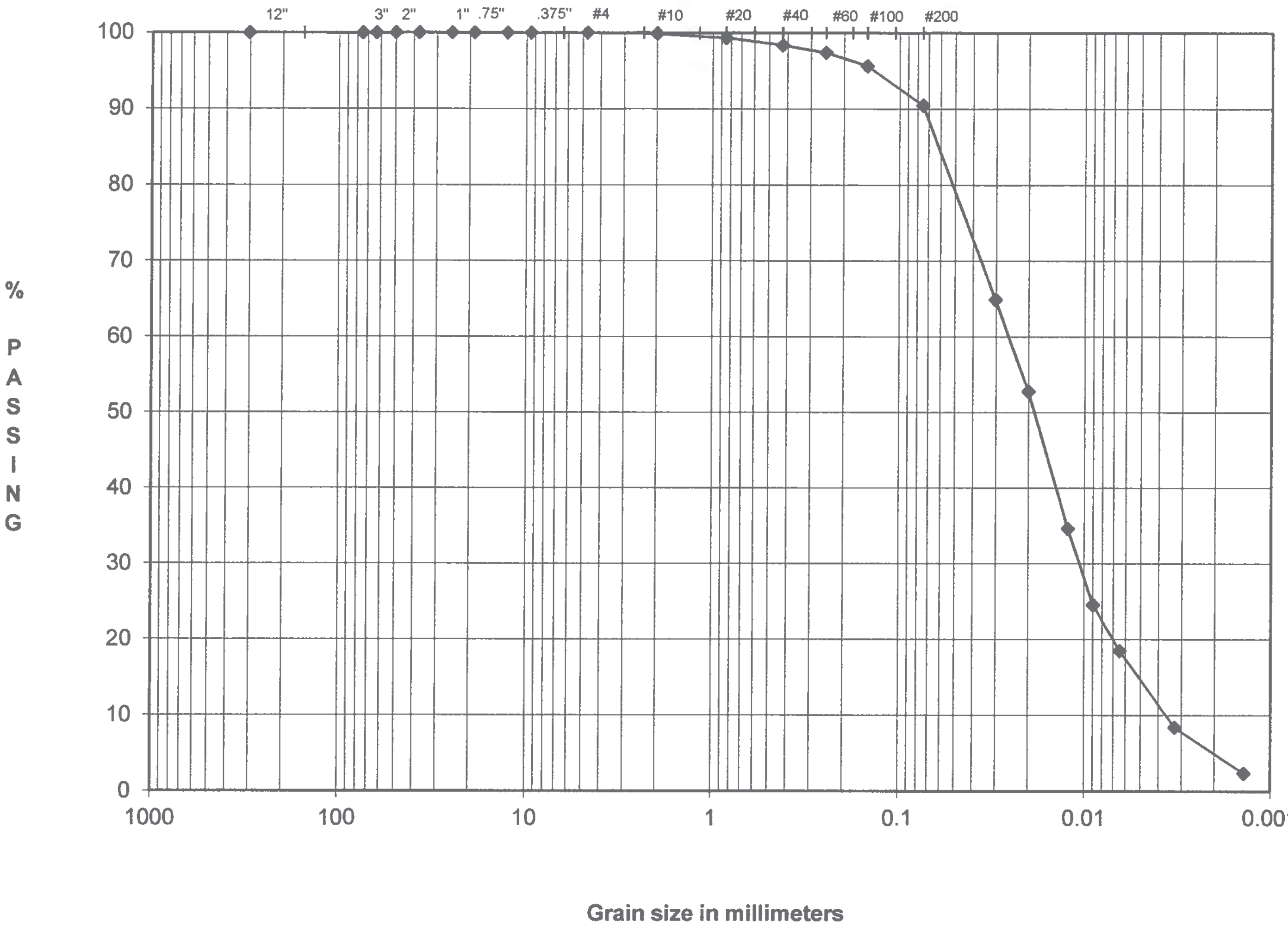
Description Bluish gray, SILT, little sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	TDS
REVIEW	BSW

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	GRAVEL		SAND			FINES
		0.00		9.54			90.46

SAMPLE ID	SB-1204
SAMPLE TYPE	Jar
SAMPLE DEPTH	15.0'-17.0'

LL	-
PL	-
PI	-

DESCRIPTION	Bluish gray, SILT, little sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BST

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:	PROJECT NAME:	Consumers Campbell Ash Impoundment
	PROJECT NUMBER:	123-88896
	SAMPLE ID:	SB-1205
	SAMPLE TYPE:	Jar
	SAMPLE DEPTH:	0.0'-2.0'
	DESCRIPTION:	Bluish gray, SILT, trace sand
	USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	33.60
Weight of Dry Soil & Tare	29.51
Weight of Tare	14.07
Weight of Water	4.09
Weight of Dry Soil	15.44
Water Content	26.49%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	TDS
REVIEW	BSV

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1205
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	0.0'-2.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	33.60
Wt. Dry Soil & Tare (gm)	(W2)	29.51
Weight of Tare (gm)	(W3)	14.07
Weight of Water (gm)	(W4=W1-W2)	4.09
Weight of Dry Soil (gm)	(W5=W2-W3)	15.44
Moisture Content (%)	(W4/W5)*100	26.49%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	34.18
Dry Soil & Tare (gm)	33.66
Tare Weight (gm)	14.06
Moisture Content (%)	2.65

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	869.90	
Tare Weight (gm)	216.12	
Total Weight (gm)	636.88	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.70
Calculated Dry Wt. used in test (gm)	49.39
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.43

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.44	0.01	100.0	#10	medium sand
#20	30.46	0.03	99.9	#20	medium sand
#40	30.53	0.10	99.8	#40	fine sand
#60	30.62	0.19	99.6	#60	fine sand
#100	30.87	0.44	99.1	#100	fine sand
#200	32.42	1.99	96.0	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 11:37	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	11:39	2.00	43.0	21.00	0.013	5.83	37.17	9.2	1.00
6/22/2012	11:42	5.00	38.0	21.00	0.013	5.83	32.17	10.1	1.00
6/22/2012	11:52	15.00	30.0	21.00	0.013	5.83	24.17	11.4	1.00
6/22/2012	12:07	30.00	25.0	21.00	0.013	5.83	19.17	12.2	1.00
6/22/2012	12:37	60.00	21.0	21.00	0.013	5.83	15.17	12.9	1.00
6/22/2012	15:47	250.00	14.0	21.00	0.013	5.83	8.17	14.0	1.00
6/23/2012	11:37	1440.00	8.0	21.00	0.013	5.83	2.17	15.0	1.00

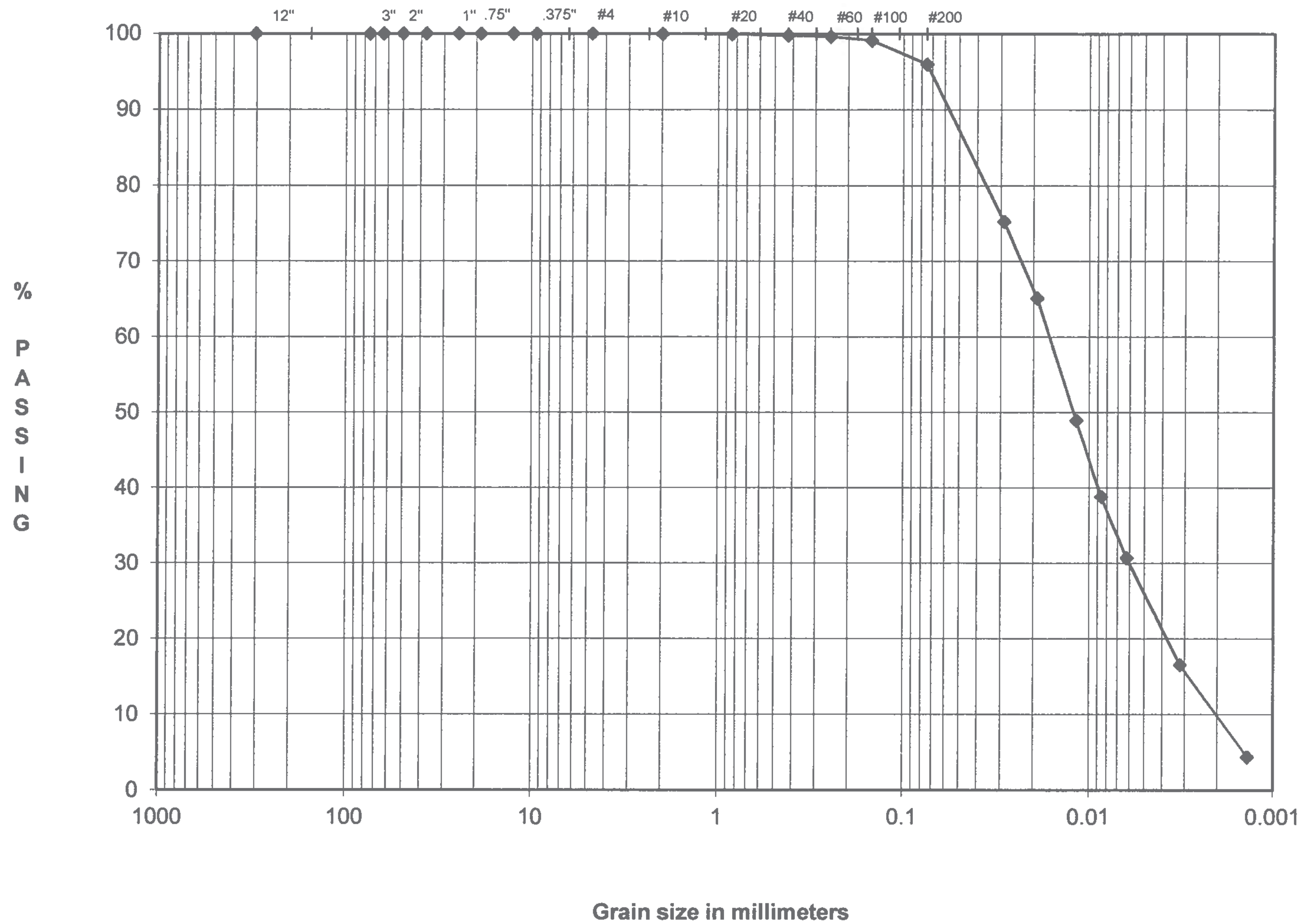
GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0289	75.3	% COARSE GRAVEL	0.00	
0.0192	65.1	% FINE GRAVEL	0.00	0.00
0.0118	48.9	% COARSE SAND	0.02	
0.0086	38.8	% MEDIUM SAND	0.18	
0.0063	30.7	% FINE SAND	3.83	4.03
0.0032	16.5	% FINES	95.97	
0.0014	4.4	% TOTAL SAMPLE	100.00	

Description	Bluish gray, SILT, trace sand
USCS	FLY ASH/ML
LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BSJ

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		0.00		4.03			95.97

SAMPLE ID	SB-1205
SAMPLE TYPE	Jar
SAMPLE DEPTH	0.0'-2.0'

LL	-
PL	-
PI	-

DESCRIPTION Bluish gray, SILT, trace sand

USCS **FLY ASH/ML**

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BJN

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:	PROJECT NAME:	Consumers Campbell Ash Impoundment
	PROJECT NUMBER:	123-88896
	SAMPLE ID:	SB-1206
	SAMPLE TYPE:	Jar
	SAMPLE DEPTH:	5.0'-7.0'
	DESCRIPTION:	Dark gray, SILT WITH SAND
	USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	30.12
Weight of Dry Soil & Tare	25.51
Weight of Tare	14.02
Weight of Water	4.61
Weight of Dry Soil	11.49
Water Content	40.12%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	PS
REVIEW	BSJ

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1206
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	5.0'-7.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	30.12
Wt. Dry Soil & Tare (gm)	(W2)	25.51
Weight of Tare (gm)	(W3)	14.02
Weight of Water (gm)	(W4=W1-W2)	4.61
Weight of Dry Soil (gm)	(W5=W2-W3)	11.49
Moisture Content (%)	(W4/W5)*100	40.12%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	35.70
Dry Soil & Tare (gm)	35.50
Tare Weight (gm)	14.02
Moisture Content (%)	0.93

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	641.50	
Tare Weight (gm)	225.90	
Total Weight (gm)	411.77	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.63
Calculated Dry Wt. used in test (gm)	50.16
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.18

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.18	0.00	100.0	#10	medium sand
#20	30.33	0.15	99.7	#20	medium sand
#40	30.65	0.47	99.1	#40	fine sand
#60	32.08	1.90	96.2	#60	fine sand
#100	37.06	6.88	86.3	#100	fine sand
#200	51.99	21.81	56.5	#200	fines

HYDROMETER CALCULATIONS

DATE 6/21/2012	TIME 9:23	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/21/2012	9:25	2.00	24.0	21.00	0.013	5.83	18.17	12.4	1.00
6/21/2012	9:28	5.00	20.0	21.00	0.013	5.83	14.17	13.0	1.00
6/21/2012	9:38	15.00	16.0	21.00	0.013	5.83	10.17	13.7	1.00
6/21/2012	9:53	30.00	14.0	21.00	0.013	5.83	8.17	14.0	1.00
6/21/2012	10:23	60.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/21/2012	13:33	250.00	10.0	21.00	0.013	5.83	4.17	14.7	1.00
6/22/2012	9:23	1440.00	9.0	21.00	0.013	5.83	3.17	14.8	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0336	36.2	% COARSE GRAVEL	0.00	
0.0217	28.2	% FINE GRAVEL	0.00	0.00
0.0129	20.3	% COARSE SAND	0.00	
0.0092	16.3	% MEDIUM SAND	0.94	
0.0066	12.3	% FINE SAND	42.54	43.48
0.0033	8.3	% FINES	56.52	
0.0014	6.3	% TOTAL SAMPLE	100.00	

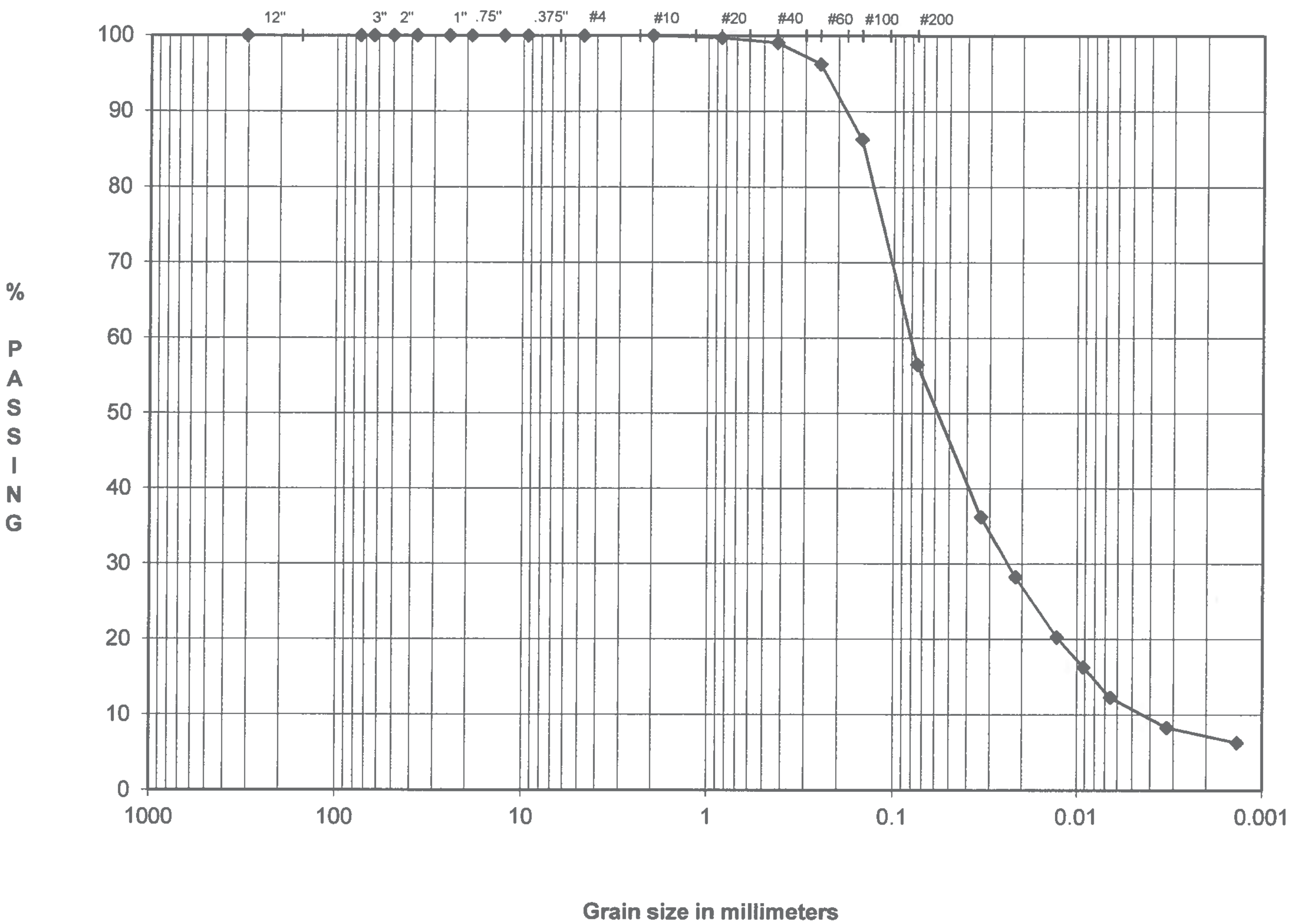
Description Dark gray, SILT WITH SAND

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	RPS
REVIEW	RGT

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		**SAND**			**FINES**
		0.00		43.48			56.52

SAMPLE ID	SB-1206
SAMPLE TYPE	Jar
SAMPLE DEPTH	5.0'-7.0'

LL	-
PL	-
PI	-

DESCRIPTION	Dark gray, SILT WITH SAND
USCS	**FLY ASH/ML**

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BST

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1207
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	10.0'-12.0'
DESCRIPTION:	Light greenish gray, SILT, some sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	27.78
Weight of Dry Soil & Tare	22.50
Weight of Tare	3.55
Weight of Water	5.28
Weight of Dry Soil	18.95
Water Content	27.86%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	DS
REVIEW	DST

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1207
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	10.0'-12.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	27.78
Wt. Dry Soil & Tare (gm)	(W2)	22.50
Weight of Tare (gm)	(W3)	3.55
Weight of Water (gm)	(W4=W1-W2)	5.28
Weight of Dry Soil (gm)	(W5=W2-W3)	18.95
Moisture Content (%)	(W4/W5)*100	27.86%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	33.16
Dry Soil & Tare (gm)	33.10
Tare Weight (gm)	13.64
Moisture Content (%)	0.31

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	607.50	
Tare Weight (gm)	215.40	
Total Weight (gm)	390.89	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING		
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	53.40
Calculated Dry Wt. used in test (gm)	53.24
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 95.35

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

	(Wt+Tare)	Cumul Wt. Retained	% PASSING		
#10	95.35	0.00	**100.0**	#10	medium sand
#20	95.36	0.01	**100.0**	#20	medium sand
#40	95.42	0.07	**99.9**	#40	fine sand
#60	95.77	0.42	**99.2**	#60	fine sand
#100	96.87	1.52	**97.1**	#100	fine sand
#200	104.53	9.18	**82.8**	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 11:43	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	11:45	2.00	35.0	21.00	0.013	5.83	29.17	10.6	1.00
6/22/2012	11:48	5.00	26.0	21.00	0.013	5.83	20.17	12.0	1.00
6/22/2012	11:58	15.00	16.0	21.00	0.013	5.83	10.17	13.7	1.00
6/22/2012	12:13	30.00	13.0	21.00	0.013	5.83	7.17	14.2	1.00
6/22/2012	12:43	60.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/22/2012	15:53	250.00	8.0	21.00	0.013	5.83	2.17	15.0	1.00
6/23/2012	11:43	1440.00	6.0	21.00	0.013	5.83	0.17	15.3	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0310	54.8	% COARSE GRAVEL	0.00	
0.0209	37.9	% FINE GRAVEL	0.00	0.00
0.0129	19.1	% COARSE SAND	0.00	
0.0093	13.5	% MEDIUM SAND	0.13	
0.0066	11.6	% FINE SAND	17.11	17.24
0.0033	4.1	% FINES	82.76	
0.0014	0.3	% TOTAL SAMPLE	100.00	

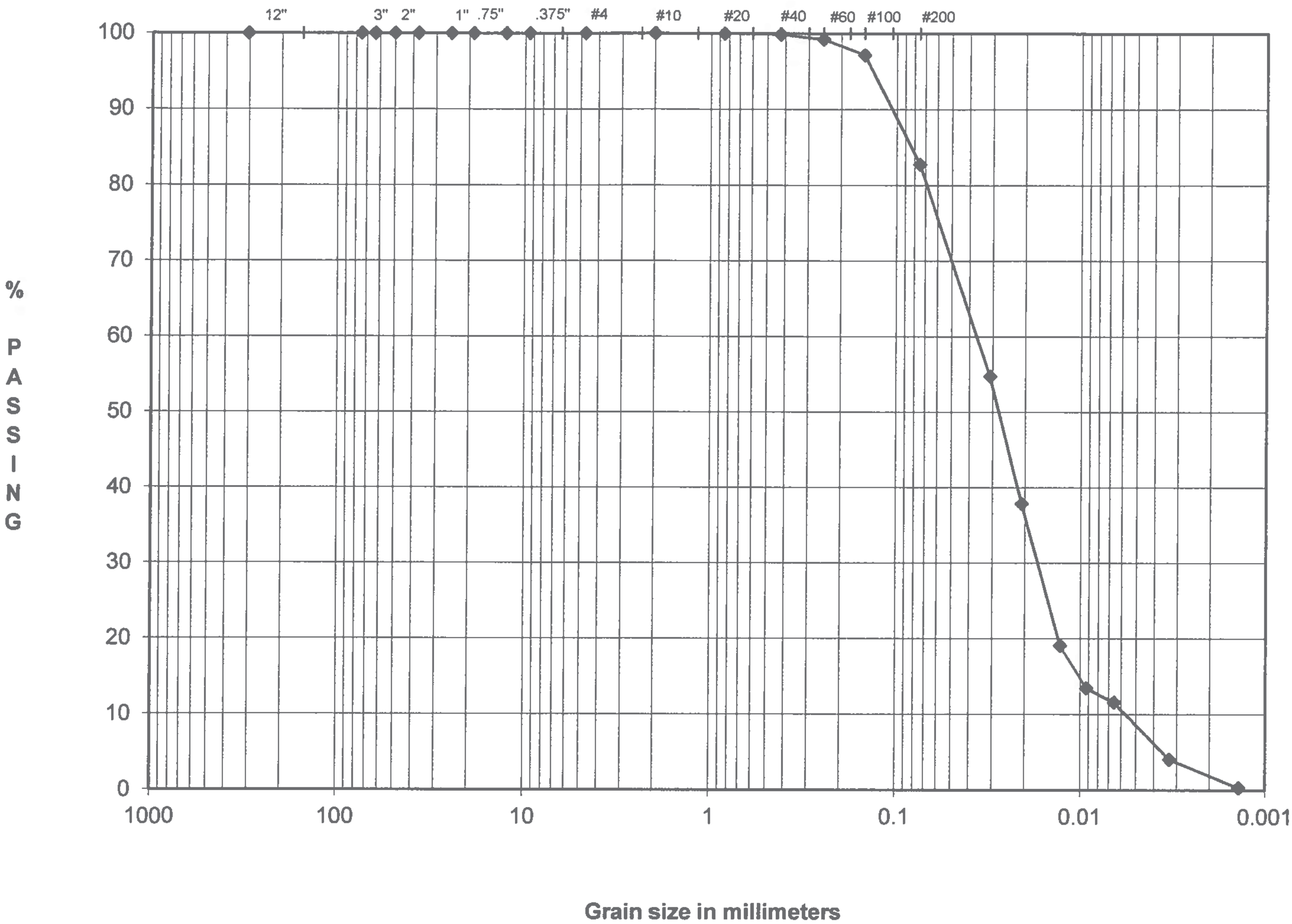
Description Light greenish gray, SILT, some sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	PS
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		0.00		17.24			82.76

SAMPLE ID	SB-1207
SAMPLE TYPE	Jar
SAMPLE DEPTH	10.0'-12.0'

LL	-
PL	-
PI	-

DESCRIPTION	Light greenish gray, SILT, some sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	[signature]
REVIEW	[signature]

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1208
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	14.0'-16.0'
DESCRIPTION:	Brownish yellow, SILT, some sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	29.78
Weight of Dry Soil & Tare	24.53
Weight of Tare	2.55
Weight of Water	5.25
Weight of Dry Soil	21.98
Water Content	23.89%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	TPS
REVIEW	BSV

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1208
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	14.0'-16.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	29.78
Wt. Dry Soil & Tare (gm)	(W2)	24.53
Weight of Tare (gm)	(W3)	2.55
Weight of Water (gm)	(W4=W1-W2)	5.25
Weight of Dry Soil (gm)	(W5=W2-W3)	21.98
Moisture Content (%)	(W4/W5)*100	23.89%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	47.28
Dry Soil & Tare (gm)	47.17
Tare Weight (gm)	14.08
Moisture Content (%)	0.33

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	730.80	
Tare Weight (gm)	216.30	
Total Weight (gm)	512.80	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.60
Calculated Dry Wt. used in test (gm)	50.43
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 97.22

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	97.22	0.00	100.0	#10	medium sand
#20	97.24	0.02	100.0	#20	medium sand
#40	97.39	0.17	99.7	#40	fine sand
#60	97.62	0.40	99.2	#60	fine sand
#100	98.86	1.64	96.7	#100	fine sand
#200	105.48	8.26	83.6	#200	fines

HYDROMETER CALCULATIONS

DATE 6/21/2012	TIME 9:41	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/21/2012	9:43	2.00	32.0	21.00	0.013	5.83	26.17	11.1	1.00
6/21/2012	9:46	5.00	20.0	21.00	0.013	5.83	14.17	13.0	1.00
6/21/2012	9:56	15.00	13.0	21.00	0.013	5.83	7.17	14.2	1.00
6/21/2012	10:11	30.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/21/2012	10:41	60.00	10.0	21.00	0.013	5.83	4.17	14.7	1.00
6/21/2012	13:51	250.00	8.0	21.00	0.013	5.83	2.17	15.0	1.00
6/22/2012	9:41	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0318	51.9	% COARSE GRAVEL	0.00	
0.0217	28.1	% FINE GRAVEL	0.00	0.00
0.0131	14.2	% COARSE SAND	0.00	
0.0093	12.2	% MEDIUM SAND	0.34	
0.0067	8.3	% FINE SAND	16.04	16.38
0.0033	4.3	% FINES	83.62	
0.0014	2.3	% TOTAL SAMPLE	100.00	

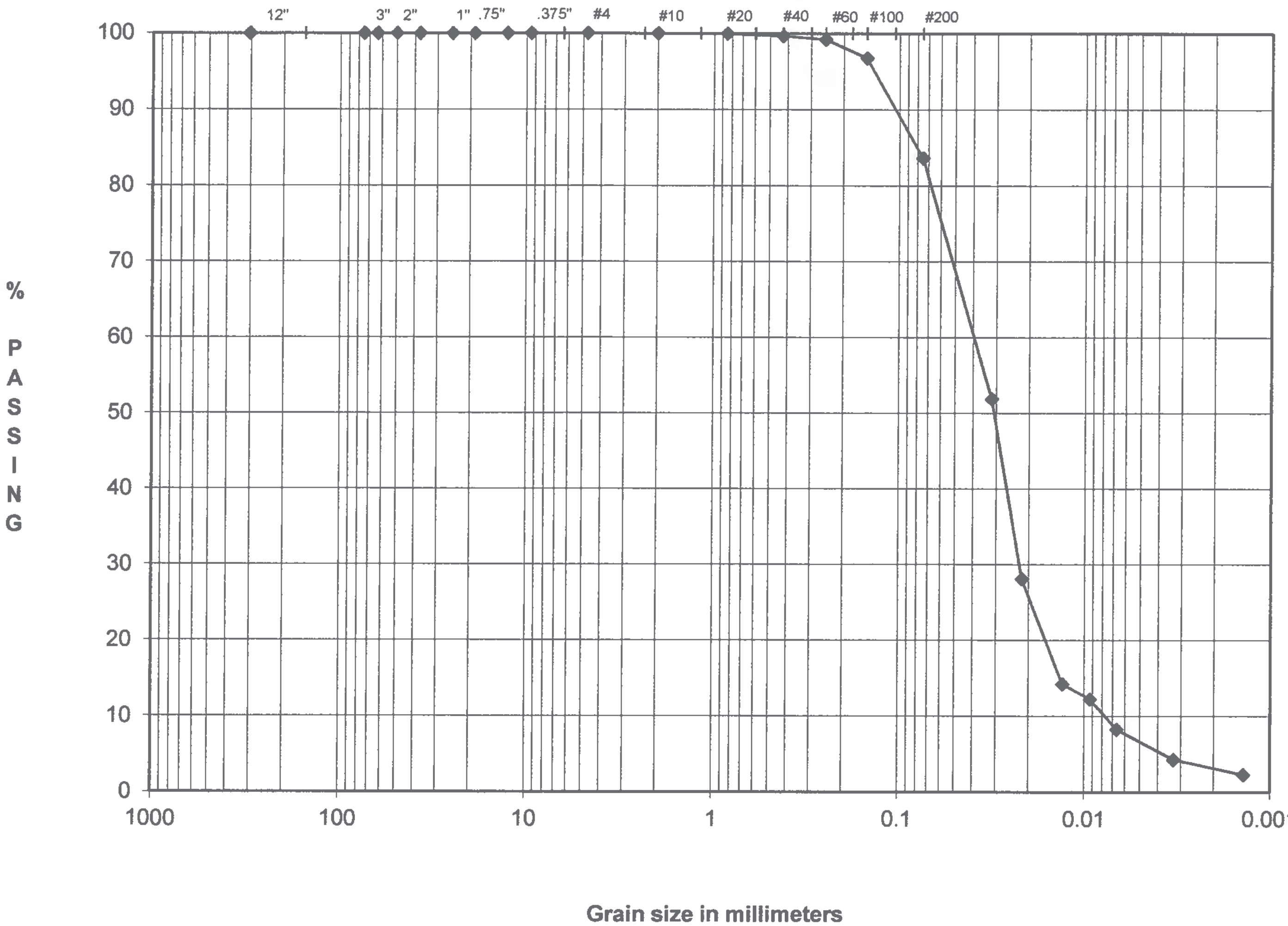
Description Brownish yellow, SILT, some sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BSV

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		SAND			FINES
		0.00		16.38			83.62

SAMPLE ID	SB-1208
SAMPLE TYPE	Jar
SAMPLE DEPTH	14.0'-16.0'

LL	-
PL	-
PI	-

DESCRIPTION	Brownish yellow, SILT, some sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BJT

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1209
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	0.0'-2.0'
DESCRIPTION:	Very dark bluish gray, SILT, little sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	23.90
Weight of Dry Soil & Tare	18.49
Weight of Tare	2.33
Weight of Water	5.41
Weight of Dry Soil	16.16
Water Content	33.48%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	DS
REVIEW	BSJ

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1209
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	0.0'-2.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	23.90
Wt. Dry Soil & Tare (gm)	(W2)	18.49
Weight of Tare (gm)	(W3)	2.33
Weight of Water (gm)	(W4=W1-W2)	5.41
Weight of Dry Soil (gm)	(W5=W2-W3)	16.16
Moisture Content (%)	(W4/W5)*100	33.48%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	39.05
Dry Soil & Tare (gm)	38.93
Tare Weight (gm)	13.92
Moisture Content (%)	0.48

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	839.60	
Tare Weight (gm)	217.20	
Total Weight (gm)	619.43	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.63
Calculated Dry Wt. used in test (gm)	50.39
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 95.75

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	95.75	0.00	**100.0**	#10	medium sand
#20	95.85	0.10	**99.8**	#20	medium sand
#40	95.95	0.20	**99.6**	#40	fine sand
#60	96.12	0.37	**99.3**	#60	fine sand
#100	96.57	0.82	**98.4**	#100	fine sand
#200	98.43	2.68	**94.7**	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 12:31	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	12:33	2.00	45.0	21.00	0.013	5.83	39.17	8.9	1.00
6/22/2012	12:36	5.00	40.0	21.00	0.013	5.83	34.17	9.7	1.00
6/22/2012	12:46	15.00	33.0	21.00	0.013	5.83	27.17	10.9	1.00
6/22/2012	13:01	30.00	28.0	21.00	0.013	5.83	22.17	11.7	1.00
6/22/2012	13:31	60.00	22.0	21.00	0.013	5.83	16.17	12.7	1.00
6/22/2012	16:41	250.00	13.0	21.00	0.013	5.83	7.17	14.2	1.00
6/23/2012	12:31	1440.00	8.0	21.00	0.013	5.83	2.17	15.0	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0284	77.7	% COARSE GRAVEL	0.00	
0.0188	67.8	% FINE GRAVEL	0.00	0.00
0.0115	53.9	% COARSE SAND	0.00	
0.0084	44.0	% MEDIUM SAND	0.40	
0.0062	32.1	% FINE SAND	4.92	5.32
0.0032	14.2	% FINES	94.68	
0.0014	4.3	% TOTAL SAMPLE	100.00	

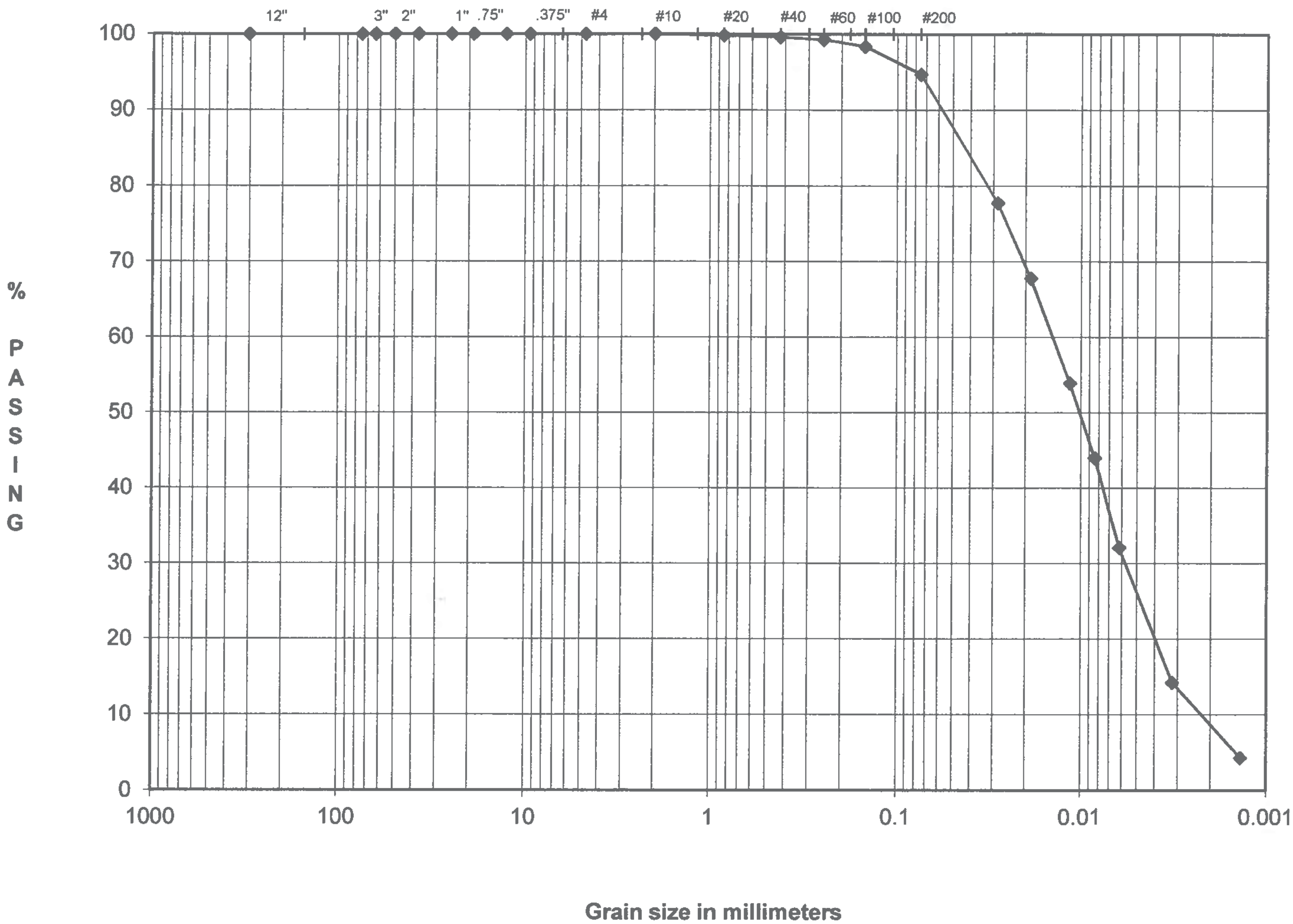
Description Very dark bluish gray, SILT, little sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		0.00		5.32			94.68

SAMPLE ID	SB-1209
SAMPLE TYPE	Jar
SAMPLE DEPTH	0.0'-2.0'

LL	-
PL	-
PI	-

DESCRIPTION	Very dark bluish gray, SILT, little sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BSV

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1210
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	4.0'-6.0'
DESCRIPTION:	Dark grayish brown, SILT, trace sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	22.93
Weight of Dry Soil & Tare	17.09
Weight of Tare	3.13
Weight of Water	5.84
Weight of Dry Soil	13.96
Water Content	41.83%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	DS
REVIEW	BSJ

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1210
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	4.0'-6.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	22.93
Wt. Dry Soil & Tare (gm)	(W2)	17.09
Weight of Tare (gm)	(W3)	3.13
Weight of Water (gm)	(W4=W1-W2)	5.84
Weight of Dry Soil (gm)	(W5=W2-W3)	13.96
Moisture Content (%)	(W4/W5)*100	41.83%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	36.71
Dry Soil & Tare (gm)	36.13
Tare Weight (gm)	14.04
Moisture Content (%)	2.63

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	889.90	
Tare Weight (gm)	218.70	
Total Weight (gm)	654.03	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.90
Calculated Dry Wt. used in test (gm)	49.60
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.69

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.69	0.00	100.0	#10	medium sand
#20	30.88	0.19	99.6	#20	medium sand
#40	31.15	0.46	99.1	#40	fine sand
#60	31.48	0.79	98.4	#60	fine sand
#100	31.84	1.15	97.7	#100	fine sand
#200	32.53	1.84	96.3	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	12:25								
6/22/2012	12:27	2.00	45.0	21.00	0.013	5.83	39.17	8.9	1.00
6/22/2012	12:30	5.00	38.0	21.00	0.013	5.83	32.17	10.1	1.00
6/22/2012	12:40	15.00	29.0	21.00	0.013	5.83	23.17	11.5	1.00
6/22/2012	12:55	30.00	23.0	21.00	0.013	5.83	17.17	12.5	1.00
6/22/2012	13:25	60.00	17.0	21.00	0.013	5.83	11.17	13.5	1.00
6/22/2012	16:35	250.00	11.0	21.00	0.013	5.83	5.17	14.5	1.00
6/23/2012	12:25	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0284	79.0	% COARSE GRAVEL	0.00	
0.0192	64.9	% FINE GRAVEL	0.00	0.00
0.0118	46.7	% COARSE SAND	0.00	
0.0087	34.6	% MEDIUM SAND	0.93	
0.0064	22.5	% FINE SAND	2.78	3.71
0.0032	10.4	% FINES	96.29	
0.0014	2.4	% TOTAL SAMPLE	100.00	

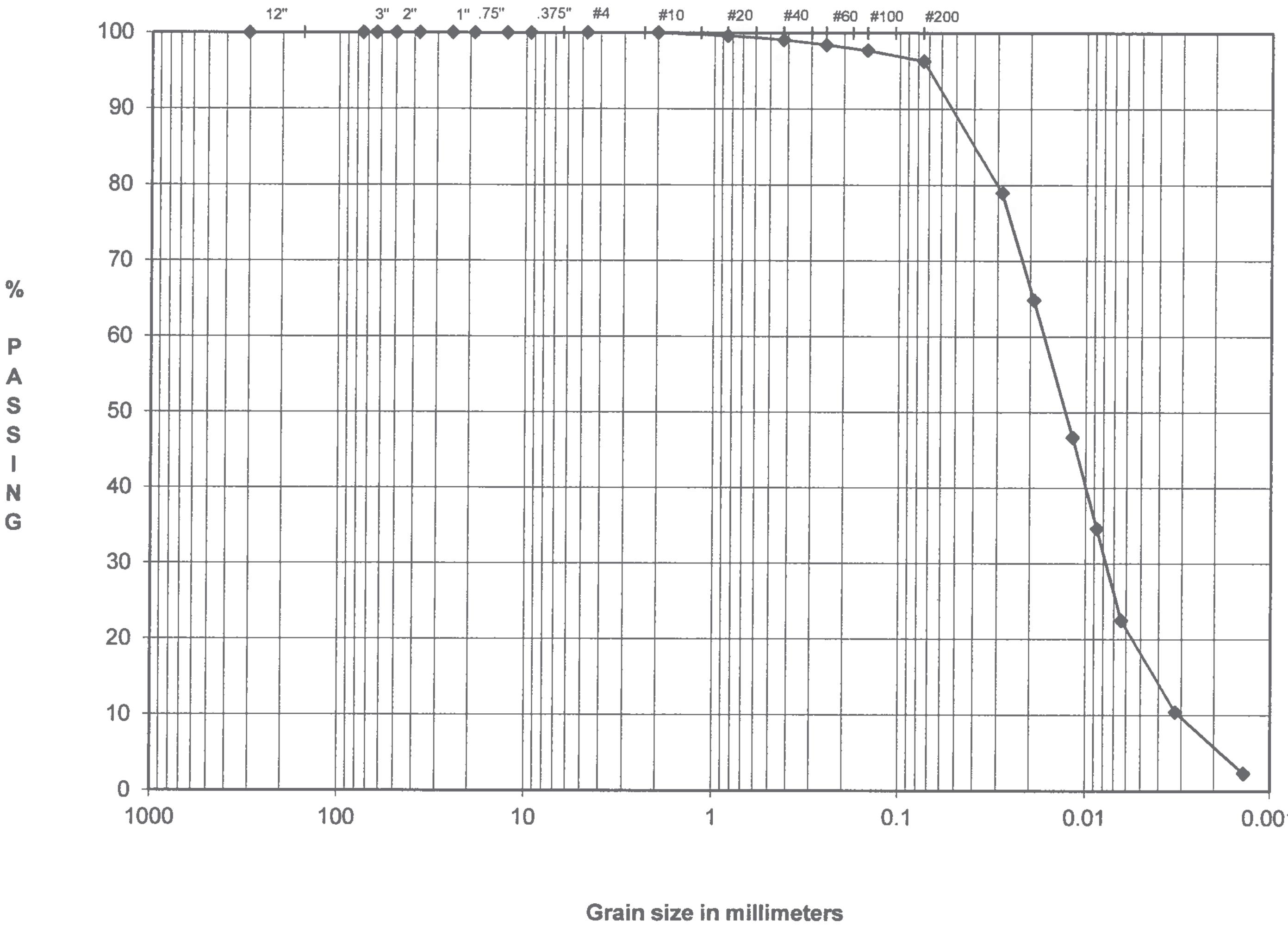
Description Dark grayish brown, SILT, trace sand

USCS FLY ASH/ML

LL	-
PL	-
PI	-

TECH	CB
DATE	6/19/2012
CHECK	TDS
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		SAND			FINES
		0.00		3.71			96.29

SAMPLE ID	SB-1210
SAMPLE TYPE	Jar
SAMPLE DEPTH	4.0'-6.0'

LL	-
PL	-
PI	-

DESCRIPTION	Dark grayish brown, SILT, trace sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BST

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896

SAMPLE ID:	SB 1211
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	5.0'-7.0'

DESCRIPTION:	Very dark bluish gray, SILT, some sand
USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	32.18
Weight of Dry Soil & Tare	25.46
Weight of Tare	11.48
Weight of Water	6.72
Weight of Dry Soil	13.98
Water Content	48.07%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	TDS
REVIEW	BSV

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB 1211
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	5.0'-7.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	32.18
Wt. Dry Soil & Tare (gm)	(W2)	25.46
Weight of Tare (gm)	(W3)	11.48
Weight of Water (gm)	(W4=W1-W2)	6.72
Weight of Dry Soil (gm)	(W5=W2-W3)	13.98
Moisture Content (%)	(W4/W5)*100	48.07%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	31.64
Dry Soil & Tare (gm)	31.52
Tare Weight (gm)	14.22
Moisture Content (%)	0.69

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	606.40	
Tare Weight (gm)	216.10	
Total Weight (gm)	387.61	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.59
Calculated Dry Wt. used in test (gm)	50.24
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 95.92

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	95.97	0.05	99.9	#10	medium sand
#20	96.02	0.10	99.8	#20	medium sand
#40	96.13	0.21	99.6	#40	fine sand
#60	96.71	0.79	98.4	#60	fine sand
#100	98.23	2.31	95.4	#100	fine sand
#200	102.19	6.27	87.5	#200	fines

HYDROMETER CALCULATIONS

DATE 6/22/2012	TIME 12:33	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
6/22/2012	12:35	2.00	41.0	21.00	0.013	5.83	35.17	9.6	1.00
6/22/2012	12:38	5.00	35.0	21.00	0.013	5.83	29.17	10.6	1.00
6/22/2012	12:48	15.00	27.0	21.00	0.013	5.83	21.17	11.9	1.00
6/22/2012	13:03	30.00	23.0	21.00	0.013	5.83	17.17	12.5	1.00
6/22/2012	13:33	60.00	19.0	21.00	0.013	5.83	13.17	13.2	1.00
6/22/2012	16:43	250.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/23/2012	12:33	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0295	70.0	% COARSE GRAVEL	0.00	
0.0196	58.1	% FINE GRAVEL	0.00	0.00
0.0120	42.1	% COARSE SAND	0.10	
0.0087	34.2	% MEDIUM SAND	0.32	
0.0063	26.2	% FINE SAND	12.06	12.48
0.0032	12.3	% FINES	87.52	
0.0014	2.3	% TOTAL SAMPLE	100.00	

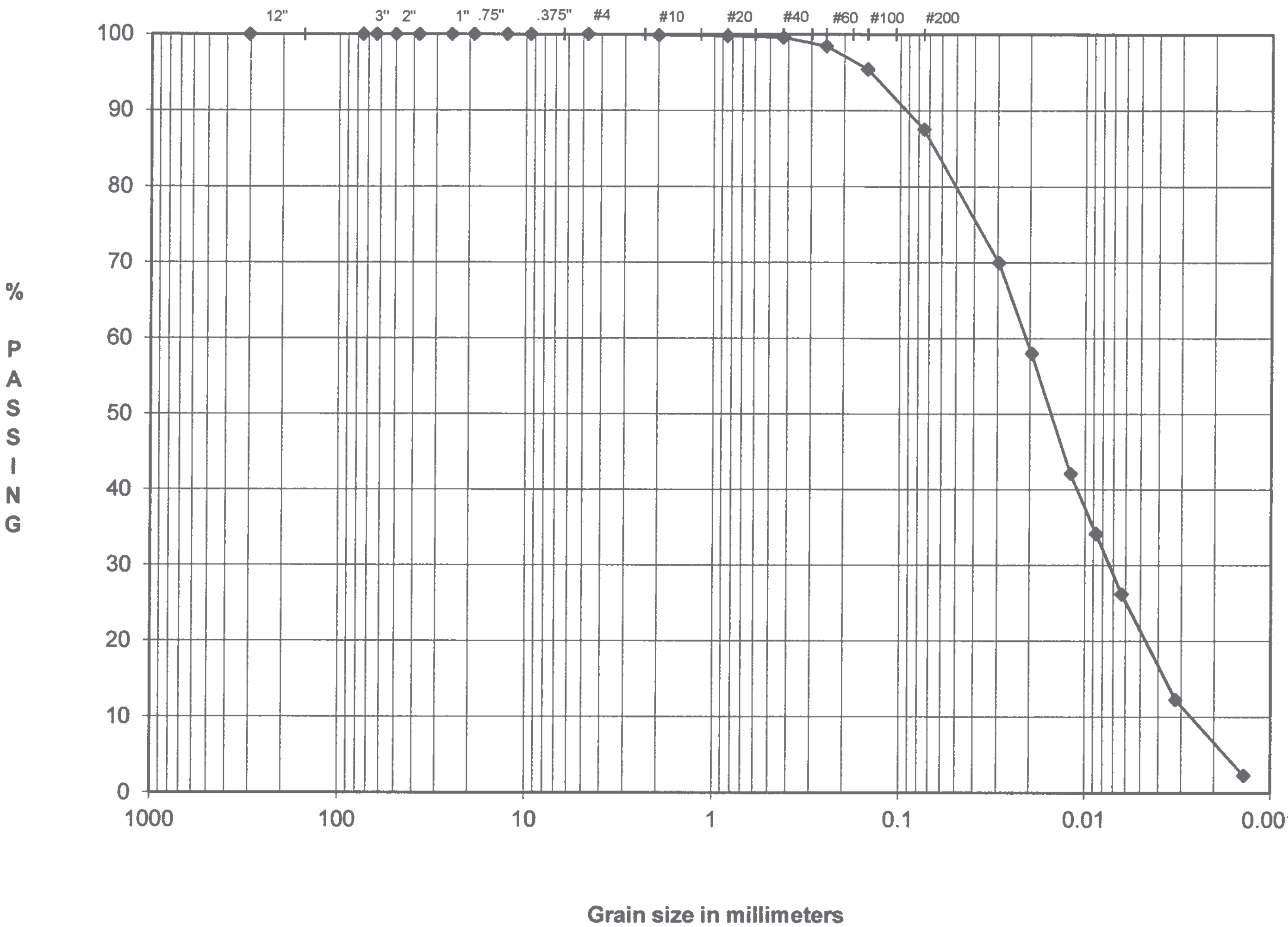
Description Very dark bluish gray, SILT, some sand

USCS FLY ASH/ML

-	LL
-	PL
-	PI

TECH	CB
DATE	6/19/2012
CHECK	BS
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		**SAND**			**FINES**
		0.00		12.48			87.52

SAMPLE ID	SB 1211
SAMPLE TYPE	Jar
SAMPLE DEPTH	5.0'-7.0'

LL	-
PL	-
PI	-

DESCRIPTION	Very dark bluish gray, SILT, some sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	DS
REVIEW	BST

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:	PROJECT NAME:	Consumers Campbell Ash Impoundment
	PROJECT NUMBER:	123-88896
	SAMPLE ID:	SB-1212
	SAMPLE TYPE:	Jar
	SAMPLE DEPTH:	10.0'-12.0'
	DESCRIPTION:	Greenish gray, SILT, little sand
	USCS:	**FLY ASH/ML**

AS-RECEIVED MOISTURE CONTENT:	Weight of Wet Soil & Tare	31.15
	Weight of Dry Soil & Tare	23.57
	Weight of Tare	3.57
	Weight of Water	7.58
	Weight of Dry Soil	20.00
	Water Content	37.90%

TITLE BLOCK:

TECH	CB
DATE	06/19/12
CHECK	TBS
REVIEW	BSV

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1212
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	10.0'-12.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	31.15
Wt. Dry Soil & Tare (gm)	(W2)	23.57
Weight of Tare (gm)	(W3)	3.57
Weight of Water (gm)	(W4=W1-W2)	7.58
Weight of Dry Soil (gm)	(W5=W2-W3)	20.00
Moisture Content (%)	(W4/W5)*100	37.90%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	33.08
Dry Soil & Tare (gm)	32.88
Tare Weight (gm)	14.16
Moisture Content (%)	1.07

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	870.20	
Tare Weight (gm)	220.10	
Total Weight (gm)	643.23	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.23
Calculated Dry Wt. used in test (gm)	49.70
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 96.07

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	96.13	0.06	99.9	#10	medium sand
#20	96.21	0.14	99.7	#20	medium sand
#40	96.30	0.23	99.5	#40	fine sand
#60	96.46	0.39	99.2	#60	fine sand
#100	96.90	0.83	98.3	#100	fine sand
#200	99.08	3.01	93.9	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET	READING	TEMP	TEMP.COR.	HYD.COR.	READING	EFFECTIVE	
6/22/2012	11:35	(min)	R	T	K	Cc	C	LENGTH	A
6/22/2012	11:37	2.00	37.0	21.00	0.013	5.83	31.17	10.2	1.00
6/22/2012	11:40	5.00	33.0	21.00	0.013	5.83	27.17	10.9	1.00
6/22/2012	11:50	15.00	26.0	21.00	0.013	5.83	20.17	12.0	1.00
6/22/2012	12:05	30.00	22.0	21.00	0.013	5.83	16.17	12.7	1.00
6/22/2012	12:35	60.00	19.0	21.00	0.013	5.83	13.17	13.2	1.00
6/22/2012	15:45	250.00	12.0	21.00	0.013	5.83	6.17	14.3	1.00
6/23/2012	11:35	1440.00	7.0	21.00	0.013	5.83	1.17	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0304	62.7	% COARSE GRAVEL	0.00	
0.0199	54.7	% FINE GRAVEL	0.00	0.00
0.0121	40.6	% COARSE SAND	0.12	
0.0088	32.5	% MEDIUM SAND	0.34	
0.0063	26.5	% FINE SAND	5.59	6.06
0.0032	12.4	% FINES	93.94	
0.0014	2.3	% TOTAL SAMPLE	100.00	

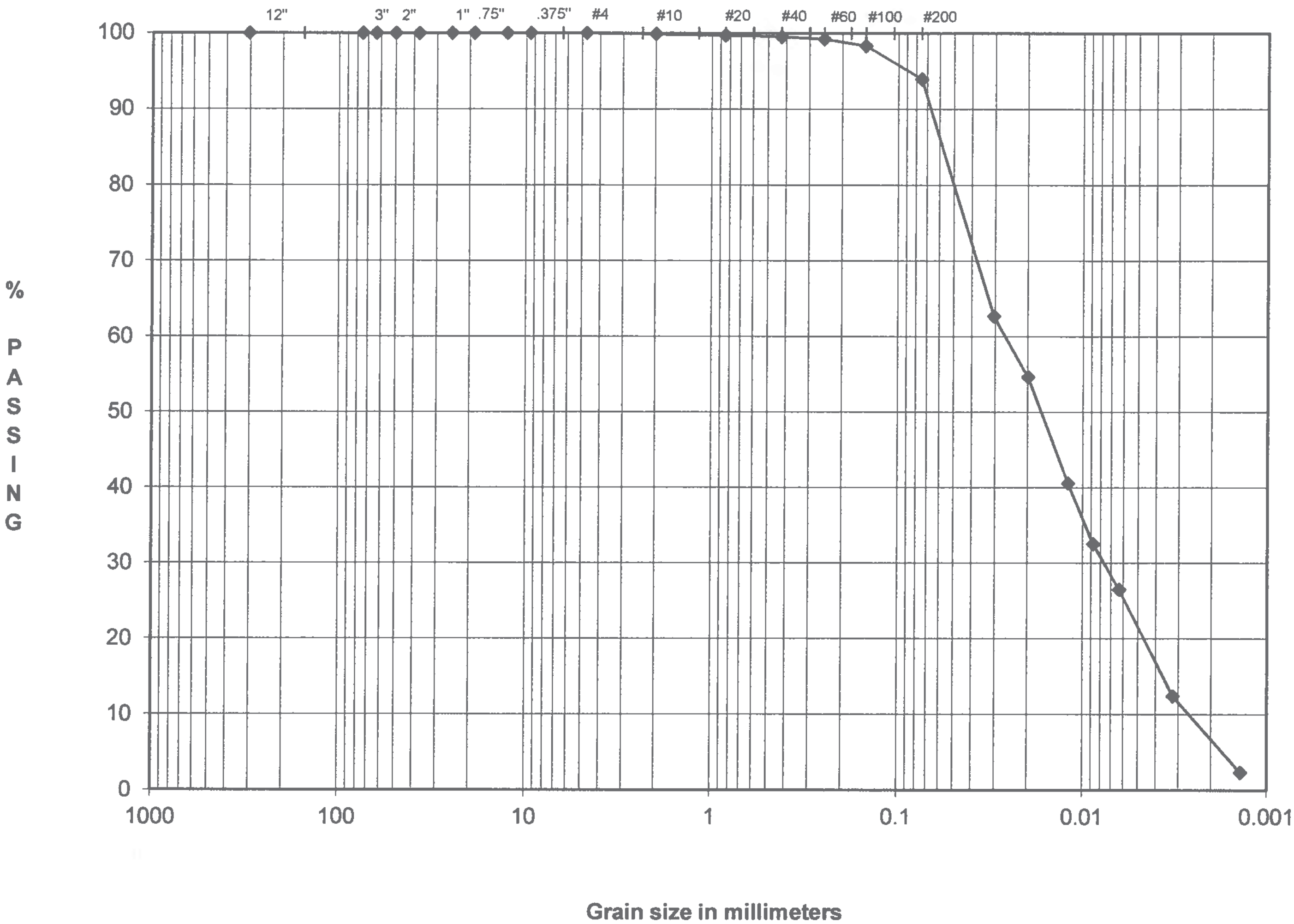
Description Greenish gray, SILT, little sand

USCS FLY ASH/ML

-	LL
-	PL
-	PI

TECH	CB
DATE	6/19/2012
CHECK	TDC
REVIEW	BST

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		GRAVEL		SAND			FINES
		0.00		6.06			93.94

SAMPLE ID	SB-1212
SAMPLE TYPE	Jar
SAMPLE DEPTH	10.0'-12.0'

LL	-
PL	-
PI	-

DESCRIPTION	Greenish gray, SILT, little sand
USCS	FLY ASH/ML

Consumers Campbell Ash Impoundment
123-88896

TECH	CB
DATE	6/19/2012
CHECK	RS
REVIEW	BJT

Template For Sand Grain-size and Perm

Global Information:

PROJECT NAME:	Consumer Energy
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1215
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	20.0'-24.0'
DESCRIPTION:	Brown, POORLY GRADED SAND, trace gravel, trace fines
USCS:	SP

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	40.80
Weight of Dry Soil & Tare	39.69
Weight of Tare	14.30
Weight of Water	1.11
Weight of Dry Soil	25.39
Water Content	4.37%

TITLE BLOCK:

TECH	MGG
DATE	09/10/12
CHECK	[signature]
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136, C 142

PROJECT TITLE	Consumer Energy	**SAMPLE ID**	SB-1215
PROJECT NO.	123-88896	**SAMPLE TYPE**	Jar
REMARKS		**SAMPLE DEPTH**	20.0'-24.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	40.80
Wt Dry Soil & Tare (gm)	(w2)	39.69
Weight of Tare (gm)	(w3)	14.30
Weight of Water (gm)	(w4=w1-w2)	1.11
Weight of Dry Soil (gm)	(w5=w2-w3)	25.39
Moisture Content (%)	(w4/w5)*100	4.37

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	60.71
Dry Soil & Tare (gm)	60.66
Tare Weight (gm)	13.87
Moisture Content (%)	0.11

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	1469.80
Tare Weight (gm)	422.30
(W6) Total Dry Weight (gm)	1046.38

SIEVE ANALYSIS

Tare Weight: 422.30

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
3.0"	422.30	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	422.30	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	422.30	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	422.30	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	422.30	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	422.30	0.00	0.00	100.00	0.75"	fine gravel
0.50"	422.30	0.00	0.00	100.00	0.50"	fine gravel
0.375"	422.30	0.00	0.00	100.00	0.375"	fine gravel
#4	424.20	1.90	0.18	99.82	#4	coarse sand
#10	426.60	4.30	0.41	99.59	#10	medium sand
#20	428.90	6.60	0.63	99.37	#20	medium sand
#40	475.40	53.10	5.07	94.93	#40	fine sand
#60	1273.90	851.60	81.39	18.61	#60	fine sand
#100	1442.80	1020.50	97.53	2.47	#100	fine sand
#200	1463.40	1041.10	99.50	0.50	#200	fines

C 142

Percent of Clay Lumps And Friable Particles

%

P = [(M-R)/M] x 100

P = percent of clay lumps
M = Mass of Test Sample portion coarser than No.16
R = Mass of particles retained on designated sieve (No. 20).

% C GRAVEL	0.00
% F GRAVEL	0.18
% C SAND	0.23
% M SAND	4.66
% F SAND	94.42
% FINES	0.50
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

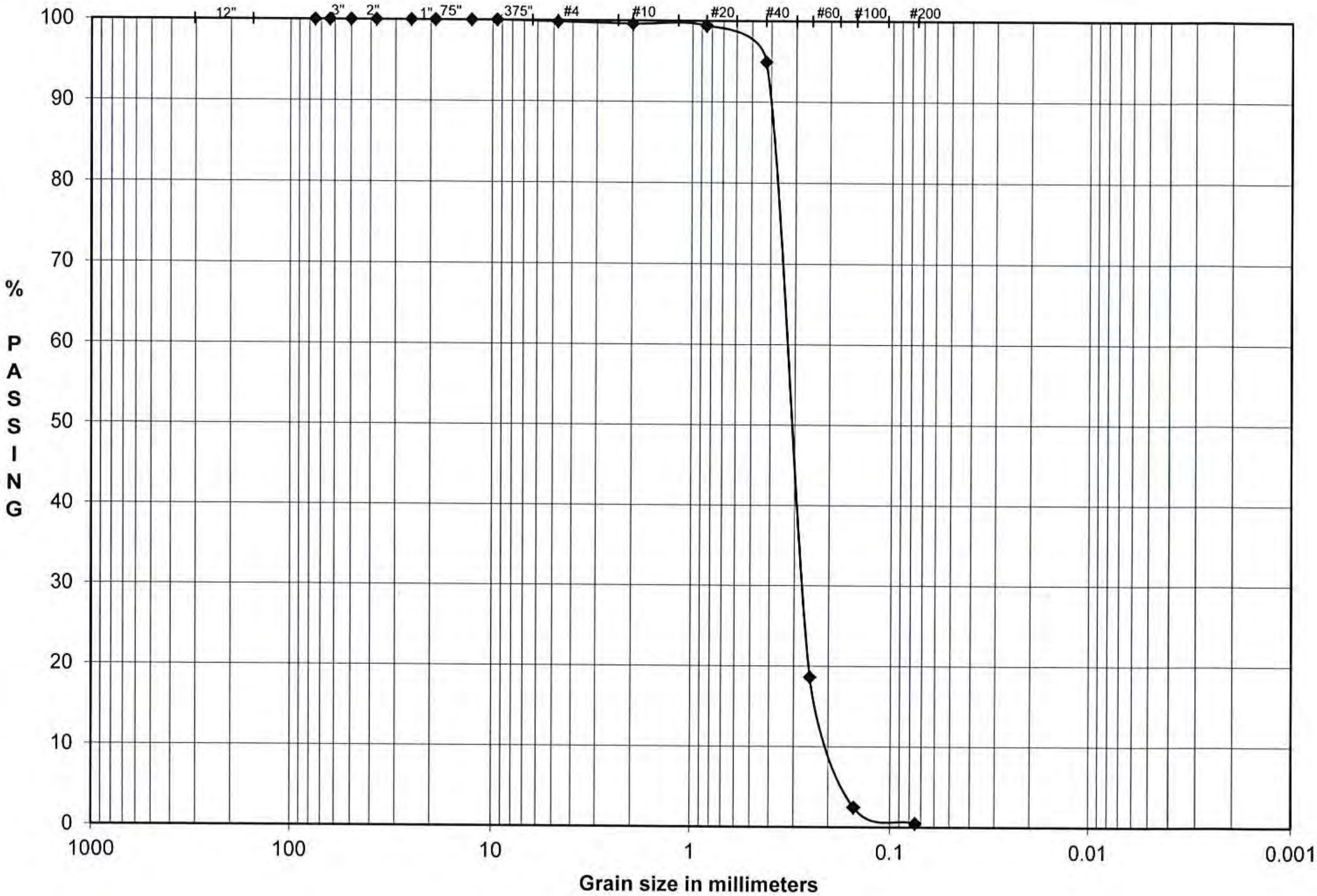
LL	-
PL	-
PI	-
Gs	-

DESCRIPTION Brown, POORLY GRADED SAND, trace gravel, trace fines

USCS SP

TECH	MGG
DATE	9/10/2012
CHECK	
REVIEW	

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



% Passing

Boulders	Cobbles	Gravel Coarse	Gravel Fine	SAND Cor	SAND Med	SAND Fine	FINES SILT OR CLAY
	0.00	0.00	0.18	0.23	4.66	94.42	0.50

SAMPLE ID	SB-1215
SAMPLE TYPE	Jar
SAMPLE DEPTH	20.0'-24.0'

LL	-
PL	-
PI	-

DESCRIPTION	Brown, POORLY GRADED SAND, trace gravel, trace fines
USCS	SP

Consumer Energy
123-88896

TECH	MGG
DATE	9/10/2012
CHECK	DGW
REVIEW	JJ

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1215
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	79.0'-81.0'
DESCRIPTION:	Gray, LEAN CLAY, trace sand
USCS:	CL

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	29.60
Weight of Dry Soil & Tare	26.71
Weight of Tare	14.10
Weight of Water	2.89
Weight of Dry Soil	12.61
Water Content	22.92%

TITLE BLOCK:

TECH	MGG
DATE	09/10/12
CHECK	CB
REVIEW	[illegible]

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1215
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	79.0'-81.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	29.60
Wt. Dry Soil & Tare (gm)	(W2)	26.71
Weight of Tare (gm)	(W3)	14.10
Weight of Water (gm)	(W4=W1-W2)	2.89
Weight of Dry Soil (gm)	(W5=W2-W3)	12.61
Moisture Content (%)	(W4/W5)*100	22.92%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	38.81
Dry Soil & Tare (gm)	38.68
Tare Weight (gm)	14.11
Moisture Content (%)	0.53

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	877.30	
Tare Weight (gm)	425.10	
Total Weight (gm)	449.82	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	50.18
Calculated Dry Wt. used in test (gm)	49.92
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.82

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.82	0.00	100.0	#10	medium sand
#20	30.83	0.01	100.0	#20	medium sand
#40	30.89	0.07	99.9	#40	fine sand
#60	31.23	0.41	99.2	#60	fine sand
#100	31.54	0.72	98.6	#100	fine sand
#200	31.91	1.09	97.8	#200	fines

HYDROMETER CALCULATIONS

DATE 9/12/2012	TIME 13:48	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
9/12/2012	13:50	2.00	51.0	22.40	0.013	5.38	45.62	7.9	1.00
9/12/2012	13:53	5.00	48.5	22.40	0.013	5.38	43.12	8.4	1.00
9/12/2012	14:03	15.00	43.5	22.40	0.013	5.38	38.12	9.2	1.00
9/12/2012	14:18	30.00	41.0	22.40	0.013	5.38	35.62	9.6	1.00
9/12/2012	14:48	60.00	37.5	22.40	0.013	5.38	32.12	10.2	1.00
9/12/2012	17:58	250.00	31.0	22.80	0.013	5.24	25.76	11.2	1.00
9/13/2012	13:48	1440.00	25.0	22.80	0.013	5.24	19.76	12.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING			
		% COBBLES	0.00	
0.0265	91.4	% COARSE GRAVEL	0.00	
0.0173	86.4	% FINE GRAVEL	0.00	0.00
0.0104	76.4	% COARSE SAND	0.00	
0.0075	71.4	% MEDIUM SAND	0.14	
0.0055	64.4	% FINE SAND	2.04	2.18
0.0028	51.6	% FINES	97.82	
0.0012	39.6	% TOTAL SAMPLE	100.00	

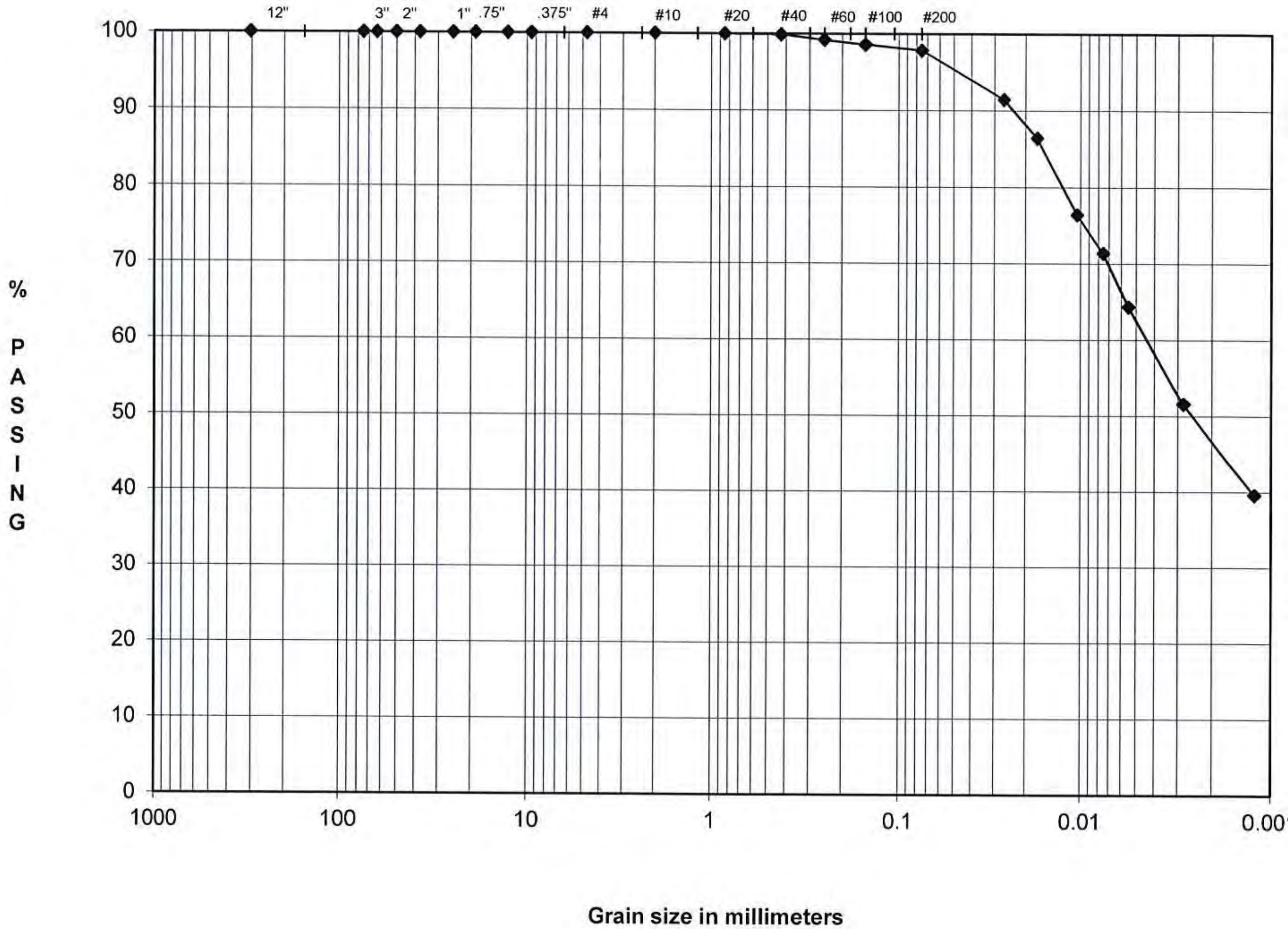
Description Gray, LEAN CLAY, trace sand

USCS CL

35	LL
17	PL
18	PI

TECH	MGG
DATE	9/10/2012
CHECK	SR
REVIEW	JRG

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL Coarse	GRAVEL Fine	SAND Cor	SAND Med	SAND Fine	FINES SILT OR CLAY
		0.00		2.18			97.82

SAMPLE ID	SB-1215
SAMPLE TYPE	Jar
SAMPLE DEPTH	79.0'-81.0'

LL	35
PL	17
PI	18

DESCRIPTION	Gray, LEAN CLAY, trace sand
USCS	CL

Consumers Campbell Ash Impoundment
123-88896

TECH	MGG
DATE	9/10/2012
CHECK	CB
REVIEW	JBJ

Template For Sand Grain-size and Perm

Global Information:

PROJECT NAME:	Consumer Energy
PROJECT NUMBER:	123-88896
SAMPLE ID:	SB-1216
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	18.0'-22.0'
DESCRIPTION:	Brown, POORLY GRADED SAND, trace gravel, trace fines
USCS:	SP

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	41.10
Weight of Dry Soil & Tare	39.39
Weight of Tare	14.10
Weight of Water	1.71
Weight of Dry Soil	25.29
Water Content	6.76%

TITLE BLOCK:

TECH	MGG
DATE	09/10/12
CHECK	D.W.
REVIEW	

ASTM GRAIN SIZE ANALYSIS
ASTM D 421, D 2217, D 1140, C 117, D 422, C 136, C 142

PROJECT TITLE	Consumer Energy	**SAMPLE ID**	SB-1216
PROJECT NO.	123-88896	**SAMPLE TYPE**	Jar
REMARKS		**SAMPLE DEPTH**	18.0'-22.0'

WATER CONTENT (Delivered Moisture)

Wt Wet Soil & Tare (gm)	(w1)	41.10
Wt Dry Soil & Tare (gm)	(w2)	39.39
Weight of Tare (gm)	(w3)	14.10
Weight of Water (gm)	(w4=w1-w2)	1.71
Weight of Dry Soil (gm)	(w5=w2-w3)	25.29
Moisture Content (%)	(w4/w5)*100	6.76

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	59.84
Dry Soil & Tare (gm)	59.71
Tare Weight (gm)	14.04
Moisture Content (%)	0.28

Total Weight Of Sample Used For Sieve Corrected For Hygroscopic Moisture

Weight Of Sample (gm)	1360.70
Tare Weight (gm)	456.70
(W6) Total Dry Weight (gm)	901.43

SIEVE ANALYSIS

Tare Weight: 456.70

	Wt Ret +Tare	(Wt-Tare)	Cumulative (%Retained) {(wt ret/w6)*100}	% PASS (100-%ret)	SIEVE	
3.0"	456.70	0.00	0.00	100.00	3.0"	coarse gravel
2.5"	456.70	0.00	0.00	100.00	2.5"	coarse gravel
2.0"	456.70	0.00	0.00	100.00	2.0"	coarse gravel
1.5"	456.70	0.00	0.00	100.00	1.5"	coarse gravel
1.0"	456.70	0.00	0.00	100.00	1.0"	coarse gravel
0.75"	456.70	0.00	0.00	100.00	0.75"	fine gravel
0.50"	456.70	0.00	0.00	100.00	0.50"	fine gravel
0.375"	456.70	0.00	0.00	100.00	0.375"	fine gravel
#4	457.70	1.00	0.11	99.89	#4	coarse sand
#10	460.50	3.80	0.42	99.58	#10	medium sand
#20	466.00	9.30	1.03	98.97	#20	medium sand
#40	528.10	71.40	7.92	92.08	#40	fine sand
#60	1052.20	595.50	66.06	33.94	#60	fine sand
#100	1284.20	827.50	91.80	8.20	#100	fine sand
#200	1350.60	893.90	99.16	0.84	#200	fines

C 142

Percent of Clay Lumps And Friable Particles

%

P = [(M-R)/M] x 100

P = percent of clay lumps
M = Mass of Test Sample portion coarser than No.16
R = Mass of particles retained on designated sieve (No. 20).

% C GRAVEL	0.00
% F GRAVEL	0.11
% C SAND	0.31
% M SAND	7.50
% F SAND	91.24
% FINES	0.84
% TOTAL	100.00

Descriptive Terms	
trace	0 to 5%
little	5 to 12%
some	12 to 30%
and	30 to 50%

> 10% mostly coarse (c)
> 10% mostly medium (m)
< 10% fine (c-m)
< 10% coarse (m-f)
< 10% coarse and fine (m)
< 10% coarse and medium (f)
> 10% equal amounts each (c-f)

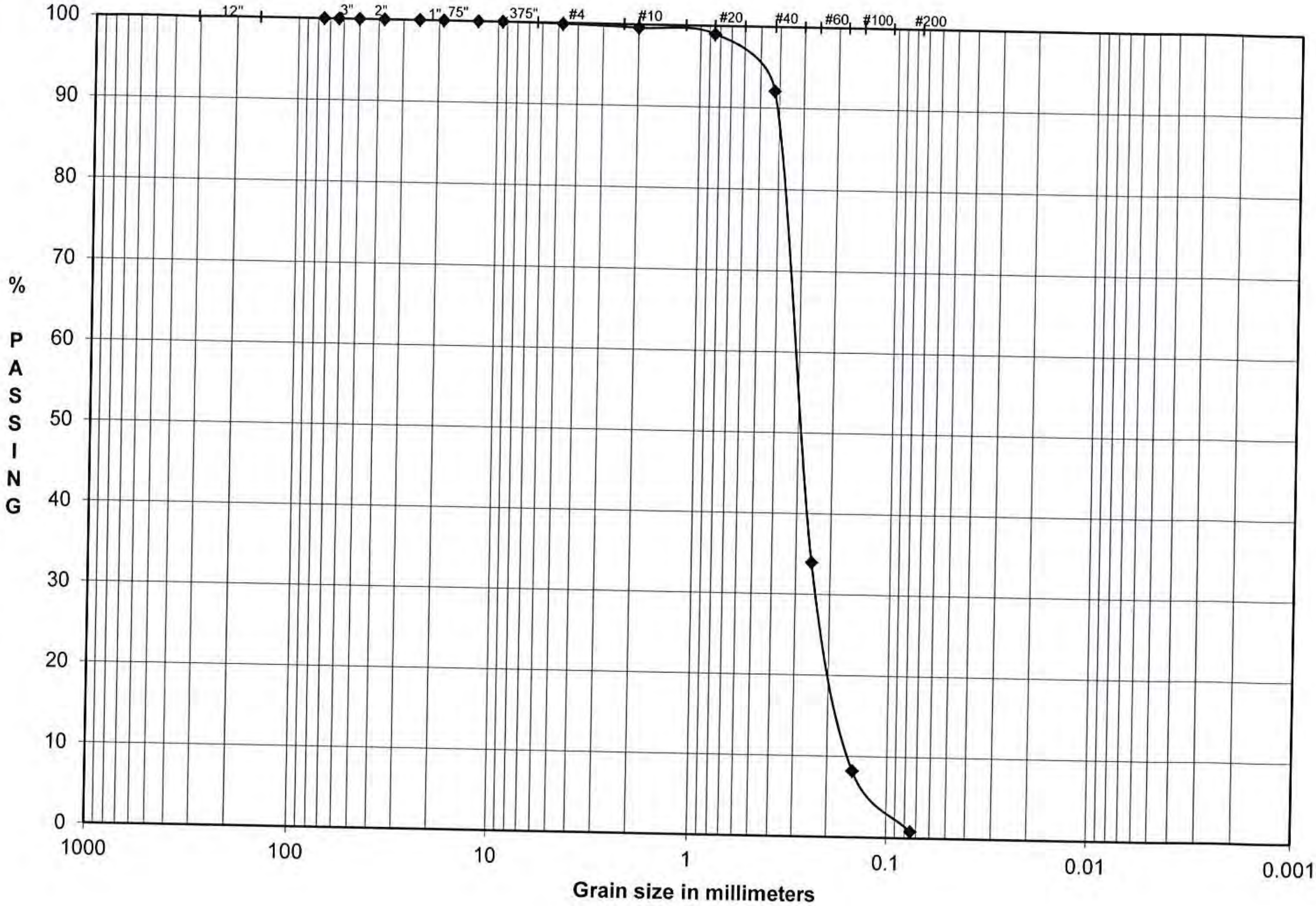
LL	-
PL	-
PI	-
Gs	-

DESCRIPTION Brown, POORLY GRADED SAND, trace gravel, trace fines

USCS SP

TECH	MGG
DATE	9/10/2012
CHECK	D.W
REVIEW	JDG

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



		% Passing						
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
Boulders	Cobbles	Gravel		SAND			FINES
	0.00	0.00	0.11	0.31	7.50	91.24	0.84

SAMPLE ID	SB-1216
SAMPLE TYPE	Jar
SAMPLE DEPTH	18.0'-22.0'

LL	-
PL	-
PI	-

DESCRIPTION Brown, POORLY GRADED SAND, trace gravel, trace fines

USCS SP

Consumer Energy
123-88896

TECH	MGG
DATE	9/10/2012
CHECK	D.G.
REVIEW	[illegible]

Template For Proctor, Sieve-Hydro, Atterberg, and Spec Grav.

Global Information:

PROJECT NAME:	Consumers Campbell Ash Impoundment
PROJECT NUMBER:	123-88896

SAMPLE ID:	SB-1217
SAMPLE TYPE:	Jar
SAMPLE DEPTH:	10.0'-14.0'

DESCRIPTION:	Gray, SILT, little sand
USCS:	**FLY ASH / ML***

*Classified Visually

AS-RECEIVED MOISTURE CONTENT:

Weight of Wet Soil & Tare	41.30
Weight of Dry Soil & Tare	36.03
Weight of Tare	14.10
Weight of Water	5.27
Weight of Dry Soil	21.93
Water Content	24.03%

TITLE BLOCK:

TECH	MGG
DATE	09/10/12
CHECK	CB
REVIEW	[illegible]

ASTM GRAIN SIZE ANALYSIS
ASTM C117, C136, D421, D422, D1140 and D2217

PROJECT TITLE	Consumers Campbell Ash Impoundment	SAMPLE ID	SB-1217
PROJECT NO.	123-88896	SAMPLE TYPE	Jar
		SAMPLE DEPTH	10.0'-14.0'

AS RECEIVED WATER CONTENT

Wt. Wet Soil & Tare (gm)	(W1)	41.30
Wt. Dry Soil & Tare (gm)	(W2)	36.03
Weight of Tare (gm)	(W3)	14.10
Weight of Water (gm)	(W4=W1-W2)	5.27
Weight of Dry Soil (gm)	(W5=W2-W3)	21.93
Moisture Content (%)	(W4/W5)*100	24.03%

Hygroscopic Moisture For Sieve Sample

Wet Soil & Tare (gm)	55.71
Dry Soil & Tare (gm)	55.64
Tare Weight (gm)	14.21
Moisture Content (%)	0.17

Total Weight of Sample Used For Sieve Analysis Corrected For Hygroscopic Moisture

Weight + Tare, Before Separating On The #4 Sieve (gm)	1044.30	
Tare Weight (gm)	458.50	
Total Weight (gm)	584.81	(W6)

Plus #4 Material Sieve

TARE WEIGHT 0.00

Sieve	(Wt+Tare)	(((Wt-Tare)/W6)*100)	%PASSING	Sieve	
12.0"	0.00	0.0	100.0	12.0"	cobbles
3.0"	0.00	0.0	100.0	3.0"	coarse gravel
2.5"	0.00	0.0	100.0	2.5"	coarse gravel
2.0"	0.00	0.0	100.0	2.0"	coarse gravel
1.5"	0.00	0.0	100.0	1.5"	coarse gravel
1.0"	0.00	0.0	100.0	1.0"	coarse gravel
0.75"	0.00	0.0	100.0	0.75"	fine gravel
0.50"	0.00	0.0	100.0	0.50"	fine gravel
0.375"	0.00	0.0	100.0	0.375"	fine gravel
#4	0.00	0.0	100.0	#4	coarse sand

HYDROMETER ANALYSIS

Specific Gravity	(assumed)	2.65
Amount Dispersing Agent (ml)		125.00
Type Dispersion Device		Mechanical
Length of Dispersion Period		1 Minute

Weight of Sample Used For Hydrometer Test

Weight of Sample Wet or Dry (gm)	51.04
Calculated Dry Wt. used in test (gm)	50.95
Hydrometer Bulb Number	624378
% Pass #4 Sieve For Whole Sample	100.00

TARE WEIGHT 30.72

HYDROMETER BACKSIEVE (Percent Passing #10 - #200 Sieves)

Sieve	(Wt+Tare)	Cumul Wt. Retained	% PASSING	Sieve	
#10	30.73	0.01	100.0	#10	medium sand
#20	30.78	0.06	99.9	#20	medium sand
#40	30.84	0.12	99.8	#40	fine sand
#60	30.97	0.25	99.5	#60	fine sand
#100	31.41	0.69	98.6	#100	fine sand
#200	34.27	3.55	93.0	#200	fines

HYDROMETER CALCULATIONS

DATE	TIME	ET (min)	READING R	TEMP T	TEMP.COR. K	HYD.COR. Cc	READING C	EFFECTIVE LENGTH	A
9/12/2012	13:50								
9/12/2012	13:52	2.00	39.0	22.40	0.013	5.38	33.62	9.9	1.00
9/12/2012	13:55	5.00	32.0	22.40	0.013	5.38	26.62	11.1	1.00
9/12/2012	14:05	15.00	23.5	22.40	0.013	5.38	18.12	12.5	1.00
9/12/2012	14:20	30.00	19.0	22.40	0.013	5.38	13.62	13.2	1.00
9/12/2012	14:50	60.00	14.5	22.40	0.013	5.38	9.12	14.0	1.00
9/12/2012	18:00	250.00	8.5	22.80	0.013	5.24	3.26	15.0	1.00
9/13/2012	13:50	1440.00	7.0	22.80	0.013	5.24	1.76	15.2	1.00

GRAIN SIZE PERCENTAGES

Particle Diameter	% PASSING
0.0296	66.0
0.0198	52.3
0.0122	35.6
0.0088	26.7
0.0064	17.9
0.0033	6.4
0.0014	3.4

% COBBLES	0.00	
% COARSE GRAVEL	0.00	
% FINE GRAVEL	0.00	0.00
% COARSE SAND	0.02	
% MEDIUM SAND	0.22	
% FINE SAND	6.73	6.97
% FINES	93.03	
% TOTAL SAMPLE	100.00	

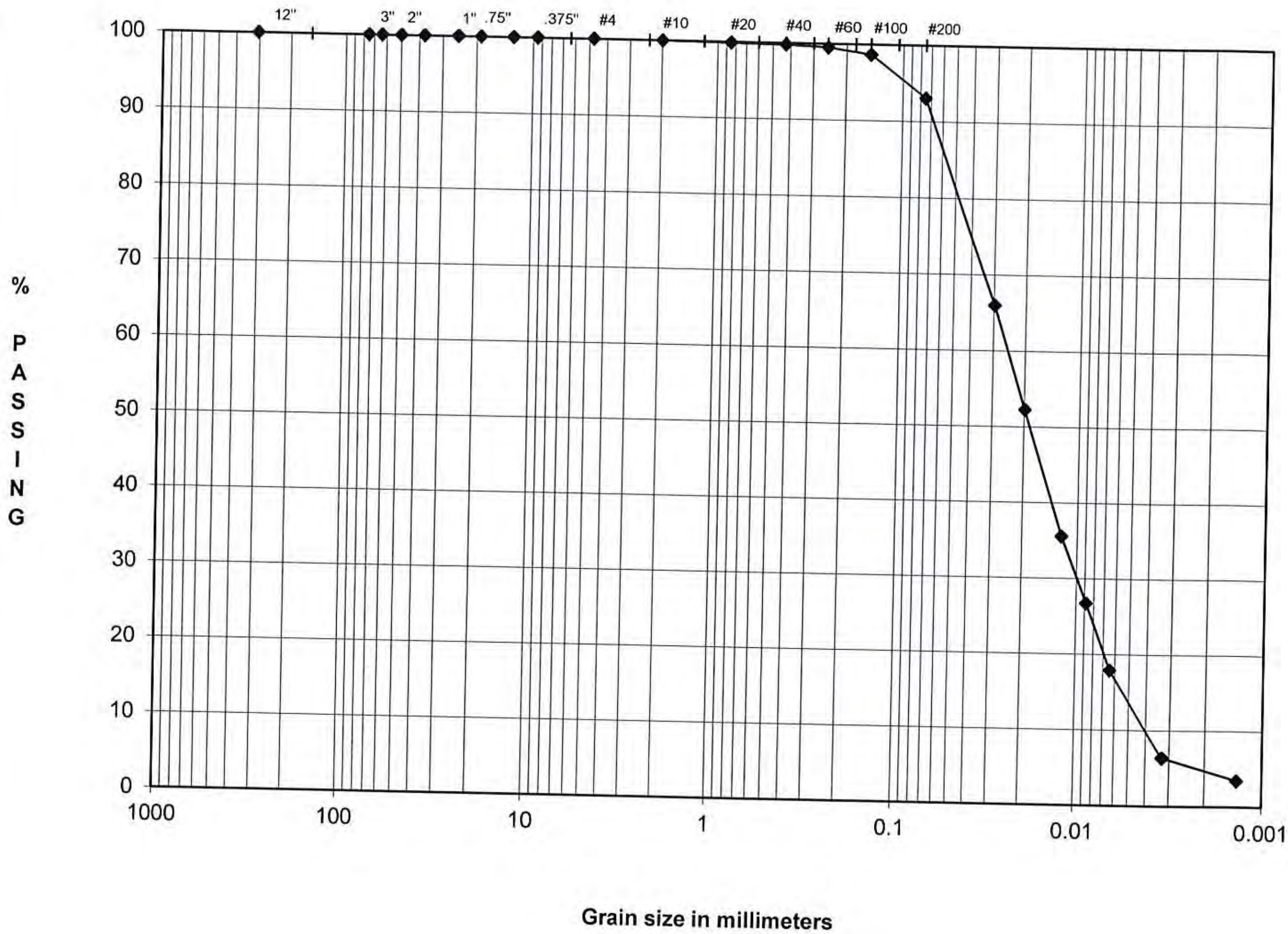
Description Gray, SILT, little sand

USCS LY ASH / ML*

-	LL
-	PL
-	PI

TECH	MGG
DATE	9/10/2012
CHECK	CB
REVIEW	JDF

PARTICLE SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



Boulders	Cobbles	GRAVEL		SAND			FINES
		Coarse	Fine	Cor	Med	Fine	SILT OR CLAY
		0.00		6.97			93.03

SAMPLE ID	SB-1217
SAMPLE TYPE	Jar
SAMPLE DEPTH	10.0'-14.0'

LL	-
PL	-
PI	-

DESCRIPTION Gray, SILT, little sand

USCS **FLY ASH / ML***

Consumers Campbell Ash Impoundment
123-88896

TECH	MGG
DATE	9/10/2012
CHECK	CB
REVIEW	[signature]

MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	BPS

Borehole Number	SB-1203	Borehole Number	SB-1202
Sample Depth	0.0'-5.0'	Sample Depth	15.0'-17.0
Sample Number		Sample Number	
Weight of Wet Soil & Tare	33.48	Weight of Wet Soil & Tare	38.59
Weight of Dry Soil & Tare	30.58	Weight of Dry Soil & Tare	33.78
Weight of Tare	13.96	Weight of Tare	13.88
Weight of Water	2.90	Weight of Water	4.81
Weight of Dry Soil	16.62	Weight of Dry Soil	19.90
Water Content	17.45%	Water Content	24.17%
Borehole Number	SB-1203	Borehole Number	SB-1202
Sample Depth	5.0'-7.0'	Sample Depth	17.0'-19.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	40.37	Weight of Wet Soil & Tare	34.00
Weight of Dry Soil & Tare	34.68	Weight of Dry Soil & Tare	29.47
Weight of Tare	13.72	Weight of Tare	13.87
Weight of Water	5.69	Weight of Water	4.53
Weight of Dry Soil	20.96	Weight of Dry Soil	15.60
Water Content	27.15%	Water Content	29.04%
Borehole Number	SB-1203	Borehole Number	SB-1202
Sample Depth	10.0'-12.0'	Sample Depth	23.0'-29.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	35.63	Weight of Wet Soil & Tare	36.16
Weight of Dry Soil & Tare	31.17	Weight of Dry Soil & Tare	29.73
Weight of Tare	13.84	Weight of Tare	14.16
Weight of Water	4.46	Weight of Water	6.43
Weight of Dry Soil	17.33	Weight of Dry Soil	15.57
Water Content	25.74%	Water Content	41.30%
Borehole Number	SB-1202	Borehole Number	SB-1202
Sample Depth	10.0'-12.0'	Sample Depth	27.0'-29.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	38.13	Weight of Wet Soil & Tare	44.40
Weight of Dry Soil & Tare	32.39	Weight of Dry Soil & Tare	38.65
Weight of Tare	14.28	Weight of Tare	13.88
Weight of Water	5.74	Weight of Water	5.75
Weight of Dry Soil	18.11	Weight of Dry Soil	24.77
Water Content	31.70%	Water Content	23.21%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	

Borehole Number	SB-1203	Borehole Number	SB-1201
Sample Depth	24.0'-26.0'	Sample Depth	0.0'-2.0'
Sample Number		Sample Number	6P5
Weight of Wet Soil & Tare	49.86	Weight of Wet Soil & Tare	35.49
Weight of Dry Soil & Tare	36.99	Weight of Dry Soil & Tare	31.59
Weight of Tare	13.65	Weight of Tare	14.11
Weight of Water	12.87	Weight of Water	3.90
Weight of Dry Soil	23.34	Weight of Dry Soil	17.48
Water Content	55.14%	Water Content	22.31%
Borehole Number	SB-1203	Borehole Number	SB-1201
Sample Depth	28.0'-30.0'	Sample Depth	5.0'-7.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	39.84	Weight of Wet Soil & Tare	34.97
Weight of Dry Soil & Tare	34.46	Weight of Dry Soil & Tare	32.26
Weight of Tare	14.08	Weight of Tare	14.34
Weight of Water	5.38	Weight of Water	2.71
Weight of Dry Soil	20.38	Weight of Dry Soil	17.92
Water Content	26.40%	Water Content	15.12%
Borehole Number	SB-1202	Borehole Number	SB-1201
Sample Depth	5.0'-7.0'	Sample Depth	10.0'-12.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	35.06	Weight of Wet Soil & Tare	35.30
Weight of Dry Soil & Tare	30.09	Weight of Dry Soil & Tare	30.66
Weight of Tare	13.93	Weight of Tare	13.98
Weight of Water	4.97	Weight of Water	4.64
Weight of Dry Soil	16.16	Weight of Dry Soil	16.68
Water Content	30.75%	Water Content	27.82%
Borehole Number	SB-1202	Borehole Number	SB-1201
Sample Depth	0.0'-2.0'	Sample Depth	29.0'-30.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	39.12	Weight of Wet Soil & Tare	51.96
Weight of Dry Soil & Tare	36.22	Weight of Dry Soil & Tare	45.05
Weight of Tare	13.99	Weight of Tare	14.02
Weight of Water	2.90	Weight of Water	6.91
Weight of Dry Soil	22.23	Weight of Dry Soil	31.03
Water Content	13.05%	Water Content	22.27%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1204	Borehole Number	SB-1204
Sample Depth	0.0'-2.0'	Sample Depth	15.0'-17.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.61	Weight of Wet Soil & Tare	32.54
Weight of Dry Soil & Tare	28.26	Weight of Dry Soil & Tare	27.84
Weight of Tare	13.91	Weight of Tare	13.36
Weight of Water	4.35	Weight of Water	4.70
Weight of Dry Soil	14.35	Weight of Dry Soil	14.48
Water Content	30.31%	Water Content	32.46%
Borehole Number	SB-1204	Borehole Number	SB-1203
Sample Depth	5.0'-7.0'	Sample Depth	15.0'-17.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	34.63	Weight of Wet Soil & Tare	42.08
Weight of Dry Soil & Tare	29.25	Weight of Dry Soil & Tare	34.69
Weight of Tare	14.17	Weight of Tare	14.22
Weight of Water	5.38	Weight of Water	7.39
Weight of Dry Soil	15.08	Weight of Dry Soil	20.47
Water Content	35.68%	Water Content	36.10%
Borehole Number	SB-1204	Borehole Number	SB-1203
Sample Depth	10.0'-12.0'	Sample Depth	22.0'-24.0'
Sample Number	11.3'-12.0'	Sample Number	
Weight of Wet Soil & Tare	33.45	Weight of Wet Soil & Tare	36.03
Weight of Dry Soil & Tare	26.78	Weight of Dry Soil & Tare	29.21
Weight of Tare	14.08	Weight of Tare	13.79
Weight of Water	6.67	Weight of Water	6.82
Weight of Dry Soil	12.70	Weight of Dry Soil	15.42
Water Content	52.52%	Water Content	44.23%
Borehole Number	SB-1204	Borehole Number	SB-1203
Sample Depth	15.0'-17.0'	Sample Depth	22.0'-24.0'
Sample Number	15.9'-16.1'	Sample Number	Top Of Spoon
Weight of Wet Soil & Tare	33.25	Weight of Wet Soil & Tare	34.99
Weight of Dry Soil & Tare	30.67	Weight of Dry Soil & Tare	28.71
Weight of Tare	14.14	Weight of Tare	14.16
Weight of Water	2.58	Weight of Water	6.28
Weight of Dry Soil	16.53	Weight of Dry Soil	14.55
Water Content	15.61%	Water Content	43.16%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1204	Borehole Number	SB-1204
Sample Depth	20.0'-22.0'	Sample Depth	34.0'-35.0'
Sample Number	20.0'-20.1'	Sample Number	35.5'-36.0'
Weight of Wet Soil & Tare	33.35	Weight of Wet Soil & Tare	40.72
Weight of Dry Soil & Tare	29.47	Weight of Dry Soil & Tare	36.06
Weight of Tare	14.05	Weight of Tare	13.93
Weight of Water	3.88	Weight of Water	4.66
Weight of Dry Soil	15.42	Weight of Dry Soil	22.13
Water Content	25.16%	Water Content	21.06%

Borehole Number	SB-1204	Borehole Number	SB-1204
Sample Depth	20.0'-22.0'	Sample Depth	36.0'-38.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	31.61	Weight of Wet Soil & Tare	40.72
Weight of Dry Soil & Tare	25.33	Weight of Dry Soil & Tare	36.65
Weight of Tare	10.07	Weight of Tare	14.01
Weight of Water	6.28	Weight of Water	4.07
Weight of Dry Soil	15.26	Weight of Dry Soil	22.64
Water Content	41.15%	Water Content	17.98%

Borehole Number	SB-1204	Borehole Number	SB-1205
Sample Depth	22.0'-24.0'	Sample Depth	0.0'-2.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	34.88	Weight of Wet Soil & Tare	33.60
Weight of Dry Soil & Tare	27.53	Weight of Dry Soil & Tare	29.51
Weight of Tare	11.70	Weight of Tare	14.07
Weight of Water	7.35	Weight of Water	4.09
Weight of Dry Soil	15.83	Weight of Dry Soil	15.44
Water Content	46.43%	Water Content	26.49%

Borehole Number	SB-1204	Borehole Number	SB-1205
Sample Depth	24.0'-26.0'	Sample Depth	5.0'-7.0'
Sample Number	24.0'-25.4'	Sample Number	
Weight of Wet Soil & Tare	40.65	Weight of Wet Soil & Tare	35.78
Weight of Dry Soil & Tare	33.42	Weight of Dry Soil & Tare	31.47
Weight of Tare	14.06	Weight of Tare	14.04
Weight of Water	7.23	Weight of Water	4.31
Weight of Dry Soil	19.36	Weight of Dry Soil	17.43
Water Content	37.35%	Water Content	24.73%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GPS

Borehole Number	SB-1205	Borehole Number	SB-1211
Sample Depth	15.0'-17.0'	Sample Depth	15.0'-17.0'
Sample Number		Sample Number	Fine Sand Size
Weight of Wet Soil & Tare	31.01	Weight of Wet Soil & Tare	28.76
Weight of Dry Soil & Tare	27.11	Weight of Dry Soil & Tare	24.98
Weight of Tare	14.00	Weight of Tare	11.31
Weight of Water	3.90	Weight of Water	3.78
Weight of Dry Soil	13.11	Weight of Dry Soil	13.67
Water Content	29.75%	Water Content	27.65%
Borehole Number	SB-1211	Borehole Number	SB-1205
Sample Depth	0.0'-2.0'	Sample Depth	24.0'-26.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	33.23	Weight of Wet Soil & Tare	31.60
Weight of Dry Soil & Tare	28.87	Weight of Dry Soil & Tare	27.00
Weight of Tare	13.72	Weight of Tare	10.98
Weight of Water	4.36	Weight of Water	4.60
Weight of Dry Soil	15.15	Weight of Dry Soil	16.02
Water Content	28.78%	Water Content	28.71%
Borehole Number	SB-1211	Borehole Number	
Sample Depth	5.0'-7.0'	Sample Depth	
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.18	Weight of Wet Soil & Tare	
Weight of Dry Soil & Tare	25.46	Weight of Dry Soil & Tare	
Weight of Tare	11.48	Weight of Tare	
Weight of Water	6.72	Weight of Water	0.00
Weight of Dry Soil	13.98	Weight of Dry Soil	0.00
Water Content	48.07%	Water Content	
Borehole Number	SB-1211	Borehole Number	SB-1205
Sample Depth	10.0'-12.0'	Sample Depth	33.6-34
Sample Number		Sample Number	Native Sand
Weight of Wet Soil & Tare	34.10	Weight of Wet Soil & Tare	36.34
Weight of Dry Soil & Tare	29.39	Weight of Dry Soil & Tare	33.69
Weight of Tare	14.02	Weight of Tare	13.97
Weight of Water	4.71	Weight of Water	2.65
Weight of Dry Soil	15.37	Weight of Dry Soil	19.72
Water Content	30.64%	Water Content	13.44%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	

Borehole Number	SB-1206	Borehole Number	SB-1206
Sample Depth	0.0'-2.0'	Sample Depth	15.0'-17.0'
Sample Number		Sample Number	15.9'-17.0'
Weight of Wet Soil & Tare	30.38	Weight of Wet Soil & Tare	44.07
Weight of Dry Soil & Tare	26.77	Weight of Dry Soil & Tare	34.80
Weight of Tare	13.91	Weight of Tare	14.11
Weight of Water	3.61	Weight of Water	9.27
Weight of Dry Soil	12.86	Weight of Dry Soil	20.69
Water Content	28.07%	Water Content	44.80%
Borehole Number	SB-1206	Borehole Number	SB-1206
Sample Depth	5.0'-7.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	30.12	Weight of Wet Soil & Tare	41.14
Weight of Dry Soil & Tare	25.51	Weight of Dry Soil & Tare	32.27
Weight of Tare	14.02	Weight of Tare	14.09
Weight of Water	4.61	Weight of Water	8.87
Weight of Dry Soil	11.49	Weight of Dry Soil	18.18
Water Content	40.12%	Water Content	48.79%
Borehole Number	SB-1206	Borehole Number	SB-1206
Sample Depth	10.0'-12.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	33.58	Weight of Wet Soil & Tare	39.07
Weight of Dry Soil & Tare	30.27	Weight of Dry Soil & Tare	32.62
Weight of Tare	14.19	Weight of Tare	14.06
Weight of Water	3.31	Weight of Water	6.45
Weight of Dry Soil	16.08	Weight of Dry Soil	18.56
Water Content	20.58%	Water Content	34.75%
Borehole Number	SB-1206	Borehole Number	SB-1206
Sample Depth	15.0'-17.0'	Sample Depth	24.0'-26.0'
Sample Number		Sample Number	24.0'-24.5'
Weight of Wet Soil & Tare	31.67	Weight of Wet Soil & Tare	33.32
Weight of Dry Soil & Tare	27.33	Weight of Dry Soil & Tare	27.43
Weight of Tare	11.69	Weight of Tare	10.79
Weight of Water	4.34	Weight of Water	5.89
Weight of Dry Soil	15.64	Weight of Dry Soil	16.64
Water Content	27.75%	Water Content	35.40%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GDS

Borehole Number	SB-1211	Borehole Number	SB-1207
Sample Depth	26.0'-28.0'	Sample Depth	15.0'-17.0'
Sample Number	Below Ash	Sample Number	
Weight of Wet Soil & Tare	46.68	Weight of Wet Soil & Tare	29.05
Weight of Dry Soil & Tare	44.99	Weight of Dry Soil & Tare	24.69
Weight of Tare	13.91	Weight of Tare	3.38
Weight of Water	1.69	Weight of Water	4.36
Weight of Dry Soil	31.08	Weight of Dry Soil	21.31
Water Content	5.44%	Water Content	20.46%
Borehole Number	SB-1207	Borehole Number	SB-1207
Sample Depth	0.0'-2.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	30.41	Weight of Wet Soil & Tare	25.33
Weight of Dry Soil & Tare	25.15	Weight of Dry Soil & Tare	19.65
Weight of Tare	3.46	Weight of Tare	3.27
Weight of Water	5.26	Weight of Water	5.68
Weight of Dry Soil	21.69	Weight of Dry Soil	16.38
Water Content	24.25%	Water Content	34.68%
Borehole Number	SB-1207	Borehole Number	SB-1207
Sample Depth	5.0'-7.0'	Sample Depth	30.0'-32.0'
Sample Number		Sample Number	Below Ash
Weight of Wet Soil & Tare	35.26	Weight of Wet Soil & Tare	37.31
Weight of Dry Soil & Tare	28.47	Weight of Dry Soil & Tare	34.74
Weight of Tare	3.56	Weight of Tare	3.49
Weight of Water	6.79	Weight of Water	2.57
Weight of Dry Soil	24.91	Weight of Dry Soil	31.25
Water Content	27.26%	Water Content	8.22%
Borehole Number	SB-1207	Borehole Number	SB-1207
Sample Depth	10.0'-12.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	All But Loose Silt
Weight of Wet Soil & Tare	27.78	Weight of Wet Soil & Tare	27.26
Weight of Dry Soil & Tare	22.50	Weight of Dry Soil & Tare	21.00
Weight of Tare	3.55	Weight of Tare	3.54
Weight of Water	5.28	Weight of Water	6.26
Weight of Dry Soil	18.95	Weight of Dry Soil	17.46
Water Content	27.86%	Water Content	35.85%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	CB

Borehole Number	SB-1208	Borehole Number	SB-1208
Sample Depth	0.0'-2.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	23.93	Weight of Wet Soil & Tare	32.42
Weight of Dry Soil & Tare	19.21	Weight of Dry Soil & Tare	31.30
Weight of Tare	3.43	Weight of Tare	3.08
Weight of Water	4.72	Weight of Water	1.12
Weight of Dry Soil	15.78	Weight of Dry Soil	28.22
Water Content	29.91%	Water Content	3.97%
Borehole Number	SB-1208	Borehole Number	SB-1208
Sample Depth	10.0'-12.0'	Sample Depth	24.0'-26.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	44.73	Weight of Wet Soil & Tare	28.72
Weight of Dry Soil & Tare	36.36	Weight of Dry Soil & Tare	27.41
Weight of Tare	3.54	Weight of Tare	3.20
Weight of Water	8.37	Weight of Water	1.31
Weight of Dry Soil	32.82	Weight of Dry Soil	24.21
Water Content	25.50%	Water Content	5.41%
Borehole Number	SB-1208	Borehole Number	SB-1208
Sample Depth	12.0'-14.0'	Sample Depth	29.0'-31.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	29.23	Weight of Wet Soil & Tare	44.08
Weight of Dry Soil & Tare	24.15	Weight of Dry Soil & Tare	36.75
Weight of Tare	3.60	Weight of Tare	2.76
Weight of Water	5.08	Weight of Water	7.33
Weight of Dry Soil	20.55	Weight of Dry Soil	33.99
Water Content	24.72%	Water Content	21.58%
Borehole Number	SB-1208	Borehole Number	SB-1210
Sample Depth	14.0'-16.0'	Sample Depth	0.0'-2.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	29.78	Weight of Wet Soil & Tare	27.45
Weight of Dry Soil & Tare	24.53	Weight of Dry Soil & Tare	21.40
Weight of Tare	2.55	Weight of Tare	2.46
Weight of Water	5.25	Weight of Water	6.05
Weight of Dry Soil	21.98	Weight of Dry Soil	18.94
Water Content	23.89%	Water Content	31.94%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1209	Borehole Number	SB-1209
Sample Depth	0.0'-2.0'	Sample Depth	14.0'-16.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	23.90	Weight of Wet Soil & Tare	27.86
Weight of Dry Soil & Tare	18.49	Weight of Dry Soil & Tare	22.12
Weight of Tare	2.33	Weight of Tare	3.59
Weight of Water	5.41	Weight of Water	5.74
Weight of Dry Soil	16.16	Weight of Dry Soil	18.53
Water Content	33.48%	Water Content	30.98%
Borehole Number	SB-1209	Borehole Number	SB-1209
Sample Depth	5.0'-7.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	20.0'-20.08'
Weight of Wet Soil & Tare	25.48	Weight of Wet Soil & Tare	29.44
Weight of Dry Soil & Tare	21.18	Weight of Dry Soil & Tare	23.31
Weight of Tare	3.68	Weight of Tare	3.61
Weight of Water	4.30	Weight of Water	6.13
Weight of Dry Soil	17.50	Weight of Dry Soil	19.70
Water Content	24.57%	Water Content	31.12%
Borehole Number	SB-1209	Borehole Number	SB-1209
Sample Depth	10.0'-12.0'	Sample Depth	18.0'-20.0'
Sample Number		Sample Number	Stiffer Seam 18.7-19.0
Weight of Wet Soil & Tare	27.15	Weight of Wet Soil & Tare	32.24
Weight of Dry Soil & Tare	22.95	Weight of Dry Soil & Tare	31.49
Weight of Tare	3.30	Weight of Tare	3.51
Weight of Water	4.20	Weight of Water	0.75
Weight of Dry Soil	19.65	Weight of Dry Soil	27.98
Water Content	21.37%	Water Content	2.68%
Borehole Number	SB-1209	Borehole Number	SB-1209
Sample Depth	12.0'-14.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	20.8-22.0 Sand Below Ash
Weight of Wet Soil & Tare	27.41	Weight of Wet Soil & Tare	29.92
Weight of Dry Soil & Tare	22.08	Weight of Dry Soil & Tare	27.28
Weight of Tare	3.51	Weight of Tare	3.60
Weight of Water	5.33	Weight of Water	2.64
Weight of Dry Soil	18.57	Weight of Dry Soil	23.68
Water Content	28.70%	Water Content	11.15%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1210	Borehole Number	SB-1210
Sample Depth	4.0'-6.0'	Sample Depth	18.0'-20.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	22.93	Weight of Wet Soil & Tare	35.71
Weight of Dry Soil & Tare	17.09	Weight of Dry Soil & Tare	26.04
Weight of Tare	3.13	Weight of Tare	3.58
Weight of Water	5.84	Weight of Water	9.67
Weight of Dry Soil	13.96	Weight of Dry Soil	22.46
Water Content	41.83%	Water Content	43.05%
Borehole Number	SB-1210	Borehole Number	SB-1210
Sample Depth	9.0'-11.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	20.0'-21.0'
Weight of Wet Soil & Tare	23.93	Weight of Wet Soil & Tare	33.39
Weight of Dry Soil & Tare	18.53	Weight of Dry Soil & Tare	25.61
Weight of Tare	3.34	Weight of Tare	3.49
Weight of Water	5.40	Weight of Water	7.78
Weight of Dry Soil	15.19	Weight of Dry Soil	22.12
Water Content	35.55%	Water Content	35.17%
Borehole Number	SB-1210	Borehole Number	SB-1210
Sample Depth	14.0'-16.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	21.0'-22.0'
Weight of Wet Soil & Tare	26.74	Weight of Wet Soil & Tare	26.97
Weight of Dry Soil & Tare	19.53	Weight of Dry Soil & Tare	20.37
Weight of Tare	3.57	Weight of Tare	2.44
Weight of Water	7.21	Weight of Water	6.60
Weight of Dry Soil	15.96	Weight of Dry Soil	17.93
Water Content	45.18%	Water Content	36.81%
Borehole Number	SB-1210	Borehole Number	SB-1210
Sample Depth	16.0'-18.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	Below Ash
Weight of Wet Soil & Tare	29.17	Weight of Wet Soil & Tare	31.68
Weight of Dry Soil & Tare	21.72	Weight of Dry Soil & Tare	29.44
Weight of Tare	3.25	Weight of Tare	3.35
Weight of Water	7.45	Weight of Water	2.24
Weight of Dry Soil	18.47	Weight of Dry Soil	26.09
Water Content	40.34%	Water Content	8.59%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1212	Borehole Number	SB-1214
Sample Depth	10.0'-12.0'	Sample Depth	26.0'-28.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	31.15	Weight of Wet Soil & Tare	28.48
Weight of Dry Soil & Tare	23.57	Weight of Dry Soil & Tare	27.25
Weight of Tare	3.57	Weight of Tare	3.58
Weight of Water	7.58	Weight of Water	1.23
Weight of Dry Soil	20.00	Weight of Dry Soil	23.67
Water Content	37.90%	Water Content	5.20%
Borehole Number	SB-1212	Borehole Number	SB-1214
Sample Depth	17.0'-19.0'	Sample Depth	28.0'-30.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	22.39	Weight of Wet Soil & Tare	30.99
Weight of Dry Soil & Tare	18.01	Weight of Dry Soil & Tare	29.61
Weight of Tare	3.64	Weight of Tare	3.55
Weight of Water	4.38	Weight of Water	1.38
Weight of Dry Soil	14.37	Weight of Dry Soil	26.06
Water Content	30.48%	Water Content	5.30%
Borehole Number	SB-1212	Borehole Number	SB-1214
Sample Depth	23.0'-25.0'	Sample Depth	30.0'-32.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	25.20	Weight of Wet Soil & Tare	31.87
Weight of Dry Soil & Tare	21.95	Weight of Dry Soil & Tare	30.46
Weight of Tare	3.61	Weight of Tare	3.43
Weight of Water	3.25	Weight of Water	1.41
Weight of Dry Soil	18.34	Weight of Dry Soil	27.03
Water Content	17.72%	Water Content	5.22%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	24.0'-26.0'	Sample Depth	34.0'-36.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	33.79	Weight of Wet Soil & Tare	27.43
Weight of Dry Soil & Tare	32.24	Weight of Dry Soil & Tare	26.52
Weight of Tare	3.39	Weight of Tare	3.50
Weight of Water	1.55	Weight of Water	0.91
Weight of Dry Soil	28.85	Weight of Dry Soil	23.02
Water Content	5.37%	Water Content	3.95%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRG

Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	8.0'-10.0'	Sample Depth	16.0-18.0
Sample Number		Sample Number	
Weight of Wet Soil & Tare	21.85	Weight of Wet Soil & Tare	26.04
Weight of Dry Soil & Tare	21.22	Weight of Dry Soil & Tare	25.09
Weight of Tare	3.66	Weight of Tare	3.41
Weight of Water	0.63	Weight of Water	0.95
Weight of Dry Soil	17.56	Weight of Dry Soil	21.68
Water Content	3.59%	Water Content	4.38%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	10.0'-12.0'	Sample Depth	18.0'-20.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	27.67	Weight of Wet Soil & Tare	20.27
Weight of Dry Soil & Tare	26.62	Weight of Dry Soil & Tare	19.62
Weight of Tare	3.47	Weight of Tare	3.55
Weight of Water	1.05	Weight of Water	0.65
Weight of Dry Soil	23.15	Weight of Dry Soil	16.07
Water Content	4.54%	Water Content	4.04%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	12.0'-14.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	31.02	Weight of Wet Soil & Tare	24.50
Weight of Dry Soil & Tare	30.00	Weight of Dry Soil & Tare	23.60
Weight of Tare	3.46	Weight of Tare	3.57
Weight of Water	1.02	Weight of Water	0.90
Weight of Dry Soil	26.54	Weight of Dry Soil	20.03
Water Content	3.84%	Water Content	4.49%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	14.0'-16.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.79	Weight of Wet Soil & Tare	30.32
Weight of Dry Soil & Tare	31.40	Weight of Dry Soil & Tare	29.27
Weight of Tare	3.38	Weight of Tare	3.45
Weight of Water	1.39	Weight of Water	1.05
Weight of Dry Soil	28.02	Weight of Dry Soil	25.82
Water Content	4.96%	Water Content	4.07%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	ERS

Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	39.0'-41.0'	Sample Depth	0.0'-2.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	28.94	Weight of Wet Soil & Tare	32.55
Weight of Dry Soil & Tare	25.48	Weight of Dry Soil & Tare	31.98
Weight of Tare	3.24	Weight of Tare	3.25
Weight of Water	3.46	Weight of Water	0.57
Weight of Dry Soil	22.24	Weight of Dry Soil	28.73
Water Content	15.56%	Water Content	1.98%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	44.0'-46.0'	Sample Depth	2.0'-4.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	35.50	Weight of Wet Soil & Tare	26.45
Weight of Dry Soil & Tare	29.29	Weight of Dry Soil & Tare	25.87
Weight of Tare	3.33	Weight of Tare	3.31
Weight of Water	6.21	Weight of Water	0.58
Weight of Dry Soil	25.96	Weight of Dry Soil	22.56
Water Content	23.92%	Water Content	2.57%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	49.0'-51.0'	Sample Depth	4.0'-6.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	22.09	Weight of Wet Soil & Tare	29.03
Weight of Dry Soil & Tare	18.84	Weight of Dry Soil & Tare	27.95
Weight of Tare	2.40	Weight of Tare	3.52
Weight of Water	3.25	Weight of Water	1.08
Weight of Dry Soil	16.44	Weight of Dry Soil	24.43
Water Content	19.77%	Water Content	4.42%
Borehole Number	SB-1214	Borehole Number	SB-1214
Sample Depth	54.0'-56.0'	Sample Depth	6.0'-8.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	38.56	Weight of Wet Soil & Tare	25.26
Weight of Dry Soil & Tare	33.16	Weight of Dry Soil & Tare	24.40
Weight of Tare	3.30	Weight of Tare	3.49
Weight of Water	5.40	Weight of Water	0.86
Weight of Dry Soil	29.86	Weight of Dry Soil	20.91
Water Content	18.08%	Water Content	4.11%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	ABS

Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	12.0'-14.0'	Sample Depth	20.0'-22.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	26.01	Weight of Wet Soil & Tare	32.13
Weight of Dry Soil & Tare	25.11	Weight of Dry Soil & Tare	30.63
Weight of Tare	3.62	Weight of Tare	3.65
Weight of Water	0.90	Weight of Water	1.50
Weight of Dry Soil	21.49	Weight of Dry Soil	26.98
Water Content	4.19%	Water Content	5.56%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	14.0'-16.0'	Sample Depth	22.0'-24.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	27.07	Weight of Wet Soil & Tare	34.36
Weight of Dry Soil & Tare	26.04	Weight of Dry Soil & Tare	31.53
Weight of Tare	3.63	Weight of Tare	3.59
Weight of Water	1.03	Weight of Water	2.83
Weight of Dry Soil	22.41	Weight of Dry Soil	27.94
Water Content	4.60%	Water Content	10.13%
Borehole Number	SB-1213	Borehole Number	SB-1212
Sample Depth	16.0'-18.0'	Sample Depth	0.0'-2.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	28.07	Weight of Wet Soil & Tare	23.36
Weight of Dry Soil & Tare	26.62	Weight of Dry Soil & Tare	18.73
Weight of Tare	3.07	Weight of Tare	3.51
Weight of Water	1.45	Weight of Water	4.63
Weight of Dry Soil	23.55	Weight of Dry Soil	15.22
Water Content	6.16%	Water Content	30.42%
Borehole Number	SB-1213	Borehole Number	SB-1212
Sample Depth	18.0'-20.0'	Sample Depth	5.0'-7.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	26.52	Weight of Wet Soil & Tare	21.98
Weight of Dry Soil & Tare	25.85	Weight of Dry Soil & Tare	17.23
Weight of Tare	3.60	Weight of Tare	3.46
Weight of Water	0.67	Weight of Water	4.75
Weight of Dry Soil	22.25	Weight of Dry Soil	13.77
Water Content	3.01%	Water Content	34.50%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GRS

Borehole Number	SB-1209	Borehole Number	SB-1213
Sample Depth	20.0'-22.0'	Sample Depth	30.0'-32.0'
Sample Number	20.0'-20.8'	Sample Number	
Weight of Wet Soil & Tare	32.17	Weight of Wet Soil & Tare	27.75
Weight of Dry Soil & Tare	24.98	Weight of Dry Soil & Tare	26.86
Weight of Tare	3.56	Weight of Tare	3.55
Weight of Water	7.19	Weight of Water	0.89
Weight of Dry Soil	21.42	Weight of Dry Soil	23.31
Water Content	33.57%	Water Content	3.82%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	24.0'-26.0'	Sample Depth	35.0'-37.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	28.26	Weight of Wet Soil & Tare	38.01
Weight of Dry Soil & Tare	25.67	Weight of Dry Soil & Tare	32.69
Weight of Tare	3.32	Weight of Tare	3.66
Weight of Water	2.59	Weight of Water	5.32
Weight of Dry Soil	22.35	Weight of Dry Soil	29.03
Water Content	11.59%	Water Content	18.33%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	26.0'-28.0'	Sample Depth	40.0'-42.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	34.40	Weight of Wet Soil & Tare	32.05
Weight of Dry Soil & Tare	31.93	Weight of Dry Soil & Tare	27.08
Weight of Tare	3.54	Weight of Tare	3.29
Weight of Water	2.47	Weight of Water	4.97
Weight of Dry Soil	28.39	Weight of Dry Soil	23.79
Water Content	8.70%	Water Content	20.89%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	28.0'-30.0'	Sample Depth	43.0'-47.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	29.56	Weight of Wet Soil & Tare	30.90
Weight of Dry Soil & Tare	28.72	Weight of Dry Soil & Tare	26.23
Weight of Tare	3.26	Weight of Tare	3.58
Weight of Water	0.84	Weight of Water	4.67
Weight of Dry Soil	25.46	Weight of Dry Soil	22.65
Water Content	3.30%	Water Content	20.62%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	CB
Project Name	Consumers/Campbell Ash Impoundment	Date	6/15/2012
		Reviewed	GPS

Borehole Number	SB1213	Borehole Number	SB1213
Sample Depth	50.0'-52.0'	Sample Depth	4.0'-6.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	36.16	Weight of Wet Soil & Tare	29.44
Weight of Dry Soil & Tare	30.57	Weight of Dry Soil & Tare	27.90
Weight of Tare	3.00	Weight of Tare	3.68
Weight of Water	5.59	Weight of Water	1.54
Weight of Dry Soil	27.57	Weight of Dry Soil	24.22
Water Content	20.28%	Water Content	6.36%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	59.0'-60.0'	Sample Depth	6.0'-8.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	37.45	Weight of Wet Soil & Tare	35.33
Weight of Dry Soil & Tare	32.89	Weight of Dry Soil & Tare	32.09
Weight of Tare	3.58	Weight of Tare	3.30
Weight of Water	4.56	Weight of Water	3.24
Weight of Dry Soil	29.31	Weight of Dry Soil	28.79
Water Content	15.56%	Water Content	11.25%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	0.0'-2.0'	Sample Depth	8.0'-10.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	27.09	Weight of Wet Soil & Tare	31.37
Weight of Dry Soil & Tare	26.62	Weight of Dry Soil & Tare	30.41
Weight of Tare	3.53	Weight of Tare	3.65
Weight of Water	0.47	Weight of Water	0.96
Weight of Dry Soil	23.09	Weight of Dry Soil	26.76
Water Content	2.04%	Water Content	3.59%
Borehole Number	SB-1213	Borehole Number	SB-1213
Sample Depth	2.0'-4.0'	Sample Depth	10.0'-12.0'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	25.47	Weight of Wet Soil & Tare	27.18
Weight of Dry Soil & Tare	24.55	Weight of Dry Soil & Tare	26.18
Weight of Tare	3.63	Weight of Tare	3.31
Weight of Water	0.92	Weight of Water	1.00
Weight of Dry Soil	20.92	Weight of Dry Soil	22.87
Water Content	4.40%	Water Content	4.37%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	MG
Project Name	Campbell-Consumer Energy	Date	9/5/2012
		Reviewed	JBB

Borehole Number	SB-1215	Borehole Number	SB-1215
Sample Depth	0'-2'	Sample Depth	16'-18'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.67	Weight of Wet Soil & Tare	32.61
Weight of Dry Soil & Tare	30.44	Weight of Dry Soil & Tare	30.68
Weight of Tare	3.49	Weight of Tare	3.59
Weight of Water	2.23	Weight of Water	1.93
Weight of Dry Soil	26.95	Weight of Dry Soil	27.09
Water Content	8.27%	Water Content	7.12%
Borehole Number	SB-1215	Borehole Number	SB-1215
Sample Depth	4'-6'	Sample Depth	24'-26'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.26	Weight of Wet Soil & Tare	32.74
Weight of Dry Soil & Tare	31.76	Weight of Dry Soil & Tare	31.25
Weight of Tare	3.49	Weight of Tare	3.51
Weight of Water	0.50	Weight of Water	1.49
Weight of Dry Soil	28.27	Weight of Dry Soil	27.74
Water Content	1.77%	Water Content	5.37%
Borehole Number	SB-1215	Borehole Number	SB-1215
Sample Depth	8'-10'	Sample Depth	28'-30'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.92	Weight of Wet Soil & Tare	32.62
Weight of Dry Soil & Tare	32.01	Weight of Dry Soil & Tare	31.29
Weight of Tare	3.61	Weight of Tare	3.55
Weight of Water	0.91	Weight of Water	1.33
Weight of Dry Soil	28.40	Weight of Dry Soil	27.74
Water Content	3.20%	Water Content	4.79%
Borehole Number	SB-1215	Borehole Number	SB-1215
Sample Depth	12'-14'	Sample Depth	35'-37'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.78	Weight of Wet Soil & Tare	32.27
Weight of Dry Soil & Tare	31.00	Weight of Dry Soil & Tare	31.01
Weight of Tare	3.56	Weight of Tare	3.52
Weight of Water	1.78	Weight of Water	1.26
Weight of Dry Soil	27.44	Weight of Dry Soil	27.49
Water Content	6.49%	Water Content	4.58%

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MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	MG
Project Name	Campbell-Consumer Energy	Date	9/5/2012
		Reviewed	

Borehole Number	SB-1215	Borehole Number	SB-1216
Sample Depth	40'-42'	Sample Depth	10'-12'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.59	Weight of Wet Soil & Tare	32.53
Weight of Dry Soil & Tare	31.68	Weight of Dry Soil & Tare	30.51
Weight of Tare	3.54	Weight of Tare	3.50
Weight of Water	0.91	Weight of Water	2.02
Weight of Dry Soil	28.14	Weight of Dry Soil	27.01
Water Content	3.23%	Water Content	7.48%
Borehole Number	SB-1215	Borehole Number	SB-1216
Sample Depth	45'-47'	Sample Depth	14'-16'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.42	Weight of Wet Soil & Tare	32.73
Weight of Dry Soil & Tare	27.77	Weight of Dry Soil & Tare	30.87
Weight of Tare	3.66	Weight of Tare	3.51
Weight of Water	4.65	Weight of Water	1.86
Weight of Dry Soil	24.11	Weight of Dry Soil	27.36
Water Content	19.29%	Water Content	6.80%
Borehole Number	SB-1216	Borehole Number	SB-1216
Sample Depth	2'-4'	Sample Depth	22'-24'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.59	Weight of Wet Soil & Tare	32.66
Weight of Dry Soil & Tare	31.91	Weight of Dry Soil & Tare	30.57
Weight of Tare	3.57	Weight of Tare	3.59
Weight of Water	0.68	Weight of Water	2.09
Weight of Dry Soil	28.34	Weight of Dry Soil	26.98
Water Content	2.40%	Water Content	7.75%
Borehole Number	SB-1216	Borehole Number	SB-1216
Sample Depth	6'-8'	Sample Depth	26'-28'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.31	Weight of Wet Soil & Tare	32.50
Weight of Dry Soil & Tare	31.34	Weight of Dry Soil & Tare	30.44
Weight of Tare	3.53	Weight of Tare	3.62
Weight of Water	0.97	Weight of Water	2.06
Weight of Dry Soil	27.81	Weight of Dry Soil	26.82
Water Content	3.49%	Water Content	7.68%

MOISTURE CONTENT DETERMINATIONS

Project Number	123-88896	Tech	MG
Project Name	Campbell-Consumer Energy	Date	9/5/2012
		Reviewed	

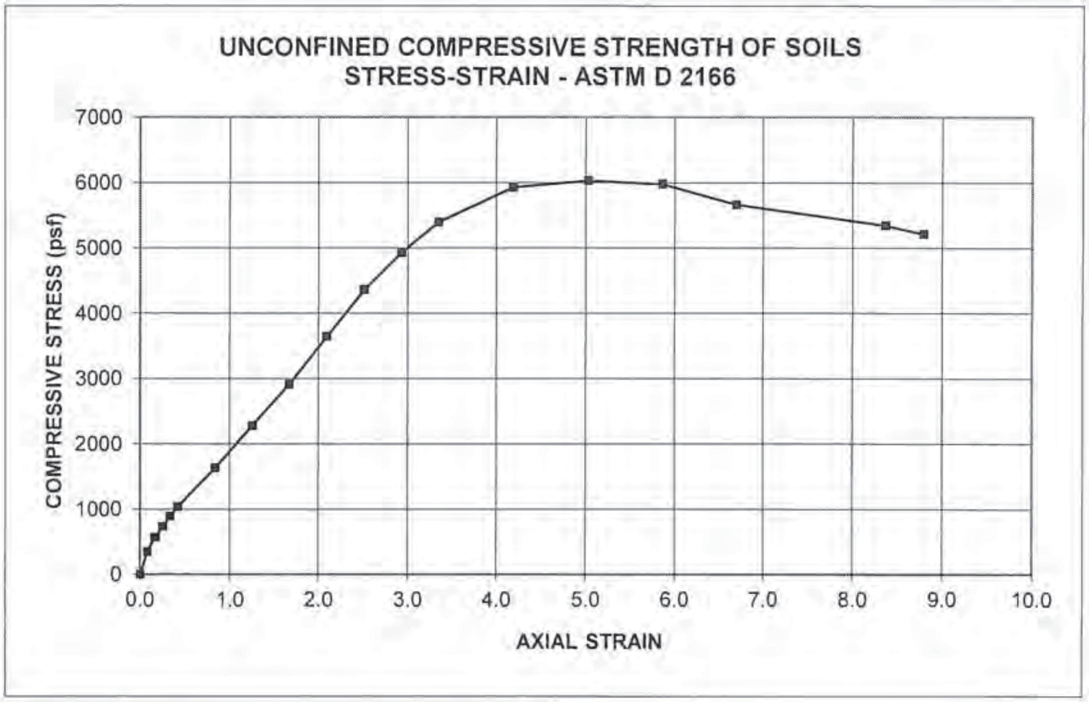
Borehole Number	SB-1217	Borehole Number	SB-1217
Sample Depth	0'-2'	Sample Depth	18'-20'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.27	Weight of Wet Soil & Tare	33.02
Weight of Dry Soil & Tare	29.21	Weight of Dry Soil & Tare	22.63
Weight of Tare	3.61	Weight of Tare	3.55
Weight of Water	3.06	Weight of Water	10.39
Weight of Dry Soil	25.60	Weight of Dry Soil	19.08
Water Content	11.95%	Water Content	54.45%

Borehole Number	SB-1217	Borehole Number	SB-1217
Sample Depth	4'-6'	Sample Depth	20'-22'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	33.49	Weight of Wet Soil & Tare	32.78
Weight of Dry Soil & Tare	26.70	Weight of Dry Soil & Tare	23.67
Weight of Tare	3.50	Weight of Tare	3.59
Weight of Water	6.79	Weight of Water	9.11
Weight of Dry Soil	23.20	Weight of Dry Soil	20.08
Water Content	29.27%	Water Content	45.37%

Borehole Number	SB-1217	Borehole Number	SB-1217
Sample Depth	14'-16'	Sample Depth	22'-23.3'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.63	Weight of Wet Soil & Tare	32.74
Weight of Dry Soil & Tare	24.50	Weight of Dry Soil & Tare	23.04
Weight of Tare	3.50	Weight of Tare	3.58
Weight of Water	8.13	Weight of Water	9.70
Weight of Dry Soil	21.00	Weight of Dry Soil	19.46
Water Content	38.71%	Water Content	49.85%

Borehole Number	SB-1217	Borehole Number	SB-1217
Sample Depth	16'-18'	Sample Depth	28'-30'
Sample Number		Sample Number	
Weight of Wet Soil & Tare	32.55	Weight of Wet Soil & Tare	32.41
Weight of Dry Soil & Tare	24.35	Weight of Dry Soil & Tare	27.16
Weight of Tare	3.50	Weight of Tare	3.56
Weight of Water	8.20	Weight of Water	5.25
Weight of Dry Soil	20.85	Weight of Dry Soil	23.60
Water Content	39.33%	Water Content	22.25%

Golder Associates - Lansing Michigan



DESCRIPTION	LL	PL	PI	SAMPLE ID
Grayish Brown, SILTY CLAY, little medium to fine sand.	39	20	19	SD 1215
	SAMPLE TYPE		UD	81.0-83.0'

USCS	CL

SAMPLE DATA

Wet Density (pcf)	125.8
Dry Density (pcf)	99.6
Moisture Content	26.3%

TIME TO FAILURE (min)	5.0
STRAIN @ FAILURE (%)	5.0
TYPE OF FAILURE	SHEAR

UNCONFINED COMPRESSIVE STRENGTH (psf)	6033.8
SHEAR STRENGTH (psf)	3016.9

123-88896
EE/CEC CAMPBELL ASH IMPOUNDMENT/MI

TECH	TW
DATE	8/30/2012
CHECK	DA
REVIEW	RWM
APPROVE	

UNCONFINED COMPRESSIVE STRENGTH OF SOILS

ASTM D 2166

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI	SAMPLE ID	SD 1215
PROJECT NO.	123-88896	SAMPLE TYPE	UD
REMARKS		SAMPLE DEPTH	81.0-83.0'

SAMPLE DATA

Height (in)	5.973
Diameter (in)	2.873
Height/Diameter Ratio	2.08
Area (in^2)	6.48
Volume (ft^3)	0.0224
Weight (gm)	1279.05
Wet Density (pcf)	125.78
Dry Density (pcf)	99.60
Machine Speed (in/min)	0.06
Strain rate (%/min)	1.00

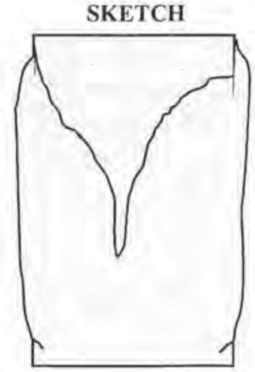
WATER CONTENT

	BEFORE SHEAR (entire)	AFTER SHEAR (partial)
Tare No.	-	-
Wt. Wet Soil & Tare (gm)	1279.05	1447.20
Wt. Dry Soil & Tare (gm)	1012.78	1181.19
Wt. Tare (gm)	0.00	169.40
Wt. Moisture (gm)	266.27	266.01
Wt. Dry Soil (gm)	1012.78	1011.79
Moisture (%)	26.29%	26.29%

TIME (min)	DEFLECT (inch)	FORCE (lbs)	% STRAIN (in/in)	Ac (in²)	COMPRESSIVE STRESS (psf)	COMPRESSIVE STRESS (psi)
0.0	0.000	0	0.00	6.48	0.00	0.00
0.1	0.005	16	0.08	6.49	346.23	2.40
0.2	0.010	26	0.17	6.49	569.91	3.96
0.3	0.015	33	0.25	6.50	733.39	5.09
0.3	0.020	40	0.33	6.50	889.96	6.18
0.4	0.025	47	0.42	6.51	1037.42	7.20
0.8	0.050	74	0.84	6.54	1632.18	11.33
1.3	0.075	104	1.26	6.57	2278.92	15.83
1.7	0.100	134	1.67	6.59	2915.75	20.25
2.1	0.125	167	2.09	6.62	3640.59	25.28
2.5	0.150	201	2.51	6.65	4359.13	30.27
2.9	0.175	229	2.93	6.68	4929.05	34.23
3.3	0.200	251	3.35	6.71	5395.15	37.47
4.2	0.250	279	4.19	6.77	5927.32	41.16
5.0	0.300	286	5.02	6.83	6033.76	41.90
5.8	0.350	286	5.86	6.89	5980.58	41.53
6.7	0.400	273	6.70	6.95	5664.19	39.33
8.3	0.500	263	8.37	7.08	5342.74	37.10
8.8	0.525	257	8.79	7.11	5210.95	36.19

TIME TO FAILURE (min)	5.0
STRAIN @ FAILURE (%)	5.0
TYPE OF FAILURE	SHEAR

FAILURE SKETCH



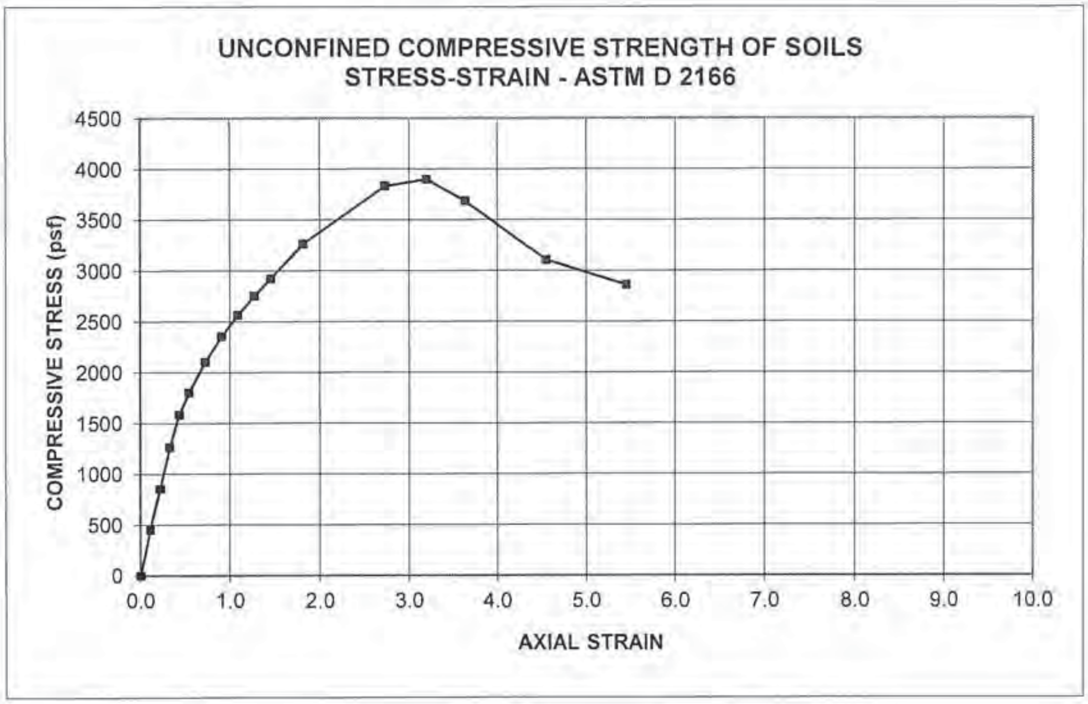
	(psf)	(psi)
UNCONFINED COMPRESSIVE STRENGTH	6033.76	41.90
SHEAR STRENGTH	3016.88	20.95

Description: Grayish Brown, SILTY CLAY, little medium to fine sand.

USCS: CL

LL	39
PL	20
PI	19

TECH	TW
DATE	8/30/12
CHECK	DA
REVIEW	PWM
APPROVE	



DESCRIPTION	LL	PL	PI	SAMPLE ID
Gray, CLAYEY SILT, little fine sand.	NP	NP	NP	SD 1216
	SAMPLE TYPE		UD	70.0-71.0'

USCS	ML

SAMPLE DATA

Wet Density (pcf)	133.8
Dry Density (pcf)	112.2
Moisture Content	19.3%

TIME TO FAILURE (min)	3.1
STRAIN @ FAILURE (%)	3.2
TYPE OF FAILURE	SHEAR

UNCONFINED COMPRESSIVE STRENGTH (psf)	3898.4
SHEAR STRENGTH (psf)	1949.2

123-88896
EE/CEC CAMPBELL ASH IMPOUNDMENT/MI

TECH	TW/DA
DATE	9/14/2012
CHECK	DA
REVIEW	FWM
APPROVE	

UNCONFINED COMPRESSIVE STRENGTH OF SOILS
ASTM D 2166

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI	SAMPLE ID	SD 1216
PROJECT NO.	123-88896	SAMPLE TYPE	UD
REMARKS		SAMPLE DEPTH	70.0-71.0'

SAMPLE DATA

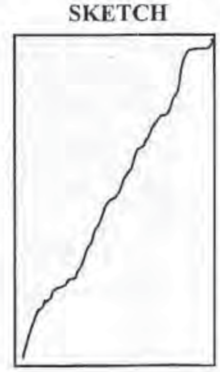
Height (in)	2.751
Diameter (in)	1.444
Height/Diameter Ratio	1.91
Area (in^2)	1.64
Volume (ft^3)	0.0026
Weight (gm)	158.35
Wet Density (pcf)	133.84
Dry Density (pcf)	112.21
Machine Speed (in/min)	0.03
Strain rate (%/min)	1.02

WATER CONTENT	BEFORE SHEAR (entire)	AFTER SHEAR (partial)
Tare No.	-	-
Wt. Wet Soil & Tare (gm)	158.35	260.41
Wt. Dry Soil & Tare (gm)	132.76	234.89
Wt. Tare (gm)	0.00	102.48
Wt. Moisture (gm)	25.59	25.52
Wt. Dry Soil (gm)	132.76	132.41
Moisture (%)	19.27%	19.27%

TIME (min)	DEFLECT (inch)	FORCE (lbs)	% STRAIN (in/in)	Ac (in²)	COMPRESSIVE STRESS (psf)	COMPRESSIVE STRESS (psi)
0.0	0.000	0	0.00	1.64	0.00	0.00
0.1	0.003	5	0.11	1.64	447.96	3.11
0.2	0.006	10	0.22	1.64	851.06	5.91
0.3	0.009	14	0.33	1.64	1262.05	8.76
0.4	0.012	18	0.44	1.64	1584.60	11.00
0.5	0.015	21	0.55	1.65	1801.49	12.51
0.7	0.020	24	0.73	1.65	2103.71	14.61
0.9	0.025	27	0.91	1.65	2352.54	16.34
1.1	0.030	30	1.09	1.66	2565.66	17.82
1.3	0.035	32	1.27	1.66	2751.93	19.11
1.4	0.040	34	1.45	1.66	2920.17	20.28
1.8	0.050	38	1.82	1.67	3263.36	22.66
2.7	0.075	45	2.73	1.68	3831.88	26.61
3.1	0.088	46	3.20	1.69	3898.38	27.07
3.6	0.100	44	3.64	1.70	3685.93	25.60
4.5	0.125	37	4.54	1.72	3105.59	21.57
5.4	0.150	34	5.45	1.73	2859.87	19.86

TIME TO FAILURE (min)	3.1
STRAIN @ FAILURE (%)	3.2
TYPE OF FAILURE	SHEAR

FAILURE SKETCH



	psf	psi
UNCONFINED COMPRESSIVE STRENGTH	3898.38	27.07
SHEAR STRENGTH	1949.19	13.54

Description: Gray, CLAYEY SILT, little fine sand.

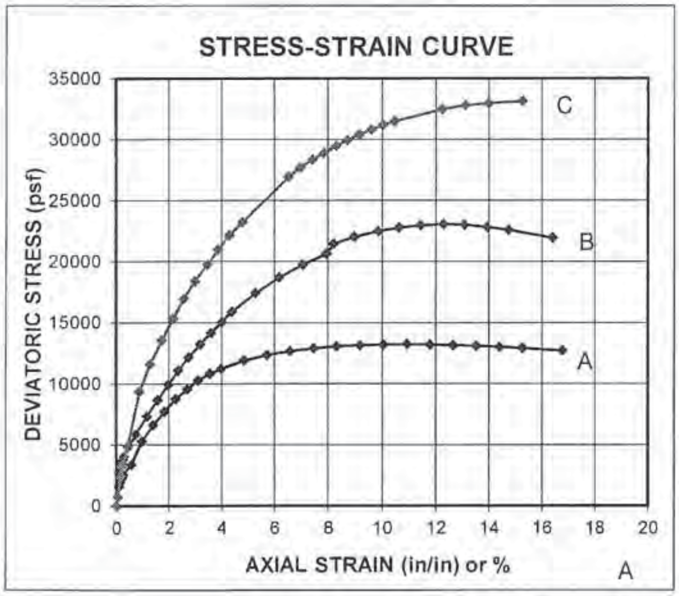
USCS: ML

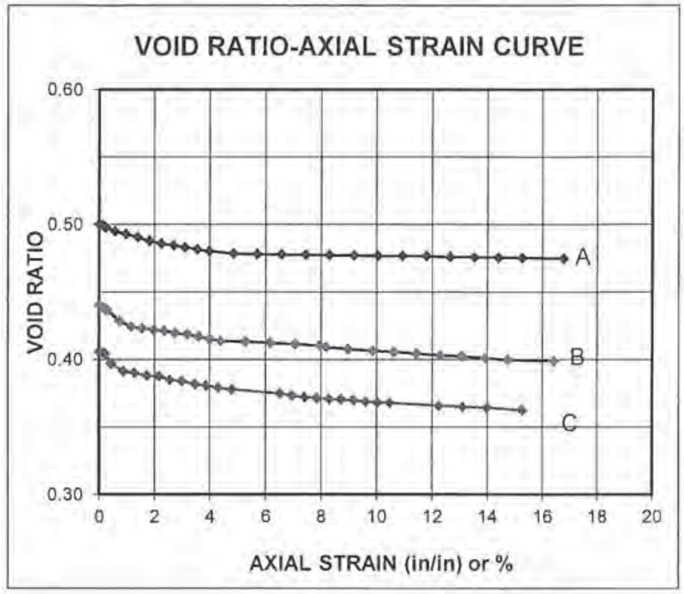
LL	NP
PL	NP
PI	NP

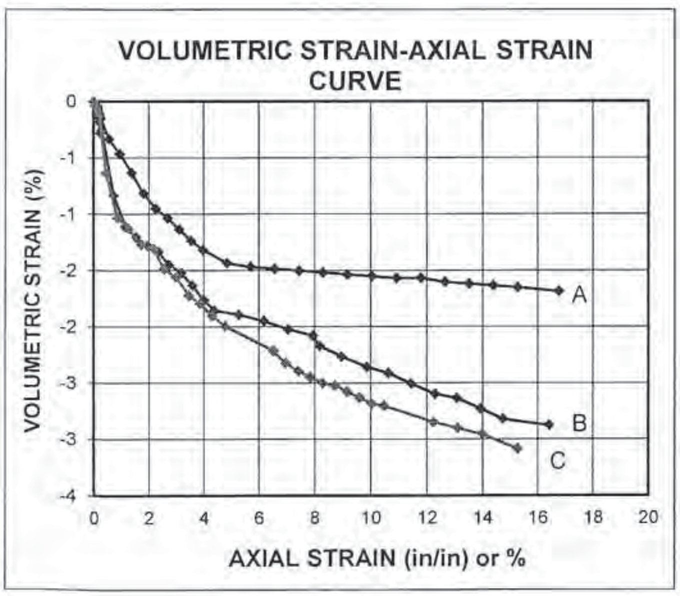
TECH	TW/DA
DATE	9/14/12
CHECK	DA
REVIEW	MWA
APPROVE	

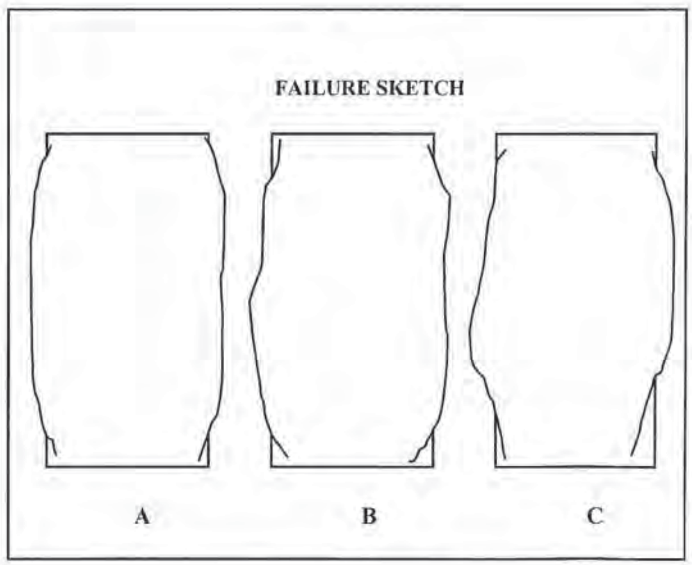
TRIAXIAL COMPRESSION TEST - CONSOLIDATED-DRAINED
EM - 1110-2-1906 APPENDIX X

PROJECT NAME EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER 123-88896
SAMPLE ID SD-1215 Depth 83.0 - 85.0' Sample Type UD









		A	B	C
BEFORE SHEAR CONDITIONS	EFFECTIVE CONSOLIDATION PRESS (psf)	7056	13968	20160
	DRY DENSITY (pcf)	113.6	118.3	121.2
	WATER CONTENT (%)	18.3	16.1	14.9
	VOID RATIO	0.500	0.440	0.406
	SATURATION (%)	100.0	100.0	100.0
	STRAIN RATE (%/min)	0.010	0.003	0.006

LL	-
PL	-
PI	-
Gs	2.73

DESCRIPTION Grayish Brown, SILTY CLAY, little medium to fine sand.

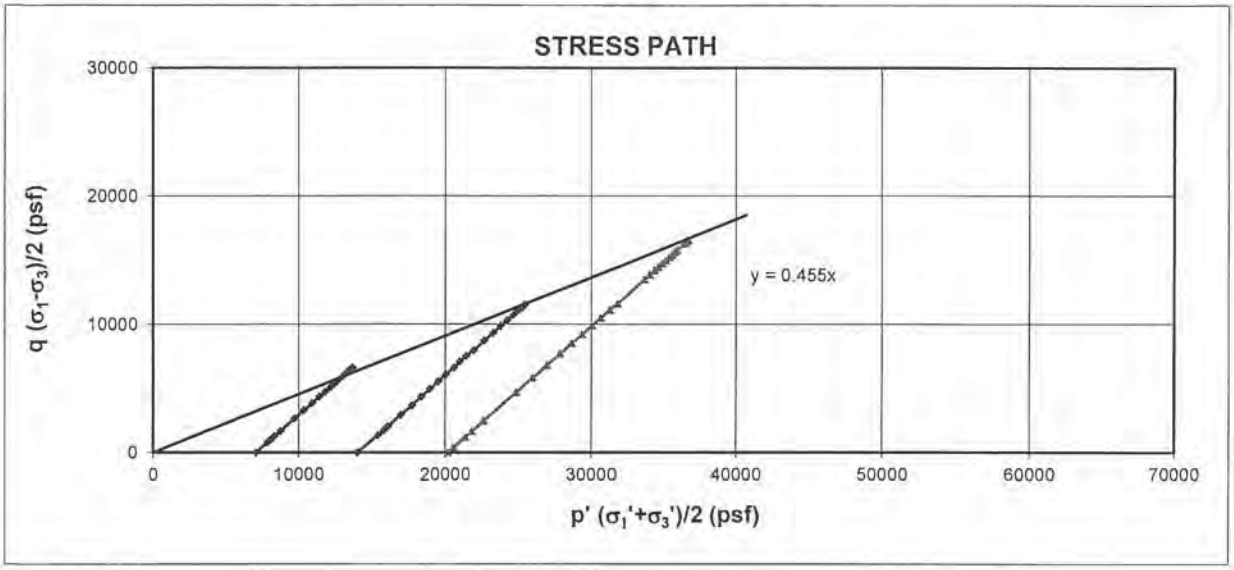
USCS (CL)

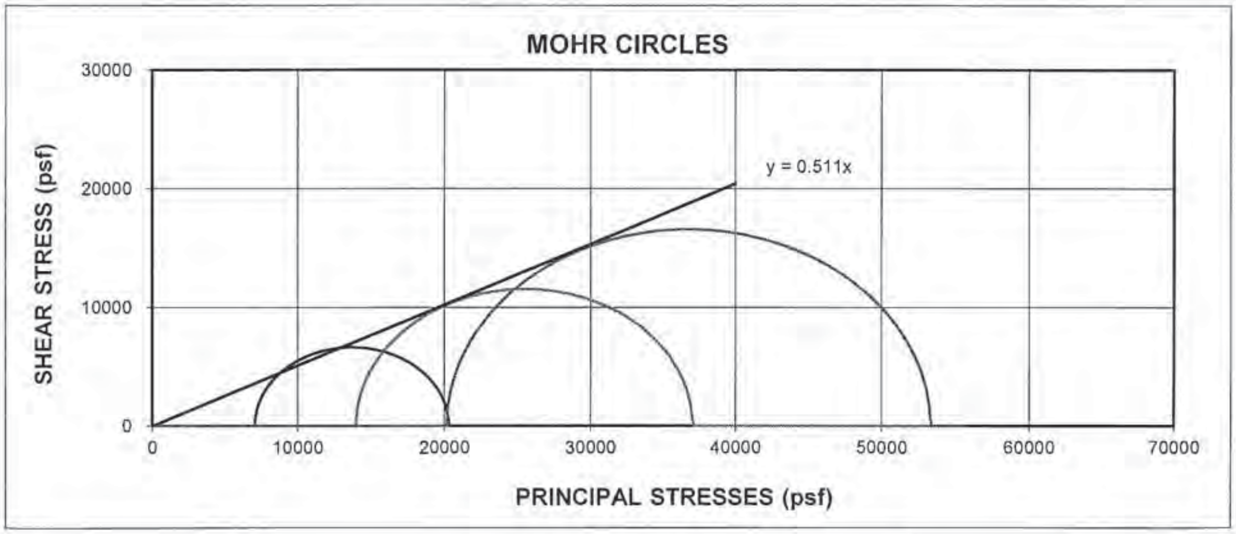
CHECK
REVIEW
APPROVE

Note: Had problem with air in specimen "B" and "C", effected pipette readings.

TRIAXIAL COMPRESSION TEST - CONSOLIDATED-DRAINED
EM - 1110-2-1906 APPENDIX X

PROJECT NAME **EE/CEC CAMPBELL ASH IMPOUNDMENT/MI**
PROJECT NUMBER **123-88896**
SAMPLE ID **SD-1215** Depth **83.0 - 85.0'** Sample Type **UD**





*EFFECTIVE STRENGTH PARAMETERS			
STRESS PATH		MOHR CIRCLES	
$\alpha =$	24.5^{0}	$\phi =$	27.1^{0}
a =	0.0 psf	c =	0.0 psf

		A	B	C
	EFFECTIVE CONSOLIDATION PRESS (psf)	7056	13968	20160
BEFORE SHEAR CONDITIONS	INITIAL DRY DENSITY (pcf)	113.6	118.3	121.2
	INITIAL WATER CONTENT %	18.3	16.1	14.9
	INITIAL VOID RATIO	0.010	0.003	0.006

DESCRIPTION Grayish Brown, SILTY CLAY, little medium to fine sand.

USCS (CL)

CHECK	DA
REVIEW	[illegible]
APPROVE	

* Failure based on maximum deviator stress.

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1215
SAMPLE TYPE	UD
DEPTH INTERVAL	83.0 - 85.0'
MACHINE SPEED (in/min)	0.0006
STRAIN RATE (%/min)	0.010
CELL PRESSURE (psi)	79.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ_3 (psi)	49.0
PRESSURE, σ_3 (psf)	7056.0
FINAL "B" VALUE	0.96
t100 (minutes)	33.64

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	15.174	5.974	5.846	
DIAMETER	7.267	2.861	2.822	
AREA	41.48	6.43	6.26	
VOLUME	629.35	38.41	36.57	599.35
WEIGHT (g)	1319.52		1290.97	
% MOISTURE	20.9		18.31	
SPECIFIC GRAVITY	2.73			
MOIST DENSITY (pcf)	130.8			
DRY DENSITY, calc (pcf)	108.2			
VOLUME OF SOLIDS	399.55			
VOLUME OF VOIDS	229.80			
VOID RATIO	0.575			
SATURATION	99.4		100.00	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	113.6
VOLUME OF SOLIDS	399.55
VOLUME OF VOIDS	199.80
VOID RATIO	0.500

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1290.97
WT SOIL & TARE, DRY (g)	1091.16
WT TARE (g)	0.00
WT MOISTURE (g)	199.81
WT DRY SOIL (g)	1091.16
% MOISTURE	18.31

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR. AREA (in²)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	15	30.2	25.0	0.00	0.0	0.00	1.00	6.26	5.846	0.0	7056.0	7056.0	7056.0	7056.0	0.0	0.0	0.500
10.0	0.006	84	30.2	24.8	-0.03	0.0	0.10	1.00	6.26	5.840	1580.1	8636.1	8636.1	7056.0	7846.1	790.1	-0.2	0.500
13.3	0.008	100	30.2	24.7	-0.05	0.0	0.14	1.00	6.26	5.838	1947.8	9003.8	9003.8	7056.0	8029.9	973.9	-0.3	0.499
18.3	0.011	113	30.2	24.4	-0.10	0.0	0.19	1.00	6.26	5.835	2246.7	9302.7	9302.7	7056.0	8179.4	1123.4	-0.6	0.499
21.7	0.013	120	30.2	24.2	-0.13	0.0	0.22	1.00	6.26	5.833	2405.4	9461.4	9461.4	7056.0	8258.7	1202.7	-0.8	0.498
23.3	0.014	127	30.2	24.1	-0.15	0.0	0.24	1.00	6.26	5.832	2561.8	9617.8	9617.8	7056.0	8336.9	1280.9	-0.9	0.498
55.0	0.033	163	30.2	23.0	-0.33	0.0	0.56	0.99	6.27	5.813	3382.5	10438.5	10438.5	7056.0	8747.3	1691.3	-2.0	0.495
93.3	0.056	246	30.2	22.2	-0.47	0.0	0.96	0.99	6.29	5.790	5295.2	12351.2	12351.2	7056.0	9703.6	2647.6	-2.8	0.493
135.0	0.081	305	30.3	21.2	-0.63	14.4	1.39	0.99	6.30	5.765	6624.3	13680.3	13665.9	7041.6	10353.8	3312.2	-3.8	0.491
176.7	0.106	354	30.2	20.1	-0.82	0.0	1.81	0.98	6.32	5.740	7719.8	14775.8	14775.8	7056.0	10915.9	3859.9	-4.9	0.488
218.3	0.131	400	30.2	19.3	-0.95	0.0	2.24	0.98	6.34	5.715	8736.9	15792.9	15792.9	7056.0	11424.5	4368.5	-5.7	0.486
261.7	0.157	437	30.3	18.8	-1.03	14.4	2.69	0.97	6.36	5.689	9551.0	16607.0	16592.6	7041.6	11817.1	4775.5	-6.2	0.485
301.7	0.181	470	30.2	18.2	-1.13	0.0	3.10	0.97	6.38	5.665	10260.3	17316.3	17316.3	7056.0	12186.1	5130.1	-6.8	0.483
345.0	0.207	496	30.3	17.6	-1.23	14.4	3.54	0.96	6.41	5.639	10808.0	17864.0	17849.6	7041.6	12445.6	5404.0	-7.4	0.482
386.7	0.232	517	30.3	17.1	-1.32	14.4	3.97	0.96	6.43	5.614	11230.6	18286.6	18272.2	7041.6	12656.9	5615.3	-7.9	0.480
471.7	0.283	551	30.3	16.4	-1.43	14.4	4.84	0.95	6.48	5.563	11903.9	18959.9	18945.5	7041.6	12993.6	5952.0	-8.6	0.479
555.0	0.333	576	30.3	16.2	-1.47	14.4	5.70	0.94	6.54	5.513	12356.1	19412.1	19397.7	7041.6	13219.6	6178.0	-8.8	0.478
640.0	0.384	596	30.3	16.1	-1.48	14.4	6.57	0.93	6.60	5.462	12676.1	19732.1	19717.7	7041.6	13379.6	6338.0	-8.9	0.478
725.0	0.435	612	30.3	16.0	-1.50	14.4	7.44	0.93	6.66	5.411	12905.9	19961.9	19947.5	7041.6	13494.5	6452.9	-9.0	0.478
808.3	0.485	625	30.3	15.9	-1.52	14.4	8.30	0.92	6.72	5.361	13067.4	20123.4	20109.0	7041.6	13575.3	6533.7	-9.1	0.477
893.3	0.536	635	30.3	15.8	-1.53	14.4	9.17	0.91	6.78	5.310	13155.5	20211.5	20197.1	7041.6	13619.4	6577.8	-9.2	0.477
978.3	0.587	643	30.3	15.7	-1.55	14.4	10.04	0.90	6.85	5.259	13208.0	20264.0	20249.6	7041.6	13645.6	6604.0	-9.3	0.477
1063.3	0.638	651	30.3	15.6	-1.57	14.4	10.91	0.89	6.91	5.208	13242.6	20298.6	20284.2	7041.6	13662.9	6621.3	-9.4	0.477
1148.3	0.689	655	30.4	15.6	-1.57	28.8	11.79	0.88	6.98	5.157	13205.7	20261.7	20232.9	7027.2	13630.1	6602.9	-9.4	0.477
1231.7	0.739	659	30.3	15.4	-1.60	14.4	12.64	0.87	7.05	5.107	13145.4	20201.4	20187.0	7041.6	13614.3	6572.7	-9.6	0.476
1316.7	0.790	662	30.3	15.3	-1.62	14.4	13.51	0.86	7.12	5.056	13093.3	20149.3	20134.9	7041.6	13588.2	6546.6	-9.7	0.476
1401.7	0.841	665	30.3	15.2	-1.64	14.4	14.39	0.86	7.19	5.005	13025.5	20081.5	20067.1	7041.6	13554.3	6512.7	-9.8	0.476
1486.7	0.892	667	30.3	15.1	-1.65	14.4	15.26	0.85	7.26	4.954	12924.7	19980.7	19966.3	7041.6	13504.0	6462.4	-9.9	0.475
1633.3	0.980	668	30.3	14.9	-1.69	14.4	16.76	0.83	7.39	4.866	12715.0	19771.0	19756.6	7041.6	13399.1	6357.5	-10.1	0.475

DEVIATORIC STRESS @ FAILURE 13242.6

TECH	SDM
DATE	9/13/12
CHECK	DH
REVIEW	RVM
APPROVE	

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1215
SAMPLE TYPE	UD
DEPTH INTERVAL	83.0 - 85.0'
MACHINE SPEED (in/min)	0.00017
STRAIN RATE (%/min)	0.0030
CELL PRESSURE (psi)	127.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ3 (psi)	97.0
PRESSURE, σ3 (psf)	13968.0
FINAL "B" VALUE	0.98
t100 (minutes)	140.25

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	14.879	5.858	5.633	
DIAMETER	7.165	2.821	2.727	
AREA	40.32	6.25	5.84	
VOLUME	599.99	36.61	32.89	538.99
WEIGHT (g)	1224.74		1186.72	
% MOISTURE	19.8		16.13	
SPECIFIC GRAVITY	2.73			
MOIST DENSITY (pcf)	127.4			
DRY DENSITY, calc (pcf)	106.3			
VOLUME OF SOLIDS	374.19			
VOLUME OF VOIDS	225.80			
VOID RATIO	0.603			
SATURATION	89.8		100.00	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	118.3
VOLUME OF SOLIDS	374.19
VOLUME OF VOIDS	164.80
VOID RATIO	0.440

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1186.72
WT SOIL & TARE, DRY (g)	1021.92
WT TARE (g)	0.00
WT MOISTURE (g)	164.80
WT DRY SOIL (g)	1021.92
% MOISTURE	16.13

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR. AREA (in²)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	22	32.0	25.0	0.00	0.0	0.00	1.00	5.84	5.633	0.0	13968.0	13968.0	13968.0	13968.0	0.0	0.0	0.440
35.3	0.006	132	31.4	24.4	-0.11	-86.4	0.11	1.00	5.84	5.627	2712.9	16680.9	16767.3	14054.4	15410.8	1356.4	-0.6	0.439
64.7	0.011	163	31.4	24.0	-0.19	-86.4	0.20	1.00	5.84	5.622	3464.6	17432.6	17519.0	14054.4	15786.7	1732.3	-1.0	0.438
82.4	0.014	175	31.4	23.5	-0.28	-86.4	0.25	1.00	5.84	5.619	3779.3	17747.3	17833.7	14054.4	15944.0	1889.6	-1.5	0.436
94.1	0.016	186	31.4	23.6	-0.26	-86.4	0.28	1.00	5.84	5.617	4043.5	18011.5	18097.9	14054.4	16076.2	2021.8	-1.4	0.437
241.2	0.041	259	31.6	20.5	-0.83	-57.6	0.73	0.99	5.83	5.592	5856.0	19824.0	19881.6	14025.6	16953.6	2928.0	-4.5	0.428
382.4	0.065	320	31.4	19.0	-1.11	-86.4	1.15	0.99	5.84	5.568	7336.2	21304.2	21390.6	14054.4	17722.5	3668.1	-6.0	0.424
511.8	0.087	375	31.6	18.5	-1.21	-57.6	1.54	0.98	5.86	5.546	8670.8	22638.8	22696.4	14025.6	18361.0	4335.4	-6.5	0.423
652.9	0.111	427	31.9	18.1	-1.28	-14.4	1.97	0.98	5.88	5.522	9927.9	23895.9	23910.3	13982.4	18946.3	4963.9	-6.9	0.422
776.5	0.132	476	32.0	17.8	-1.34	0.0	2.34	0.98	5.90	5.501	11069.8	25037.8	25037.8	13968.0	19502.9	5534.9	-7.2	0.421
905.9	0.154	522	32.1	17.2	-1.45	14.4	2.73	0.97	5.92	5.479	12162.5	26130.5	26116.1	13953.6	20034.8	6081.2	-7.8	0.420
1052.9	0.179	567	32.0	16.8	-1.52	0.0	3.18	0.97	5.94	5.454	13212.0	27180.0	27180.0	13968.0	20574.0	6606.0	-8.2	0.419
1188.2	0.202	608	32.5	16.2	-1.63	72.0	3.59	0.96	5.96	5.431	14171.9	28139.9	28067.9	13896.0	20982.0	7086.0	-8.8	0.417
1323.5	0.225	646	32.6	15.5	-1.76	86.4	3.99	0.96	5.97	5.408	15046.4	29014.4	28928.0	13881.6	21404.8	7523.2	-9.5	0.415
1452.9	0.247	684	31.9	15.0	-1.86	-14.4	4.38	0.96	5.99	5.386	15895.5	29863.5	29877.9	13982.4	21930.2	7947.8	-10.0	0.414
1747.1	0.297	754	32.2	14.8	-1.89	28.8	5.27	0.95	6.05	5.336	17432.7	31400.7	31371.9	13939.2	22655.5	8716.3	-10.2	0.413
2041.2	0.347	815	32.2	14.5	-1.95	28.8	6.16	0.94	6.10	5.286	18704.7	32672.7	32643.9	13939.2	23291.5	9352.3	-10.5	0.412
2335.3	0.397	866	32.4	14.1	-2.02	57.6	7.05	0.93	6.15	5.236	19746.7	33714.7	33657.1	13910.4	23783.8	9873.4	-10.9	0.411
2629.4	0.447	913	32.4	13.8	-2.08	57.6	7.94	0.92	6.21	5.186	20649.7	34617.7	34560.1	13910.4	24235.3	10324.9	-11.2	0.410
2711.8	0.461	949	32.2	13.3	-2.17	28.8	8.18	0.92	6.22	5.172	21451.4	35419.4	35390.6	13939.2	24664.9	10725.7	-11.7	0.409
2970.6	0.505	981	32.3	12.8	-2.26	43.2	8.97	0.91	6.27	5.128	22026.5	35994.5	35951.3	13924.8	24938.0	11013.2	-12.2	0.408
3264.7	0.555	1010	32.4	12.3	-2.36	57.6	9.85	0.90	6.32	5.078	22495.0	36463.0	36405.4	13910.4	25157.9	11247.5	-12.7	0.406
3517.6	0.598	1031	32.5	12.0	-2.41	72.0	10.62	0.89	6.37	5.035	22789.3	36757.3	36685.3	13896.0	25290.6	11394.6	-13.0	0.406
3788.2	0.644	1047	32.3	11.5	-2.50	43.2	11.43	0.89	6.43	4.989	22970.0	36938.0	36894.8	13924.8	25409.8	11485.0	-13.5	0.404
4070.6	0.692	1060	32.4	11.0	-2.60	57.6	12.28	0.88	6.48	4.941	23059.4	37027.4	36969.8	13910.4	25440.1	11529.7	-14.0	0.403
4329.4	0.736	1067	32.4	10.8	-2.63	57.6	13.07	0.87	6.54	4.897	23010.3	36978.3	36920.7	13910.4	25415.5	11505.1	-14.2	0.402
4611.8	0.784	1068	32.3	10.3	-2.73	43.2	13.92	0.86	6.60	4.849	22832.6	36800.6	36757.4	13924.8	25341.1	11416.3	-14.7	0.401
4882.4	0.830	1066	32.3	9.8	-2.82	43.2	14.73	0.85	6.65	4.803	22596.5	36564.5	36521.3	13924.8	25223.1	11298.3	-15.2	0.400
5435.3	0.924	1056	32.3	9.5	-2.88	43.2	16.40	0.84	6.78	4.709	21952.6	35920.6	35877.4	13924.8	24901.1	10976.3	-15.5	0.399

DEVIATORIC STRESS @ FAILURE 23059.4

TECH	SDM
DATE	9/13/12
CHECK	DH
REVIEW	AMM
APPROVE	

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1215
SAMPLE TYPE	UD
DEPTH INTERVAL	83.0 - 85.0'
MACHINE SPEED (in/min)	0.00036
STRAIN RATE (%/min)	0.0063
CELL PRESSURE (psi)	170.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ_3 (psi)	140.0
PRESSURE, σ_3 (psf)	20160.0
FINAL "B" VALUE	1.00
t100 (minutes)	78.25

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	15.133	5.958	5.754	
DIAMETER	7.242	2.851	2.729	
AREA	41.19	6.38	5.85	
VOLUME	623.28	38.04	33.65	551.48
WEIGHT (g)	1296.77		1230.50	
% MOISTURE	21.0		14.86	
SPECIFIC GRAVITY	2.73			
MOIST DENSITY (pcf)	129.8			
DRY DENSITY, calc (pcf)	107.3			
VOLUME OF SOLIDS	392.27			
VOLUME OF VOIDS	231.02			
VOID RATIO	0.589			
SATURATION	97.6		100.00	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	121.2
VOLUME OF SOLIDS	392.27
VOLUME OF VOIDS	159.22
VOID RATIO	0.406

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1230.50
WT SOIL & TARE, DRY (g)	1071.28
WT TARE (g)	0.00
WT MOISTURE (g)	159.22
WT DRY SOIL (g)	1071.28
% MOISTURE	14.86

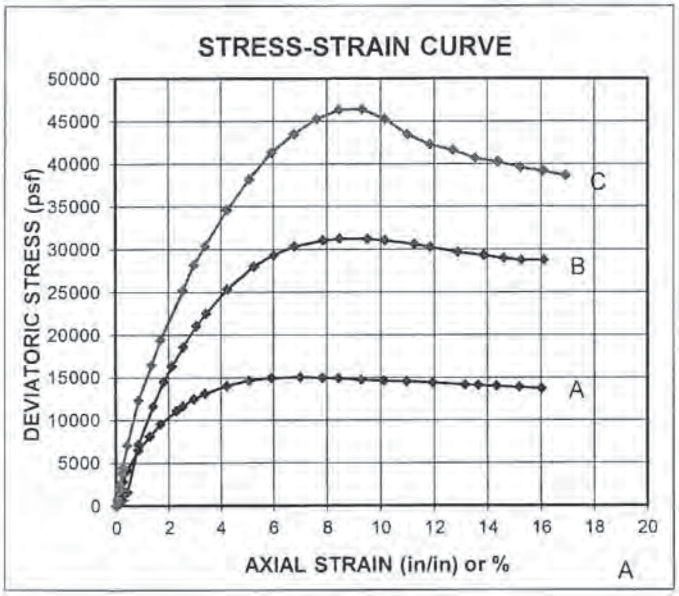
TIME (MIN)	ACCUM. DEFLECT (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR AREA (in²)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	25	30.5	25.0	0.00	0.0	0.00	1.00	5.85	5.754	0.0	20160.0	20160.0	20160.0	20160.0	0.0	0.0	0.406
8.3	0.003	56	30.4	24.8	-0.04	-14.4	0.05	1.00	5.85	5.751	755.7	20915.7	20930.1	20174.4	20552.3	377.9	-0.2	0.405
25.0	0.009	122	30.4	24.6	-0.07	-14.4	0.16	1.00	5.85	5.745	2388.7	22548.7	22563.1	20174.4	21368.7	1194.3	-0.4	0.405
33.3	0.012	157	30.4	24.4	-0.11	-14.4	0.21	1.00	5.85	5.742	3251.6	23411.6	23426.0	20174.4	21800.2	1625.8	-0.6	0.404
69.4	0.025	222	30.4	21.5	-0.63	-14.4	0.43	1.00	5.84	5.729	4862.5	25022.5	25036.9	20174.4	22605.7	2431.3	-3.5	0.397
138.9	0.050	404	30.4	19.3	-1.03	-14.4	0.87	0.99	5.84	5.704	9339.4	29499.4	29513.8	20174.4	24844.1	4669.7	-5.7	0.391
202.8	0.073	497	30.4	18.8	-1.12	-14.4	1.27	0.99	5.86	5.681	11599.1	31759.1	31773.5	20174.4	25973.9	5799.5	-6.2	0.390
275.0	0.099	578	30.4	18.0	-1.27	-14.4	1.72	0.98	5.88	5.655	13562.8	33722.8	33737.2	20174.4	26955.8	6781.4	-7.0	0.388
344.4	0.124	653	30.5	17.8	-1.31	0.0	2.16	0.98	5.90	5.630	15333.6	35493.6	35493.6	20160.0	27826.8	7666.8	-7.2	0.388
408.3	0.147	721	30.5	16.8	-1.49	0.0	2.55	0.97	5.91	5.607	16952.7	37112.7	37112.7	20160.0	28636.4	8476.4	-8.2	0.385
477.8	0.172	784	30.5	16.4	-1.56	0.0	2.99	0.97	5.93	5.582	18408.4	38568.4	38568.4	20160.0	29364.2	9204.2	-8.6	0.384
552.8	0.199	842	30.6	15.5	-1.72	14.4	3.46	0.97	5.95	5.555	19769.5	39929.5	39915.1	20145.6	30030.4	9884.8	-9.5	0.382
616.7	0.222	896	30.5	15.1	-1.80	0.0	3.86	0.96	5.97	5.532	20989.3	41149.3	41149.3	20160.0	30654.7	10494.7	-9.9	0.381
686.1	0.247	948	30.6	14.5	-1.90	14.4	4.29	0.96	5.99	5.507	22164.3	42324.3	42309.9	20145.6	31227.8	11082.2	-10.5	0.379
763.9	0.275	995	30.5	14.0	-1.99	0.0	4.78	0.95	6.02	5.479	23203.5	43363.5	43363.5	20160.0	31761.8	11601.8	-11.0	0.378
1041.7	0.375	1170	30.6	12.8	-2.21	14.4	6.52	0.93	6.12	5.379	26944.9	47104.9	47090.5	20145.6	33618.1	13472.5	-12.2	0.375
1111.1	0.400	1206	30.6	12.2	-2.32	14.4	6.95	0.93	6.14	5.354	27689.2	47849.2	47834.8	20145.6	33990.2	13844.6	-12.8	0.373
1183.3	0.426	1239	30.6	11.8	-2.39	14.4	7.40	0.93	6.17	5.328	28343.7	48503.7	48489.3	20145.6	34317.4	14171.8	-13.2	0.372
1252.8	0.451	1268	30.6	11.5	-2.45	14.4	7.84	0.92	6.19	5.303	28901.0	49061.0	49046.6	20145.6	34596.1	14450.5	-13.5	0.371
1325.0	0.477	1297	30.6	11.2	-2.50	14.4	8.29	0.92	6.22	5.277	29463.1	49623.1	49608.7	20145.6	34877.2	14731.6	-13.8	0.371
1391.7	0.501	1324	30.6	11.1	-2.52	14.4	8.71	0.91	6.25	5.253	29950.2	50110.2	50095.8	20145.6	35120.7	14975.1	-13.9	0.370
1463.9	0.527	1350	30.6	10.8	-2.57	14.4	9.16	0.91	6.27	5.227	30415.5	50575.5	50561.1	20145.6	35353.4	15207.8	-14.2	0.370
1533.3	0.552	1373	30.6	10.5	-2.63	14.4	9.59	0.90	6.30	5.202	30810.5	50970.5	50956.1	20145.6	35550.8	15405.2	-14.5	0.369
1602.8	0.577	1395	30.7	10.2	-2.68	28.8	10.03	0.90	6.33	5.177	31182.6	51342.6	51313.8	20131.2	35722.5	15591.3	-14.8	0.368
1672.2	0.602	1416	30.6	10.1	-2.70	14.4	10.46	0.90	6.36	5.152	31504.5	51664.5	51650.1	20145.6	35897.9	15752.3	-14.9	0.368
1955.6	0.704	1485	30.7	9.3	-2.85	28.8	12.23	0.88	6.47	5.050	32470.5	52630.5	52601.7	20131.2	36366.4	16235.2	-15.7	0.366
2094.4	0.754	1514	30.7	9.0	-2.90	28.8	13.10	0.87	6.54	5.000	32806.0	52966.0	52937.2	20131.2	36534.2	16403.0	-16.0	0.365
2236.1	0.805	1536	30.8	8.7	-2.96	43.2	13.99	0.86	6.60	4.949	32974.0	53134.0	53090.8	20116.8	36603.8	16487.0	-16.3	0.364
2438.9	0.878	1565	30.8	8.0	-3.08	43.2	15.26	0.85	6.69	4.876	33152.3	53312.3	53269.1	20116.8	36692.9	16576.1	-17.0	0.363

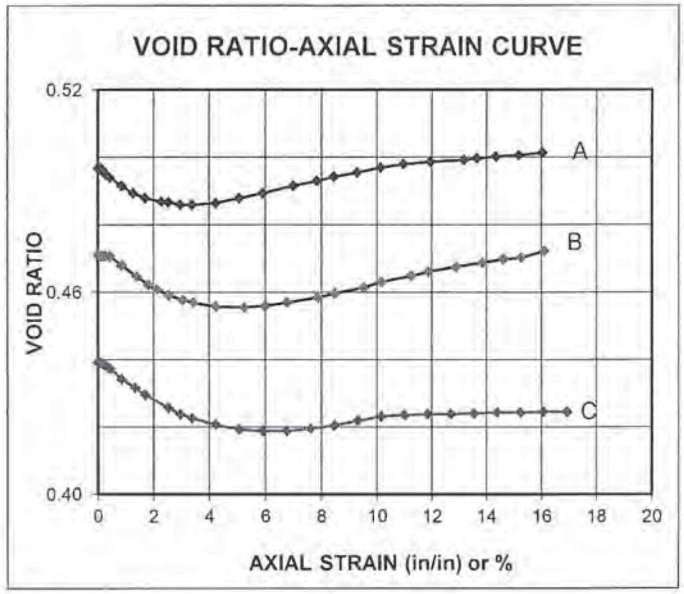
DEVIATORIC STRESS @ FAILURE 33152.3

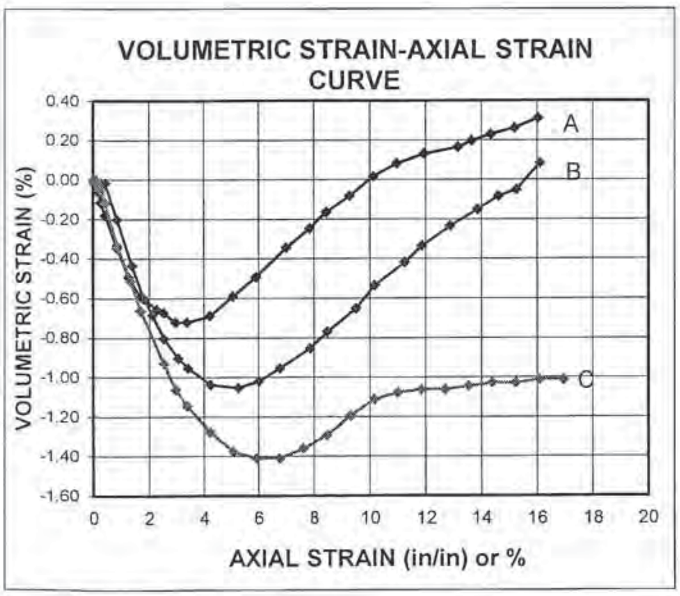
TECH	SDM
DATE	9/13/12
CHECK	
REVIEW	
APPROVE	

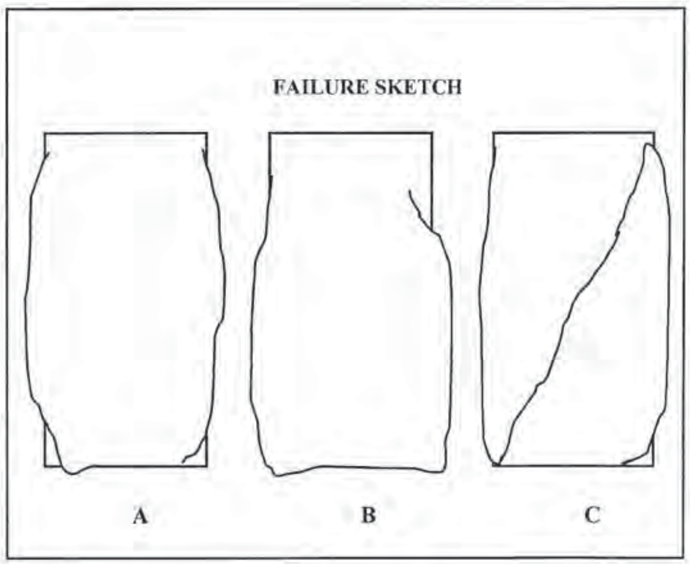
TRIAXIAL COMPRESSION TEST - CONSOLIDATED-DRAINED
EM - 1110-2-1906 APPENDIX X

PROJECT NAME EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER 123-88896
SAMPLE ID SD-1216 Depth 75.0-77.0' Sample Type UD









		A	B	C
BEFORE SHEAR CONDITIONS	EFFECTIVE CONSOLIDATION PRESS (psf)	6048	11952	18000
	DRY DENSITY (pcf)	114.5	116.5	119.1
	WATER CONTENT (%)	18.0	16.8	16.0
	VOID RATIO	0.497	0.471	0.439
	SATURATION (%)	99.6	97.8	100.0
	STRAIN RATE (%/min)	0.101	0.102	0.102

LL	-
PL	-
PI	-
Gs	2.75

DESCRIPTION Gray, CLAYEY SILT, little fine sand.

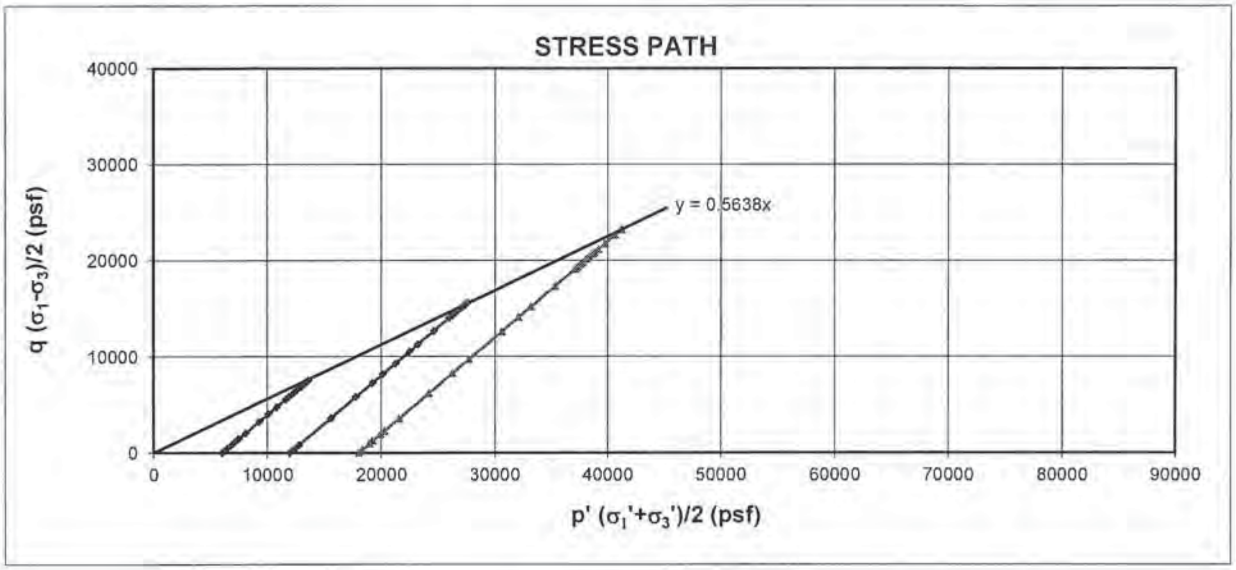
USCS (ML)

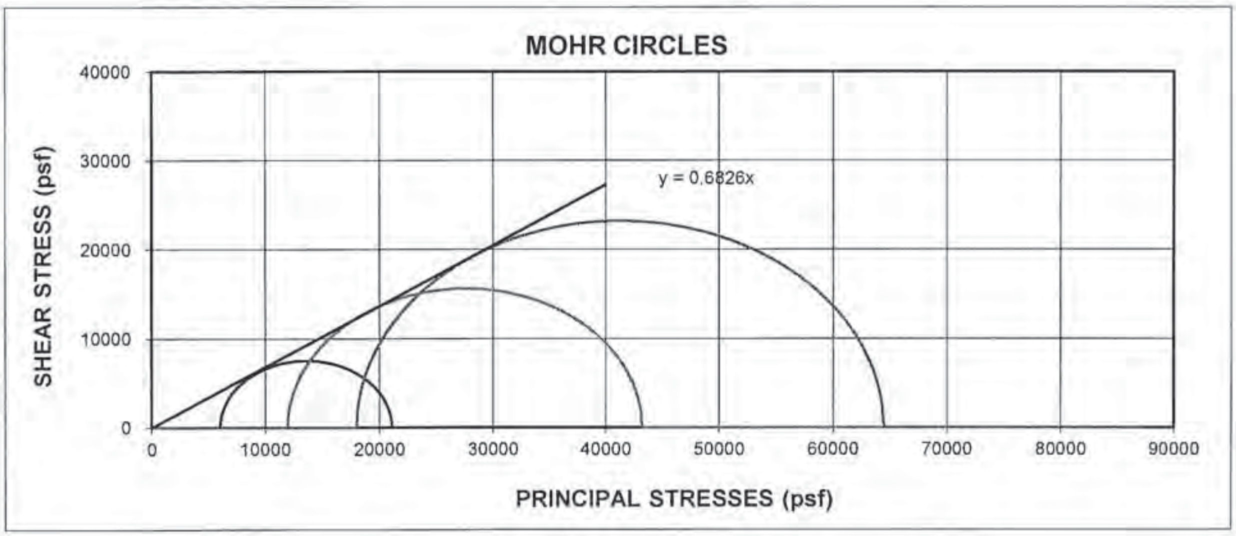
NOTE: Sample was very soft.

CHECK DA
REVIEW [illegible]
APPROVE

TRIAXIAL COMPRESSION TEST - CONSOLIDATED-DRAINED
EM - 1110-2-1906 APPENDIX X

PROJECT NAME	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI				
PROJECT NUMBER	123-88896				
SAMPLE ID	SD-1216	Depth	75.0-77.0'	Sample Type	UD





*EFFECTIVE STRENGTH PARAMETERS			
STRESS PATH		MOHR CIRCLES	
α =	29.4 ^{0}	ϕ =	34.3 ^{0}
a =	0.0 psf	c =	0.0 psf

		A	B	C
	EFFECTIVE CONSOLIDATION PRESS (psf)	6048	11952	18000
BEFORE SHEAR CONDITIONS	INITIAL DRY DENSITY (pcf)	114.5	116.5	119.1
	INITIAL WATER CONTENT %	18.0	16.8	16.0
	INITIAL VOID RATIO	0.101	0.102	0.102

DESCRIPTION: Gray, CLAYEY SILT, little fine sand.

USCS: (ML)

CHECK	DA
REVIEW	PWM
APPROVE	

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1216
SAMPLE TYPE	UD
DEPTH INTERVAL	75.0-77.0'
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.101
CELL PRESSURE (psi)	72.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ_3 (psi)	42.0
PRESSURE, σ_3 (psf)	6048.0
FINAL "B" VALUE	0.99
t100 (minutes)	0.92

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	15.131	5.957	5.930	
DIAMETER	7.264	2.86	2.827	
AREA	41.45	6.42	6.28	
VOLUME	627.12	38.27	37.23	610.02
WEIGHT (g)	1337.91		1320.81	
% MOISTURE	19.5		18.01	
SPECIFIC GRAVITY	2.75			
MOIST DENSITY (pcf)	133.1			
DRY DENSITY, calc (pcf)	111.4			
VOLUME OF SOLIDS	407.57			
VOLUME OF VOIDS	219.55			
VOID RATIO	0.539			
SATURATION	99.6		99.59	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	114.5
VOLUME OF SOLIDS	407.57
VOLUME OF VOIDS	202.45
VOID RATIO	0.497

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1320.81
WT SOIL & TARE, DRY (g)	1119.20
WT TARE (g)	0.00
WT MOISTURE (g)	201.61
WT DRY SOIL (g)	1119.20
% MOISTURE	18.01

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR. AREA (in²)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF (σ_1-dU)	SIGMA 3 EFF (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	14	30.1	25.0	0.00	0.0	0.00	1.00	6.28	5.930	0.0	6048.0	6048.0	6048.0	6048.0	0.0	0.0	0.497
0.5	0.003	23	30.1	25.0	0.00	0.0	0.05	1.00	6.28	5.927	210.9	6258.9	6258.9	6048.0	6153.5	105.5	0.0	0.497
1.0	0.006	56	30.1	24.9	-0.02	0.0	0.10	1.00	6.28	5.924	962.6	7010.6	7010.6	6048.0	6529.3	481.3	-0.1	0.496
1.5	0.009	82	30.1	24.8	-0.03	0.0	0.15	1.00	6.29	5.921	1574.0	7622.0	7622.0	6048.0	6835.0	787.0	-0.2	0.496
2.0	0.012	103	30.1	24.6	-0.07	0.0	0.20	1.00	6.29	5.918	2047.9	8095.9	8095.9	6048.0	7072.0	1024.0	-0.4	0.496
2.5	0.015	139	30.1	24.3	-0.11	0.0	0.25	1.00	6.29	5.915	2868.0	8916.0	8916.0	6048.0	7482.0	1434.0	-0.7	0.495
4.2	0.025	194	30.1	23.9	-0.18	0.0	0.42	1.00	6.29	5.905	4121.3	10169.3	10169.3	6048.0	8108.7	2060.7	-1.1	0.494
8.3	0.050	299	30.1	22.9	-0.34	0.0	0.84	0.99	6.31	5.880	6511.7	12559.7	12559.7	6048.0	9303.9	3255.9	-2.1	0.492
12.5	0.075	370	30.1	22.0	-0.49	0.0	1.26	0.99	6.33	5.855	8111.9	14159.9	14159.9	6048.0	10104.0	4056.0	-3.0	0.489
16.7	0.100	434	30.1	21.4	-0.59	0.0	1.69	0.98	6.35	5.830	9539.5	15587.5	15587.5	6048.0	10817.7	4769.7	-3.6	0.488
22.5	0.135	506	30.1	21.0	-0.66	0.0	2.28	0.98	6.38	5.795	11106.4	17154.4	17154.4	6048.0	11601.2	5553.2	-4.0	0.487
25.0	0.150	532	30.1	20.9	-0.67	0.0	2.53	0.97	6.40	5.780	11662.4	17710.4	17710.4	6048.0	11879.2	5831.2	-4.1	0.487
29.2	0.175	571	30.1	20.6	-0.72	0.0	2.95	0.97	6.42	5.755	12490.0	18538.0	18538.0	6048.0	12293.0	6245.0	-4.4	0.486
33.3	0.200	601	30.1	20.6	-0.72	0.0	3.37	0.97	6.45	5.730	13119.0	19167.0	19167.0	6048.0	12607.5	6559.5	-4.4	0.486
41.7	0.250	649	30.1	20.8	-0.69	0.0	4.22	0.96	6.51	5.680	14046.7	20094.7	20094.7	6048.0	13071.3	7023.3	-4.2	0.486
50.0	0.300	684	30.1	21.4	-0.59	0.0	5.06	0.95	6.57	5.630	14678.2	20726.2	20726.2	6048.0	13387.1	7339.1	-3.6	0.488
58.3	0.350	703	30.1	22.0	-0.49	0.0	5.90	0.94	6.64	5.580	14947.8	20995.8	20995.8	6048.0	13521.9	7473.9	-3.0	0.489
69.2	0.415	717	30.1	22.9	-0.34	0.0	7.00	0.93	6.73	5.515	15045.1	21093.1	21093.1	6048.0	13570.5	7522.5	-2.1	0.492
77.5	0.465	721	30.1	23.5	-0.25	0.0	7.84	0.92	6.79	5.465	14978.7	21026.7	21026.7	6048.0	13537.4	7489.4	-1.5	0.493
83.3	0.500	723	30.1	24.0	-0.16	0.0	8.43	0.92	6.84	5.430	14914.8	20962.8	20962.8	6048.0	13505.4	7457.4	-1.0	0.494
91.7	0.550	722	30.1	24.5	-0.08	0.0	9.27	0.91	6.91	5.380	14748.7	20796.7	20796.7	6048.0	13422.3	7374.3	-0.5	0.495
100.0	0.600	723	30.1	25.1	0.02	0.0	10.12	0.90	6.99	5.330	14622.0	20670.0	20670.0	6048.0	13359.0	7311.0	0.1	0.497
108.3	0.650	727	30.1	25.5	0.08	0.0	10.96	0.89	7.06	5.280	14561.0	20609.0	20609.0	6048.0	13328.5	7280.5	0.5	0.498
118.0	0.708	729	30.1	25.8	0.13	0.0	11.94	0.88	7.14	5.222	14424.3	20472.3	20472.3	6048.0	13260.1	7212.1	0.8	0.499
130.0	0.780	726	30.1	26.0	0.16	0.0	13.15	0.87	7.24	5.150	14159.1	20207.1	20207.1	6048.0	13127.5	7079.5	1.0	0.499
134.8	0.809	727	30.1	26.2	0.20	0.0	13.64	0.86	7.28	5.121	14106.4	20154.4	20154.4	6048.0	13101.2	7053.2	1.2	0.500
141.7	0.850	727	30.1	26.4	0.23	0.0	14.33	0.86	7.34	5.080	13988.8	20036.8	20036.8	6048.0	13042.4	6994.4	1.4	0.500
150.0	0.900	729	30.1	26.6	0.26	0.0	15.18	0.85	7.42	5.030	13875.7	19923.7	19923.7	6048.0	12985.9	6937.9	1.6	0.501
158.3	0.950	727	30.1	26.9	0.31	0.0	16.02	0.84	7.50	4.980	13702.3	19750.3	19750.3	6048.0	12899.1	6851.1	1.9	0.501

DEVIATORIC STRESS @ FAILURE 15045.1

TECH	SDM
DATE	9/13/12
CHECK	
REVIEW	RWM
APPROVE	

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1216
SAMPLE TYPE	UD
DEPTH INTERVAL	75.0-77.0'
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.1017
CELL PRESSURE (psi)	113.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ_3 (psi)	83.0
PRESSURE, σ_3 (psf)	11952.0
FINAL "B" VALUE	0.96
t100 (minutes)	2.06

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	14.996	5.904	5.902	
DIAMETER	7.264	2.86	2.806	
AREA	41.45	6.42	6.18	
VOLUME	621.54	37.93	36.49	597.94
WEIGHT (g)	1327.10		1303.50	
% MOISTURE	18.9		16.78	
SPECIFIC GRAVITY	2.75			
MOIST DENSITY (pcf)	133.2			
DRY DENSITY, calc (pcf)	112.1			
VOLUME OF SOLIDS	406.49			
VOLUME OF VOIDS	215.05			
VOID RATIO	0.529			
SATURATION	98.1		97.82	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	116.5
VOLUME OF SOLIDS	406.49
VOLUME OF VOIDS	191.45
VOID RATIO	0.471

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1303.50
WT SOIL & TARE, DRY (g)	1116.21
WT TARE (g)	0.00
WT MOISTURE (g)	187.29
WT DRY SOIL (g)	1116.21
% MOISTURE	16.78

TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR. AREA (in^2)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF (σ_1-dU)	SIGMA 3 EFF (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	20	30.0	25.0	0.00	0.0	0.00	1.00	6.18	5.902	0.0	11952.0	11952.0	11952.0	11952.0	0.0	0.0	0.471
0.5	0.003	46	30.0	24.9	-0.02	0.0	0.05	1.00	6.18	5.899	600.7	12552.7	12552.7	11952.0	12252.4	300.4	-0.1	0.471
1.0	0.006	47	30.0	24.9	-0.02	0.0	0.10	1.00	6.19	5.896	619.0	12571.0	12571.0	11952.0	12261.5	309.5	-0.1	0.471
1.5	0.009	47	30.0	24.9	-0.02	0.0	0.15	1.00	6.19	5.893	618.7	12570.7	12570.7	11952.0	12261.4	309.4	-0.1	0.471
2.0	0.012	48	30.0	24.9	-0.02	0.0	0.20	1.00	6.19	5.890	653.3	12605.3	12605.3	11952.0	12278.6	326.6	-0.1	0.471
2.5	0.015	48	30.0	24.9	-0.02	0.0	0.25	1.00	6.20	5.887	652.9	12604.9	12604.9	11952.0	12278.5	326.5	-0.1	0.471
4.2	0.025	89	30.0	24.9	-0.02	0.0	0.42	1.00	6.21	5.877	1589.0	13541.0	13541.0	11952.0	12746.5	794.5	-0.1	0.471
8.3	0.050	332	30.0	23.8	-0.20	0.0	0.85	0.99	6.22	5.852	7208.4	19160.4	19160.4	11952.0	15556.2	3604.2	-1.2	0.468
13.7	0.082	524	30.1	22.4	-0.43	14.4	1.39	0.99	6.24	5.820	11631.2	23583.2	23568.8	11937.6	17753.2	5815.6	-2.6	0.465
17.8	0.107	651	30.1	21.4	-0.60	14.4	1.81	0.98	6.26	5.795	14515.8	26467.8	26453.4	11937.6	19195.5	7257.9	-3.6	0.462
20.8	0.125	732	30.1	20.9	-0.69	14.4	2.12	0.98	6.27	5.777	16340.1	28292.1	28277.7	11937.6	20107.6	8170.0	-4.1	0.461
25.0	0.150	832	30.1	20.2	-0.80	14.4	2.54	0.97	6.29	5.752	18574.6	30526.6	30512.2	11937.6	21224.9	9287.3	-4.8	0.459
30.0	0.180	944	30.1	19.6	-0.90	14.4	3.05	0.97	6.32	5.722	21053.2	33005.2	32990.8	11937.6	22464.2	10526.6	-5.4	0.458
33.7	0.202	1012	30.1	19.3	-0.95	14.4	3.42	0.97	6.34	5.700	22520.4	34472.4	34458.0	11937.6	23197.8	11260.2	-5.7	0.457
41.7	0.250	1145	30.1	18.8	-1.04	14.4	4.24	0.96	6.39	5.652	25347.3	37299.3	37284.9	11937.6	24611.3	12673.7	-6.2	0.456
51.7	0.310	1277	30.1	18.7	-1.05	14.4	5.25	0.95	6.46	5.592	28026.6	39978.6	39964.2	11937.6	25950.9	14013.3	-6.3	0.456
59.0	0.354	1346	30.1	18.9	-1.02	14.4	6.00	0.94	6.51	5.548	29334.0	41286.0	41271.6	11937.6	26604.6	14667.0	-6.1	0.456
66.7	0.400	1405	30.1	19.3	-0.95	14.4	6.78	0.93	6.57	5.502	30358.0	42310.0	42295.6	11937.6	27116.6	15179.0	-5.7	0.457
77.3	0.464	1455	30.1	19.9	-0.85	14.4	7.86	0.92	6.65	5.438	31065.4	43017.4	43003.0	11937.6	27470.3	15532.7	-5.1	0.458
83.3	0.500	1474	30.1	20.4	-0.77	14.4	8.47	0.92	6.70	5.402	31242.0	43194.0	43179.6	11937.6	27558.6	15621.0	-4.6	0.460
93.5	0.561	1492	30.1	21.1	-0.65	14.4	9.51	0.90	6.79	5.341	31226.2	43178.2	43163.8	11937.6	27550.7	15613.1	-3.9	0.461
100.0	0.600	1496	30.1	21.8	-0.54	14.4	10.17	0.90	6.85	5.302	31058.5	43010.5	42996.1	11937.6	27466.8	15529.2	-3.2	0.463
110.7	0.664	1496	30.0	22.5	-0.42	0.0	11.25	0.89	6.94	5.238	30630.9	42582.9	42582.9	11952.0	27267.4	15315.4	-2.5	0.465
116.7	0.700	1490	30.0	23.0	-0.33	0.0	11.86	0.88	6.99	5.202	30269.2	42221.2	42221.2	11952.0	27086.6	15134.6	-2.0	0.466
126.7	0.760	1480	30.0	23.6	-0.23	0.0	12.88	0.87	7.08	5.142	29702.8	41654.8	41654.8	11952.0	26803.4	14851.4	-1.4	0.468
136.3	0.818	1479	30.0	24.1	-0.15	0.0	13.86	0.86	7.17	5.084	29307.0	41259.0	41259.0	11952.0	26605.5	14653.5	-0.9	0.469
143.7	0.862	1475	30.1	24.5	-0.08	14.4	14.61	0.85	7.23	5.040	28968.2	40920.2	40905.8	11937.6	26421.7	14484.1	-0.5	0.470
150.0	0.900	1477	30.1	24.7	-0.05	14.4	15.25	0.85	7.29	5.002	28765.9	40717.9	40703.5	11937.6	26320.5	14382.9	-0.3	0.470
158.3	0.950	1492	30.0	25.5	0.08	0.0	16.10	0.84	7.37	4.952	28739.0	40691.0	40691.0	11952.0	26321.5	14369.5	0.5	0.472
																	-25.0	0.409

DEVIATORIC STRESS @ FAILURE 31242.0

TECH	SDM
DATE	9/13/12
CHECK	DA
REVIEW	[illegible]
APPROVE	

TRIAXIAL COMPRESSION TEST (EM - 1110-2-1906 APPENDIX X) CONSOLIDATED-DRAINED

PROJECT TITLE	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER	123-88896
SAMPLE ID	SD-1216
SAMPLE TYPE	UD
DEPTH INTERVAL	75.0-77.0'
MACHINE SPEED (in/min)	0.006
STRAIN RATE (%/min)	0.1015
CELL PRESSURE (psi)	155.0
SAMPLE PRESSURE (psi)	30.0
EFF. CONSOLIDATION	
PRESSURE, σ_3 (psi)	125.0
PRESSURE, σ_3 (psf)	18000.0
FINAL "B" VALUE	1.00
t100 (minutes)	2.42

INITIAL SAMPLE DATA	cm	in	corrected	cm
HEIGHT	15.240	6.000	5.910	
DIAMETER	7.264	2.86	2.816	
AREA	41.45	6.42	6.23	
VOLUME	631.65	38.55	36.80	603.05
WEIGHT (g)	1365.37		1334.71	
% MOISTURE	18.7		15.99	
SPECIFIC GRAVITY	2.75			
MOIST DENSITY (pcf)	134.9			
DRY DENSITY, calc (pcf)	113.7			
VOLUME OF SOLIDS	419.05			
VOLUME OF VOIDS	212.60			
VOID RATIO	0.507			
SATURATION	101.0		100.00	

CORRECTED SAMPLE DATA	
DRY DENSITY, calc (pcf)	119.1
VOLUME OF SOLIDS	419.05
VOLUME OF VOIDS	184.00
VOID RATIO	0.439

WATER CONTENT (% MOISTURE)	
WT SOIL & TARE, MOIST (g)	1334.71
WT SOIL & TARE, DRY (g)	1150.71
WT TARE (g)	0.00
WT MOISTURE (g)	184.00
WT DRY SOIL (g)	1150.71
% MOISTURE	15.99

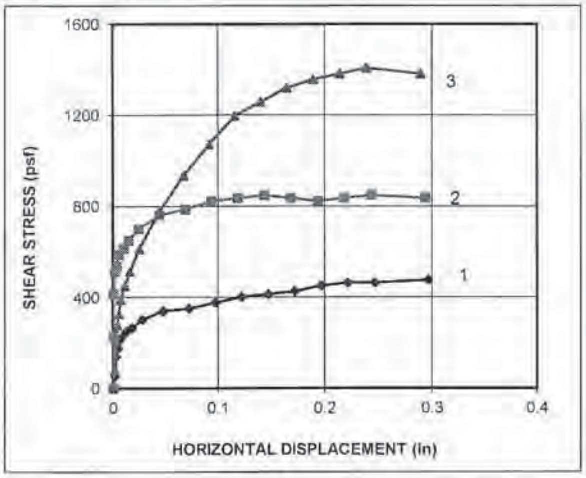
TIME (MIN)	ACCUM. DEFLECT. (inches)	AXIAL LOAD (lbs)	PORE PRESS. (psi)=U	BURETTE READING (cc)	VOLUME STRAIN (%)	PWP change DU (psf)	AXIAL STRAIN (%)	(1-ε)	CORR. AREA (in²)	CORR. HEIGHT (in)	DEVIATOR STRESS (psf)	SIGMA 1 devstr+cp (σ_1)	SIGMA 1 EFF. (σ_1-dU)	SIGMA 3 EFF. (σ_3-dU)	$\frac{(\sigma_1'+\sigma_3')}{2}$ (p)	$\frac{(\sigma_1-\sigma_3)}{2}$ (q)	VOLUME CHANGE (cc)	VOID RATIO e
0.0	0.000	25	30.7	25.0	0.00	0.0	0.00	1.00	6.23	5.910	0.0	18000.0	18000.0	18000.0	18000.0	0.0	0.0	0.439
0.5	0.003	53	30.7	25.0	0.00	0.0	0.05	1.00	6.23	5.907	642.6	18642.6	18642.6	18000.0	18321.3	321.3	0.0	0.439
1.0	0.006	105	30.7	25.0	0.00	0.0	0.10	1.00	6.23	5.904	1850.5	19850.5	19850.5	18000.0	18925.3	925.3	0.0	0.439
1.5	0.009	129	30.7	24.9	-0.02	0.0	0.15	1.00	6.24	5.901	2401.8	20401.8	20401.8	18000.0	19200.9	1200.9	-0.1	0.439
2.0	0.012	189	30.7	24.8	-0.03	0.0	0.20	1.00	6.24	5.898	3781.6	21781.6	21781.6	18000.0	19890.8	1890.8	-0.2	0.439
2.5	0.015	221	30.7	24.7	-0.05	0.0	0.25	1.00	6.24	5.895	4516.5	22516.5	22516.5	18000.0	20258.3	2258.3	-0.3	0.438
4.2	0.025	332	30.7	24.3	-0.12	0.0	0.42	1.00	6.25	5.885	7082.5	25082.5	25082.5	18000.0	21541.2	3541.2	-0.7	0.437
8.3	0.050	562	30.8	23.0	-0.33	14.4	0.85	0.99	6.26	5.860	12345.4	30345.4	30331.0	17985.6	24158.3	6172.7	-2.0	0.434
13.2	0.079	744	30.8	21.9	-0.51	14.4	1.34	0.99	6.28	5.831	16499.3	34499.3	34484.9	17985.6	26235.2	8249.6	-3.1	0.432
16.7	0.100	873	30.8	21.0	-0.66	14.4	1.69	0.98	6.29	5.810	19407.7	37407.7	37393.3	17985.6	27689.5	9703.9	-4.0	0.430
25.0	0.150	1134	30.8	19.4	-0.93	14.4	2.54	0.97	6.33	5.760	25232.3	43232.3	43217.9	17985.6	30601.8	12616.2	-5.6	0.426
29.2	0.175	1268	30.8	18.6	-1.06	14.4	2.96	0.97	6.35	5.735	28186.8	46186.8	46172.4	17985.6	32079.0	14093.4	-6.4	0.424
33.3	0.200	1371	30.8	18.1	-1.14	14.4	3.38	0.97	6.37	5.710	30411.0	48411.0	48396.6	17985.6	33191.1	15205.5	-6.9	0.423
41.7	0.250	1568	30.8	17.3	-1.28	14.4	4.23	0.96	6.42	5.660	34613.7	52613.7	52599.3	17985.6	35292.4	17306.8	-7.7	0.421
50.0	0.300	1742	30.8	16.7	-1.38	14.4	5.08	0.95	6.47	5.610	38211.0	56211.0	56196.6	17985.6	37091.1	19105.5	-8.3	0.419
58.3	0.350	1898	30.8	16.5	-1.41	14.4	5.92	0.94	6.53	5.560	41325.7	59325.7	59311.3	17985.6	38648.5	20662.9	-8.5	0.419
66.7	0.400	2014	30.8	16.5	-1.41	14.4	6.77	0.93	6.58	5.510	43497.5	61497.5	61483.1	17985.6	39734.3	21748.7	-8.5	0.419
75.0	0.450	2115	30.8	16.8	-1.36	14.4	7.61	0.92	6.65	5.460	45268.6	63268.6	63254.2	17985.6	40619.9	22634.3	-8.2	0.420
83.3	0.500	2186	30.8	17.2	-1.29	14.4	8.46	0.92	6.71	5.410	46353.1	64353.1	64338.7	17985.6	41162.2	23176.6	-7.8	0.420
91.7	0.550	2212	30.8	17.8	-1.19	14.4	9.31	0.91	6.78	5.360	46426.1	64426.1	64411.7	17985.6	41198.7	23213.1	-7.2	0.422
100.0	0.600	2180	30.8	18.3	-1.11	14.4	10.15	0.90	6.85	5.310	45280.0	63280.0	63265.6	17985.6	40625.6	22640.0	-6.7	0.423
108.3	0.650	2115	30.8	18.5	-1.08	14.4	11.00	0.89	6.92	5.260	43479.9	61479.9	61465.5	17985.6	39725.6	21740.0	-6.5	0.424
116.7	0.700	2077	30.8	18.6	-1.06	14.4	11.84	0.88	6.99	5.210	42276.4	60276.4	60262.0	17985.6	39123.8	21138.2	-6.4	0.424
125.0	0.750	2065	30.8	18.6	-1.06	14.4	12.69	0.87	7.06	5.160	41633.9	59633.9	59619.5	17985.6	38802.6	20817.0	-6.4	0.424
133.3	0.800	2039	30.8	18.7	-1.04	14.4	13.54	0.86	7.13	5.110	40704.3	58704.3	58689.9	17985.6	38337.7	20352.1	-6.3	0.424
141.7	0.850	2037	30.8	18.8	-1.03	14.4	14.38	0.86	7.20	5.060	40247.2	58247.2	58232.8	17985.6	38109.2	20123.6	-6.2	0.424
150.0	0.900	2023	30.8	18.8	-1.03	14.4	15.23	0.85	7.27	5.010	39576.2	57576.2	57561.8	17985.6	37773.7	19788.1	-6.2	0.424
158.3	0.950	2023	30.8	18.9	-1.01	14.4	16.07	0.84	7.34	4.960	39166.8	57166.8	57152.4	17985.6	37569.0	19583.4	-6.1	0.425
166.7	1.000	2015	30.8	18.9	-1.01	14.4	16.92	0.83	7.42	4.910	38614.8	56614.8	56600.4	17985.6	37293.0	19307.4	-6.1	0.425

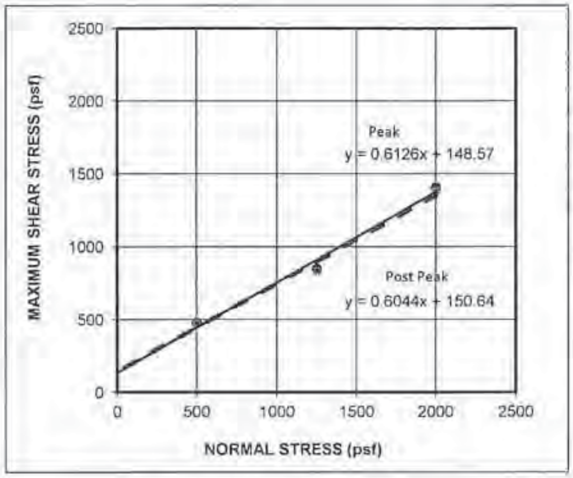
DEVIATORIC STRESS @ FAILURE 46426.1

TECH	SDM
DATE	9/13/12
CHECK	DA
REVIEW	[illegible]
APPROVE	

DIRECT SHEAR
ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SP 1201 - DEPTH: 15.0 - 25.0'





Peak
ϕ = 31.5 °
C= 148.6 psf

Post Peak
ϕ = 31.1 °
C= 150.6 psf

	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3
Normal Stress (psf)	500	1250	2000
t50 (minutes)	0.10	0.13	0.55
SPEED mm/min	0.060	0.060	0.060
Sample Diameter (in)	2.50	2.50	2.50
Moisture Content (%)	25.3	25.3	25.3
Wet Density (pcf)	87.9	87.9	87.9
Dry Density (pcf)	70.2	70.2	70.2
Void Ratio	1.046	1.046	1.046
Saturation (%)	56	56	56

SPECIMEN 1 HORIZONTAL DISPLACEMENT (in)	SPECIMEN 1 SHEAR STRESS (psf)	SPECIMEN 2 HORIZONTAL DISPLACEMENT (in)	SPECIMEN 2 SHEAR STRESS (psf)	SPECIMEN 3 HORIZONTAL DISPLACEMENT (in)	SPECIMEN 3 SHEAR STRESS (psf)
0.000	0.0	0.000	0.0	0.000	0.0
0.002	53.4	0.000	227.2	0.002	78.2
0.003	140.3	0.001	413.5	0.002	214.8
0.005	177.5	0.002	512.8	0.004	276.9
0.006	214.8	0.004	537.7	0.006	326.6
0.008	227.2	0.005	587.4	0.007	388.7
0.013	252.1	0.010	612.2	0.012	450.8
0.018	264.5	0.015	649.4	0.016	512.8
0.028	301.7	0.025	699.1	0.025	612.2
0.047	339.0	0.044	761.2	0.044	773.6
0.072	351.4	0.069	786.0	0.068	935.1
0.097	376.2	0.094	823.3	0.092	1071.7
0.122	401.1	0.118	835.7	0.116	1195.9
0.147	413.5	0.143	848.1	0.140	1257.9
0.172	425.9	0.168	835.7	0.165	1320.0
0.197	450.8	0.194	823.3	0.189	1357.3
0.221	463.2	0.218	835.7	0.214	1382.1
0.246	463.2	0.243	848.1	0.239	1407.0
0.296	475.6	0.293	835.7	0.289	1382.1

	Specimen 1	Specimen 2	Specimen 3
Max Shear Stress	475.6	848.1	1407.0

REMARKS: Per client request, sample was remolded to a targeted density of 60 pcf at a moisture content of 25%. Density too low, increased density to 70 pcf. Sample was not inundated.

DESCRIPTION: Coal Ash - Dark Gray, SILT, some fine sand.

USCS: (ML)

TECH	AK
DATE	6/26/2012
CHECK	[illegible]
REVIEW	[illegible]
APROVE	

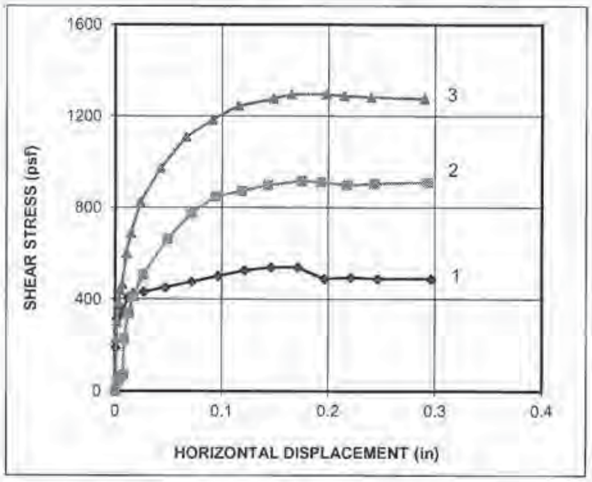
Golder Associates Inc.

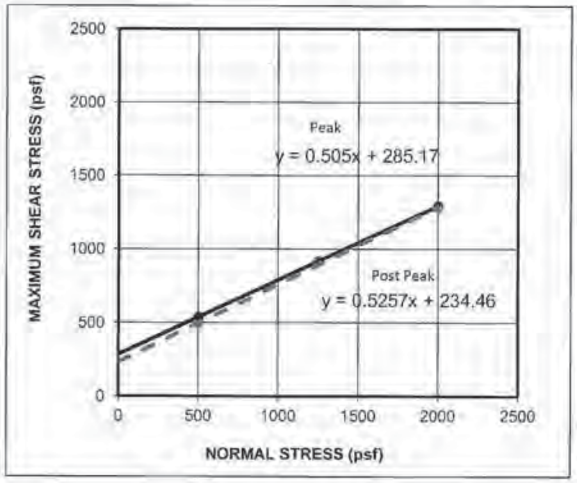
JULY 2012 | 123-88896

DIRECT SHEAR

ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SB 1204 - **DEPTH:** 10.0-16.0





	Peak			Post Peak	
φ =	26.8	°	φ =	27.7	°
C =	285.2	psf	C =	234.5	psf

SPECIMEN 1	
Normal Stress (psf)	500
t50 (minutes)	0.14
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	15.4
Wet Density (pcf)	93.4
Dry Density (pcf)	80.9
Void Ratio	0.774
Saturation (%)	46

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.001	190.0
0.002	314.1
0.003	339.0
0.005	339.0
0.007	351.4
0.012	407.3
0.017	425.9
0.027	432.1
0.047	450.8
0.071	475.6
0.096	500.4
0.121	525.3
0.146	537.7
0.171	537.7
0.196	488.0
0.221	494.2
0.246	488.0
0.296	488.0

537.7 Max Shear Stress

SPECIMEN 2	
Normal Stress (psf)	1250
t50 (minutes)	0.16
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	15.4
Wet Density (pcf)	93.4
Dry Density (pcf)	80.9
Void Ratio	0.774
Saturation (%)	46

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.002	40.9
0.004	53.4
0.006	65.8
0.008	72.0
0.008	227.2
0.012	339.0
0.017	413.5
0.026	506.6
0.049	661.9
0.071	773.6
0.093	848.1
0.118	873.0
0.143	897.8
0.175	916.4
0.193	910.2
0.218	897.8
0.243	904.0
0.293	910.2

916.4 Max Shear Stress

SPECIMEN 3	
Normal Stress (psf)	2000
t50 (minutes)	0.23
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	15.4
Wet Density (pcf)	93.4
Dry Density (pcf)	80.9
Void Ratio	0.774
Saturation (%)	46

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.000	227.2
0.002	301.7
0.003	388.7
0.005	438.3
0.006	463.2
0.010	599.8
0.015	686.7
0.024	823.3
0.042	972.3
0.066	1108.9
0.091	1183.4
0.115	1245.5
0.148	1276.6
0.165	1295.2
0.198	1295.2
0.215	1289.0
0.240	1282.8
0.290	1276.6

1295.2 Max Shear Stress

REMARKS Per client request, sample was remolded to a targeted density of 60 pcf at a moisture content of 15.4%. Density too low, increased density to 81 pcf. Sample was inundated.

DESCRIPTION Coal Ash - Brownish Gray, SILT, some fine sand.

USCS (ML)

TECH	TW/SDM/AK
DATE	7/5/2012
CHECK	AK
REVIEW	PWM
APROVE	

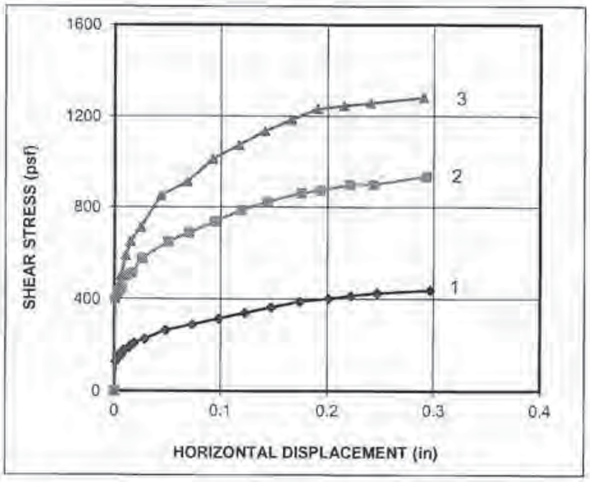
Golder Associates Inc.

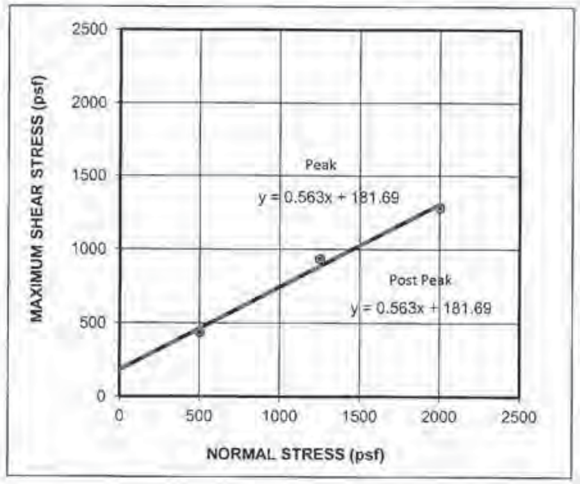
JUNE 2012 123-88896

DIRECT SHEAR

ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SB 1205 - DEPTH: 0.0 - 10.0'





	Peak	
ϕ =	29.4	°
C=	181.7	psf

	Post Peak	
ϕ =	29.4	°
C=	181.7	psf

SPECIMEN 1	
Normal Stress (psf)	500
t50 (minutes)	0.28
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	20.1
Wet Density (pcf)	66.1
Dry Density (pcf)	55.0
Void Ratio	1.611
Saturation (%)	29

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.001	127.9
0.003	152.7
0.005	152.7
0.007	158.9
0.009	177.5
0.014	190.0
0.018	208.6
0.028	227.2
0.048	264.5
0.073	289.3
0.098	314.1
0.122	339.0
0.147	363.8
0.174	388.7
0.201	401.1
0.222	413.5
0.247	425.9
0.297	438.3

438.3
Max Shear Stress

SPECIMEN 2	
Normal Stress (psf)	1250
t50 (minutes)	0.13
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	20.1
Wet Density (pcf)	66.1
Dry Density (pcf)	55.0
Void Ratio	1.611
Saturation (%)	29

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.000	301.7
0.001	401.1
0.003	425.9
0.005	438.3
0.007	450.8
0.011	500.4
0.016	512.8
0.026	574.9
0.050	649.4
0.070	686.7
0.094	736.4
0.119	786.0
0.144	823.3
0.175	860.6
0.193	873.0
0.221	897.8
0.243	897.8
0.293	935.1

935.1
Max Shear Stress

SPECIMEN 3	
Normal Stress (psf)	2000
t50 (minutes)	0.10
SPEED mm/min	0.080
Sample Diameter (in)	2.50
Moisture Content (%)	20.1
Wet Density (pcf)	66.1
Dry Density (pcf)	55.0
Void Ratio	1.611
Saturation (%)	29

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.000	276.9
0.001	401.1
0.003	425.9
0.005	450.8
0.006	500.4
0.010	587.4
0.015	649.4
0.024	711.5
0.043	848.1
0.068	910.2
0.092	1009.6
0.117	1071.7
0.141	1133.8
0.166	1183.4
0.190	1233.1
0.215	1245.5
0.240	1257.9
0.290	1282.8

1282.8
Max Shear Stress

REMARKS: Per client request, sample was remolded to a targeted density of 55 pcf at a moisture content of 20%. Sample was not inundated.

DESCRIPTION: Coal Ash - Gray, SILT, some fine sand.

USCS: (ML)

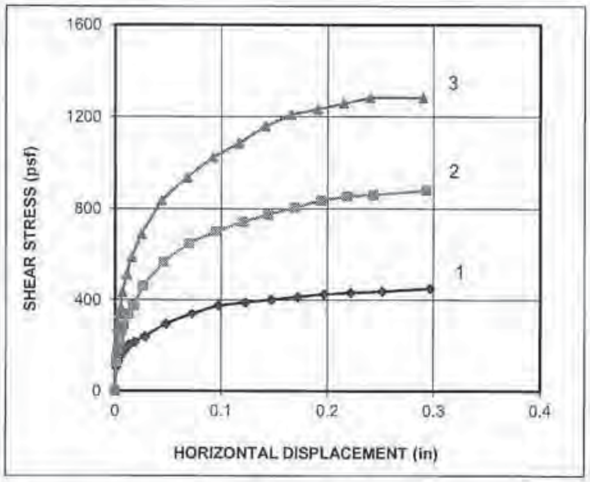
TECH	TW/DA
DATE	6/29/2012
CHECK	A/C
REVIEW	[signature]
APROVE	

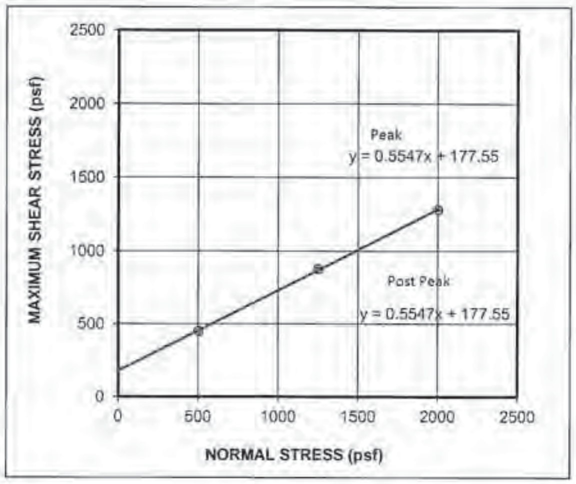
Golder Associates Inc.

JUNE 2012 | 123-88896

DIRECT SHEAR
ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SB 1207 - DEPTH: 15.0 - 25.0'





Peak
ϕ = 29.0 °
C= 177.6 psf

Post Peak
ϕ = 29.0 °
C= 177.6 psf

SPECIMEN 1		SPECIMEN 2		SPECIMEN 3	
Normal Stress (psf)	500	Normal Stress (psf)	1250	Normal Stress (psf)	2000
t50 (minutes)	0.35	t50 (minutes)	0.23	t50 (minutes)	0.19
SPEED mm/min	0.060	SPEED mm/min	0.060	SPEED mm/min	0.060
Sample Diameter (in)	2.50	Sample Diameter (in)	2.50	Sample Diameter (in)	2.50
Moisture Content (%)	25.1	Moisture Content (%)	25.1	Moisture Content (%)	25.1
Wet Density (pcf)	75.1	Wet Density (pcf)	75.1	Wet Density (pcf)	75.1
Dry Density (pcf)	60.0	Dry Density (pcf)	60.0	Dry Density (pcf)	60.0
Void Ratio	1.393	Void Ratio	1.393	Void Ratio	1.393
Saturation (%)	41	Saturation (%)	41	Saturation (%)	41
HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)	HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)	HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0	0.000	0.0	0.000	0.0
0.001	103.0	0.001	127.9	0.001	177.5
0.003	127.9	0.003	183.8	0.002	276.9
0.005	152.7	0.004	227.2	0.003	339.0
0.007	165.1	0.006	264.5	0.005	363.8
0.009	177.5	0.008	289.3	0.007	432.1
0.014	202.4	0.012	339.0	0.011	512.8
0.018	214.8	0.017	376.2	0.015	587.4
0.028	239.6	0.026	463.2	0.025	686.7
0.048	295.5	0.046	568.7	0.043	835.7
0.072	339.0	0.070	649.4	0.068	935.1
0.097	376.2	0.095	699.1	0.092	1022.0
0.122	388.7	0.120	742.6	0.116	1084.1
0.147	401.1	0.144	773.6	0.141	1158.6
0.172	413.5	0.169	804.7	0.165	1208.3
0.197	425.9	0.193	835.7	0.190	1233.1
0.222	432.1	0.218	854.3	0.215	1257.9
0.252	438.3	0.243	860.6	0.240	1282.8
0.297	450.8	0.293	879.2	0.290	1282.8
Max Shear Stress	450.8	Max Shear Stress	879.2	Max Shear Stress	1282.8

REMARKS: Per client request, sample was remolded to a targeted density of 60 pcf at a moisture content of 25%. Sample was not inundated.

DESCRIPTION: Coal Ash - Dark Gray, SILT, some fine sand.

USCS: (ML)

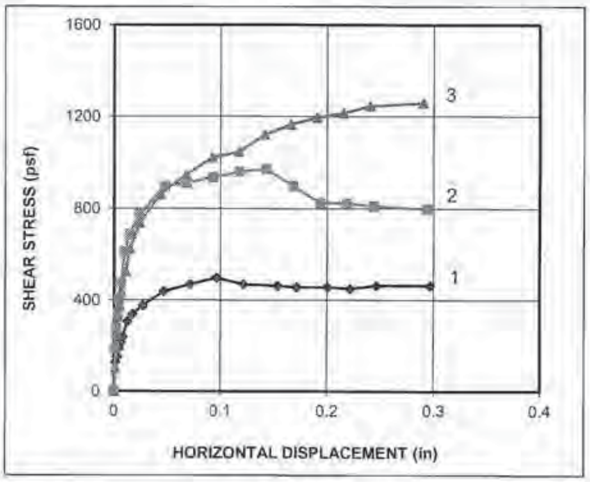
TECH	TW/AK
DATE	7/2/2012
CHECK	AK
REVIEW	[illegible]
APROVE	

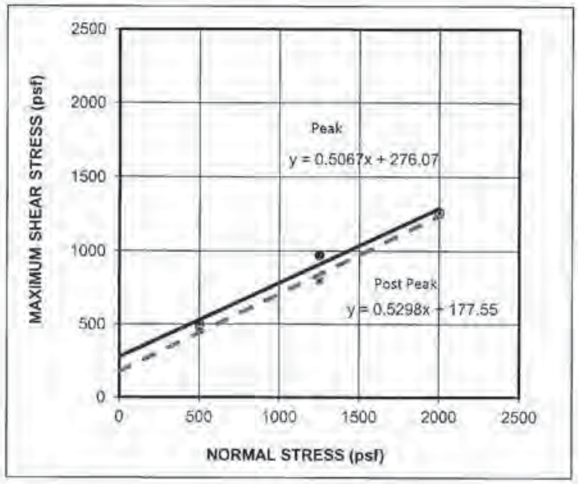
Golder Associates Inc.

DIRECT SHEAR

ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SB 1209 - **DEPTH:** 10.0-16.0





	Peak		Post Peak	
ϕ =	26.9	°	27.9	°
C=	276.1	psf	177.6	psf

	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3
Normal Stress (psf)	500	1250	2000
t50 (minutes)	0.70	0.31	0.70
SPEED mm/min	0.080	0.080	0.080
Sample Diameter (in)	2.50	2.50	2.50
Moisture Content (%)	20.0	20.0	20.0
Wet Density (pcf)	78.0	78.0	78.0
Dry Density (pcf)	65.0	65.0	65.0
Void Ratio	1.209	1.209	1.209
Saturation (%)	38	38	38

SPECIMEN 1 HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)	SPECIMEN 2 HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)	SPECIMEN 3 HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0	0.000	0.0	0.000	0.0
0.001	127.9	0.001	190.0	0.001	103.0
0.003	152.7	0.002	276.9	0.002	252.1
0.005	190.0	0.003	339.0	0.004	326.6
0.006	214.8	0.005	401.1	0.005	376.2
0.008	239.6	0.006	475.6	0.007	438.3
0.013	307.9	0.010	612.2	0.011	525.3
0.017	339.0	0.015	686.7	0.015	624.6
0.027	376.2	0.024	773.6	0.024	736.4
0.047	438.3	0.048	897.8	0.043	860.6
0.071	469.4	0.068	910.2	0.068	947.5
0.096	497.9	0.093	935.1	0.092	1022.0
0.121	469.4	0.117	959.9	0.117	1046.8
0.153	463.2	0.142	972.3	0.141	1121.3
0.171	457.0	0.168	897.8	0.166	1164.8
0.200	457.0	0.194	823.3	0.191	1195.9
0.222	450.8	0.219	823.3	0.215	1214.5
0.246	463.2	0.244	810.9	0.240	1245.5
0.296	463.2	0.294	798.5	0.290	1257.9
Max Shear Stress	497.9	Max Shear Stress	972.3	Max Shear Stress	1257.9

REMARKS Per client request, sample was remolded to a targeted density of 65 pcf at a moisture content of 20%. Sample was not inundated.

DESCRIPTION Coal Ash - Dark Gray, SILT, some fine sand.

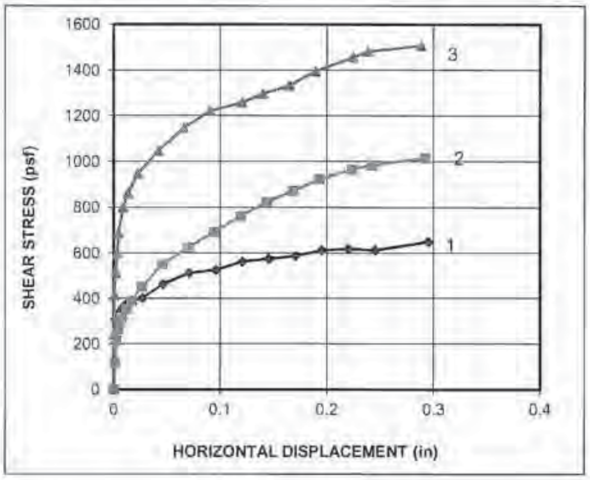
USCS (ML)

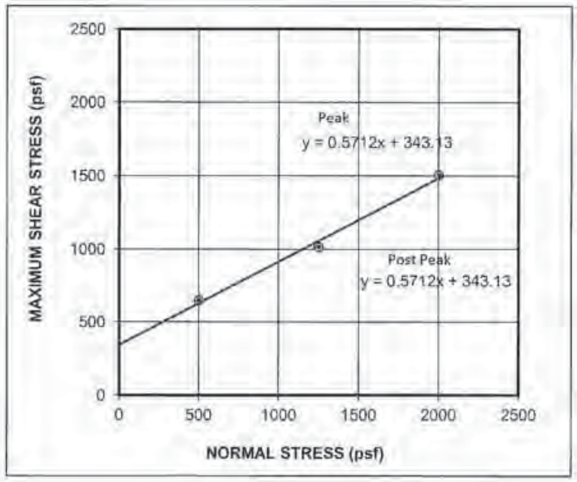
TECH	TW/SDM
DATE	7/3/2012
CHECK	AJL
REVIEW	
APROVE	

DIRECT SHEAR

ASTM D 3080

PROJECT NAME: EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
PROJECT NUMBER: 123-88896
SAMPLE ID: SB 1210 - **DEPTH:** 0.0 - 7.0'





	Peak	Post Peak
ϕ =	29.7 °	29.7 °
C=	343.1 psf	343.1 psf

SPECIMEN 1	
Normal Stress (psf)	500
t50 (minutes)	0.60
SPEED mm/min	0.060
Sample Diameter (in)	2.50
Moisture Content (%)	25.0
Wet Density (pcf)	75.0
Dry Density (pcf)	60.0
Void Ratio	1.392
Saturation (%)	41

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.000	301.7
0.002	307.9
0.004	326.6
0.005	339.0
0.007	351.4
0.012	376.2
0.017	388.7
0.027	401.1
0.046	463.2
0.071	512.8
0.096	525.3
0.121	562.5
0.146	574.9
0.170	587.4
0.195	612.2
0.220	618.4
0.245	612.2
0.295	649.4

649.4 Max Shear Stress

SPECIMEN 2	
Normal Stress (psf)	1250
t50 (minutes)	0.53
SPEED mm/min	0.060
Sample Diameter (in)	2.50
Moisture Content (%)	25.0
Wet Density (pcf)	75.0
Dry Density (pcf)	60.0
Void Ratio	1.392
Saturation (%)	41

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.001	115.5
0.002	214.8
0.004	264.5
0.006	289.3
0.008	314.1
0.012	351.4
0.017	388.7
0.027	450.8
0.046	550.1
0.070	624.6
0.095	692.9
0.119	761.2
0.144	823.3
0.168	873.0
0.193	922.6
0.223	966.1
0.242	984.7
0.292	1015.8

1015.8 Max Shear Stress

SPECIMEN 3	
Normal Stress (psf)	2000
t50 (minutes)	0.7
SPEED mm/min	0.060
Sample Diameter (in)	2.50
Moisture Content (%)	25.0
Wet Density (pcf)	75.0
Dry Density (pcf)	60.0
Void Ratio	1.392
Saturation (%)	41

HORIZONTAL DISPLACEMENT (in)	SHEAR STRESS (psf)
0.000	0.0
0.000	239.6
0.001	413.5
0.002	512.8
0.003	599.8
0.005	686.7
0.009	798.5
0.013	860.6
0.023	947.5
0.042	1046.8
0.066	1146.2
0.090	1220.7
0.120	1257.9
0.140	1295.2
0.164	1332.5
0.189	1394.5
0.224	1456.6
0.238	1481.5
0.288	1506.3

1506.3 Max Shear Stress

REMARKS Per client request, sample was remolded to a targeted density of 60 pcf at a moisture content of 25%. Sample was not inundated.

DESCRIPTION Coal Ash - Gray, SILT, some fine sand.

USCS (ML)

TECH	TW
DATE	6/28/2012
CHECK	AH
REVIEW	PWM
APROVE	

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B

PROJECT NAME	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI	DESCRIPTION	Coal Ash - Dark Gray, SILT, and fine sand.			LL	-
PROJECT NUMBER	123-88896					PL	-
SAMPLE ID	SB 1203	CLASSIFICATION	(ML)			PI	-
SAMPLE DEPTH	0 - 10.0'					Gs	2.349
SAMPLE TYPE	Bag	CONSOLIDOMETER #	1				
		ASTM D 2435 Method	B				

Sample Data	Trimmings	Before Test	After Test
Tare plus wet soil, g	159.97	172.06	171.23
Tare plus dry soil, g	138.00	152.65	152.65
Tare, g	50.91	75.54	75.54
Water, g	21.97	19.41	18.58
Dry soil, g	87.09	77.11	77.11
Water Content	25.2%	25.2%	24.1%

Diameter (in)	2.498
Height of sample (in)	0.750
Area of sample (in^2)	4.901
Volume of sample (in^3)	3.676
Water Content	25.2%
Sample Wt (wet, g)	96.52
Sample Wt (dry, g)	77.11
Water Wt (g)	19.41

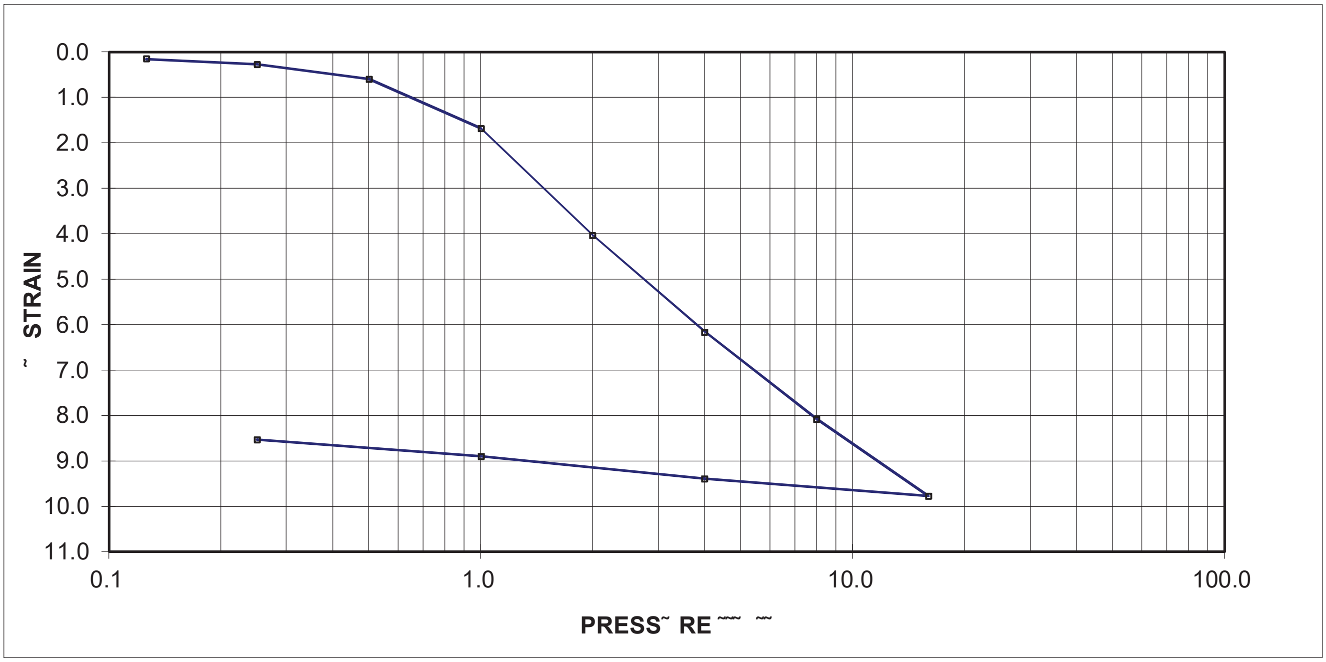
Sample Data	Initial	Final
Total Height (in)	0.750	0.685
Height of solids (in)	0.409	0.409
Height of voids (in)	0.341	0.276
Height of water (in)	0.242	0.231
Void ratio	0.834	0.675
Degree of saturation	70.9%	83.9%
Dry unit wt (pcf)	79.9	87.5
Wet unit wt (pcf)	100.0	108.6

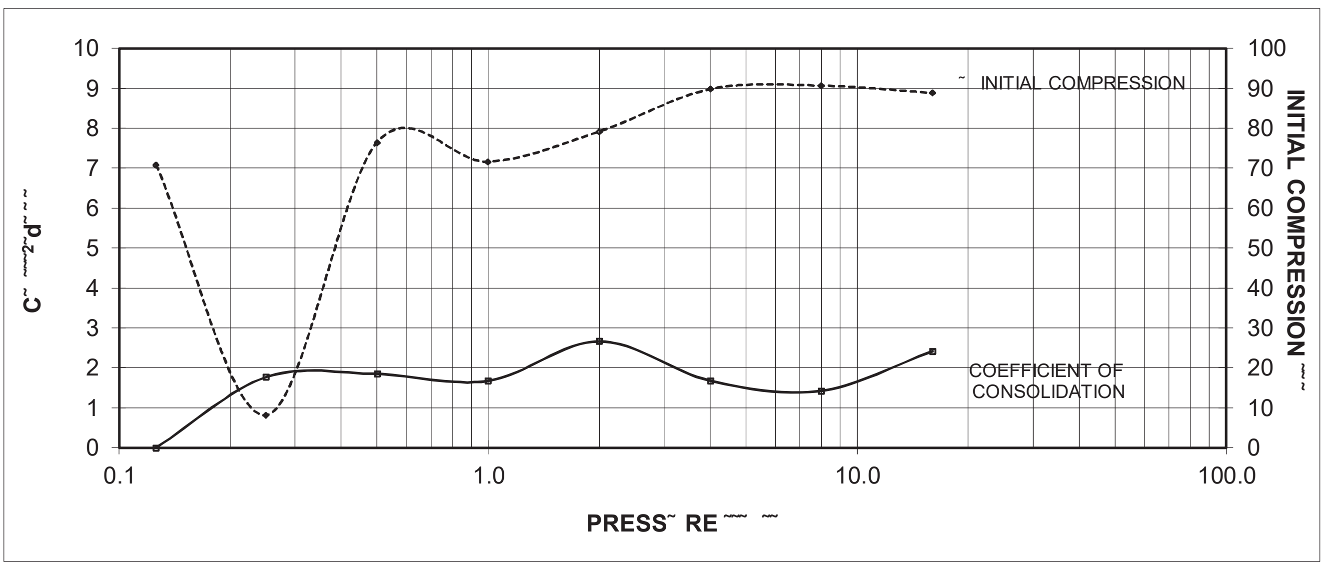
PRESSURE (ksf)	H100 DIAL READING	MACHINE / STONE CORR.	DIAL CHANGE (in)	FITTING TIME (sec) t90	SAMPLE HEIGHT (in)	HEIGHT OF VOIDS Hv	VOID RATIO e	CHANGE IN HEIGHT (accum)	STRAIN %	LENGTH OF DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	H^2 (cm^2)	PERCENT INITIAL COMPRESSION	COEFFICIENT OF CONSOLIDATION (ft^2/day)
0.125	0.0014	0.0000	0.0000	0	0.750	0.3411	0.8341	0.0000	0.0	0.375	0.907	0.0	0.0
0.126	0.0025	0.0000	0.0011	82	0.749	0.3399	0.8313	0.0011	0.2	0.375	0.906	70.8	0.0
0.250	0.0034	0.0000	0.0020	40	0.748	0.3391	0.8292	0.0020	0.3	0.374	0.903	8.1	1.8
0.500	0.0059	0.0000	0.0045	38	0.746	0.3366	0.8232	0.0045	0.6	0.373	0.899	76.4	1.8
1.000	0.0140	0.0000	0.0126	42	0.737	0.3285	0.8032	0.0126	1.7	0.371	0.887	71.6	1.7
2.000	0.0317	0.0000	0.0303	25	0.720	0.3108	0.7601	0.0303	4.0	0.364	0.856	79.2	2.7
4.000	0.0477	0.0000	0.0463	38	0.704	0.2948	0.7210	0.0463	6.2	0.356	0.817	89.8	1.7
8.000	0.0620	0.0000	0.0606	43	0.689	0.2805	0.6859	0.0606	8.1	0.348	0.783	90.7	1.4
16.000	0.0747	0.0000	0.0733	25	0.677	0.2677	0.6548	0.0733	9.8	0.342	0.752	88.8	2.4
4.000	0.0719	0.0000	0.0705	76	0.680	0.2706	0.6618	0.0705	9.4	0.339	0.742	91.6	0.8
1.000	0.0682	0.0000	0.0668	60	0.683	0.2743	0.6708	0.0668	8.9	0.341	0.749	90.6	1.0
0.250	0.0654	0.0000	0.0640	60	0.686	0.2770	0.6775	0.0640	8.5	0.342	0.756	80.0	1.0

FINAL DIAL READING = 0.0651

TECH	TW/AK
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B





Remarks	Per client request, sample was targeted for a remolded density of 60 pcf at a moisture content of 25%. Density too low, increased density to 80 pcf . Specimen was not inundated.

					Initial	Final
SAMPLE ID	SB 1203	LL	-	Dry Unit Weight (pcf)	79.9	87.5
SAMPLE TYPE	Bag	PL	-	Wet Unit Weight (pcf)	100.0	108.6
SAMPLE DEPTH	0 - 10.0'	PI	-	Moisture Content	25.2%	24.1%
		Gs	2.35	Void Ratio	0.8341	0.6749
				Degree of Saturation	70.9%	83.9%

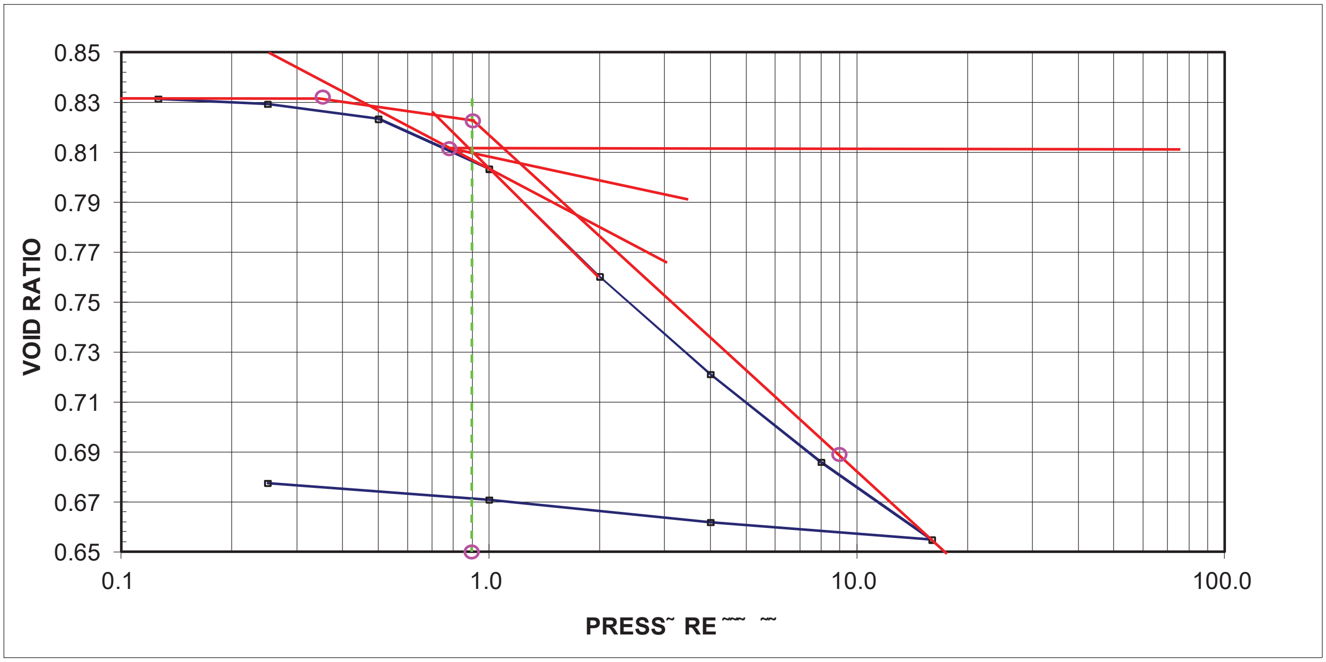
DESCRIPTION: Coal Ash - Dark Gray, SILT, and fine sand.

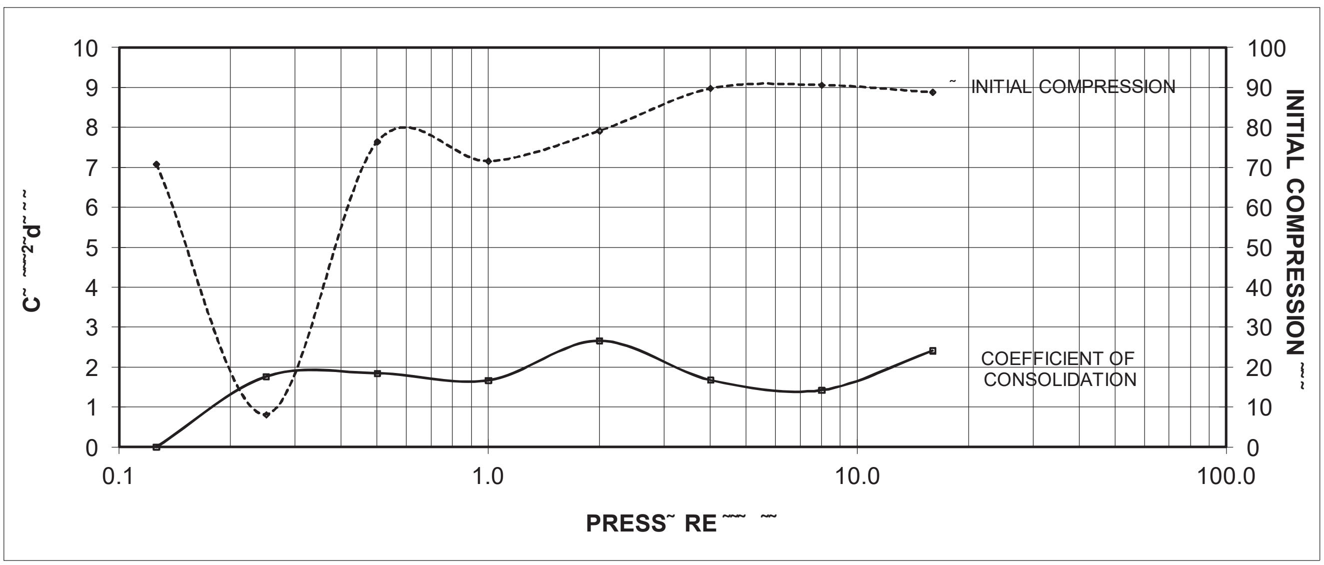
USCS: (ML)

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW/AK
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B





Remarks: Per client request, sample was targeted for a remolded density of 60 pcf at a moisture content of 25%. Density too low, increased density to 80 pcf . Specimen was not inundated.

SAMPLE ID	SB 1203	LL	-	Dry Unit Weight (pcf)	79.9	87.5
SAMPLE TYPE	Bag	PL	-	Wet Unit Weight (pcf)	100.0	108.6
SAMPLE DEPTH	0 - 10.0'	PI	-	Moisture Content	25.2%	24.1%
		Gs	2.35	Void Ratio	0.8341	0.6749
				Degree of Saturation	70.9%	83.9%

(Columns at right: Initial, Final)

DESCRIPTION: Coal Ash - Dark Gray, SILT, and fine sand.

USCS: (ML)

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW/AK
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

Soil Compressibilty

Find Preconsolidation Stress Using
Casagrande Procedure

$\sigma_{c'} := 0.9\ ksf$ Preconsolidation Stress

Reconstruction Field Consolidation Curve
Using Schmertmann Procedure

$e_a := .825$

$e_b := 0.69$

$\sigma'_{za} := 0.9$

$\sigma'_{zb} := 9$

$$C_c := \frac{e_a - e_b}{\log\left(\sigma'_{zb}\right) - \log\left(\sigma'_{za}\right)}$$

$C_c = 0.135$ Cc=Compression Index

$e_c := 0.835$

$e_d := 0.825$

$\sigma'_{zc} := 0.35$

$\sigma'_{zd} := 0.9$

$$C_r := \frac{e_c - e_d}{\log\left(\sigma'_{zd}\right) - \log\left(\sigma'_{zc}\right)}$$

$C_r = 0.024$ Cr=Recompression Index

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B

PROJECT NAME	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI	DESCRIPTION	Coal Ash - Dark Gray, SILTY, some fine sand.	LL	-
PROJECT NUMBER	123-88896			PL	-
SAMPLE ID	SB 1208	CLASSIFICATION	(ML)	PI	-
SAMPLE DEPTH	10.0 - 14.0'			Gs	2.463
SAMPLE TYPE	Bag	CONSOLIDOMETER #	3		
		ASTM D 2435 Method	B		

Sample Data	Trimmings	Before Test	After Test
Tare plus wet soil, g	154.40	151.23	152.68
Tare plus dry soil, g	137.70	138.70	138.70
Tare, g	51.34	74.73	74.73
Water, g	16.70	12.53	13.98
Dry soil, g	86.36	63.97	63.97
Water Content	19.3%	19.6%	21.9%

Diameter (in)	2.490
Height of sample (in)	0.745
Area of sample (in^2)	4.870
Volume of sample (in^3)	3.628
Water Content	19.6%
Sample Wt (wet, g)	76.5
Sample Wt (dry, g)	63.97
Water Wt (g)	12.53

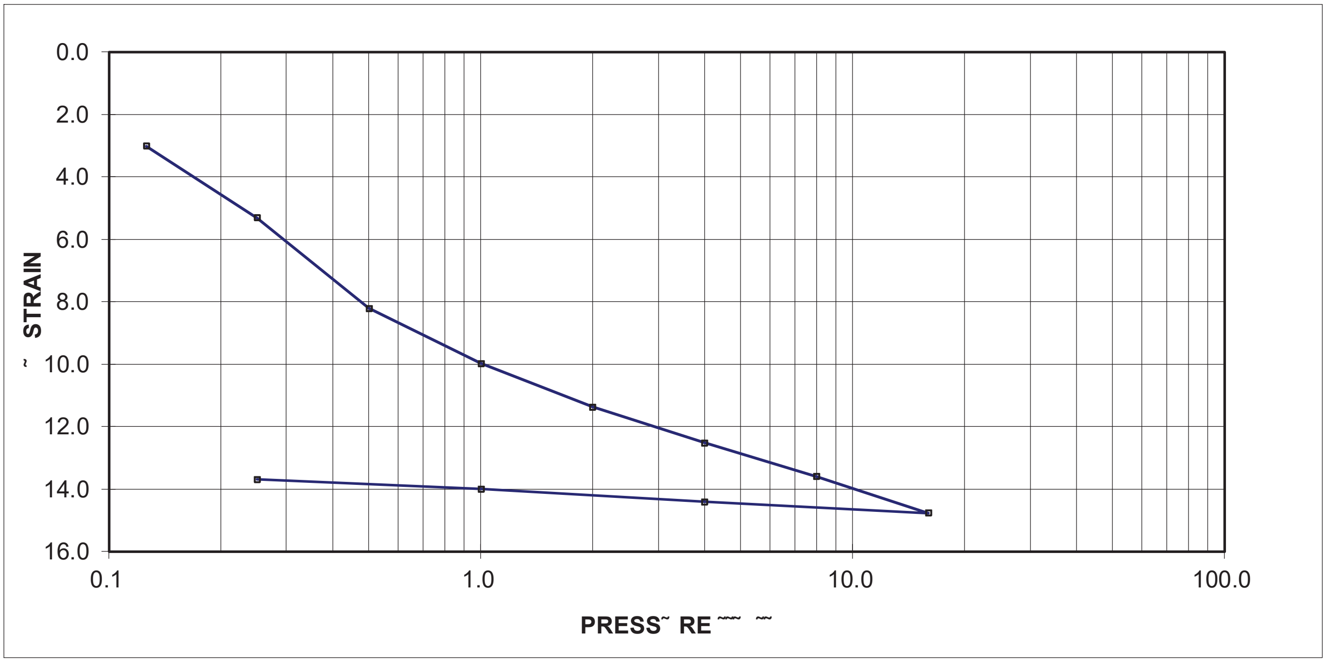
Sample Data	Initial	Final
Total Height (in)	0.745	0.623
Height of solids (in)	0.326	0.326
Height of voids (in)	0.419	0.297
Height of water (in)	0.157	0.175
Void ratio	1.288	0.913
Degree of saturation	37.5%	59.0%
Dry unit wt (pcf)	67.2	80.4
Wet unit wt (pcf)	80.3	97.9

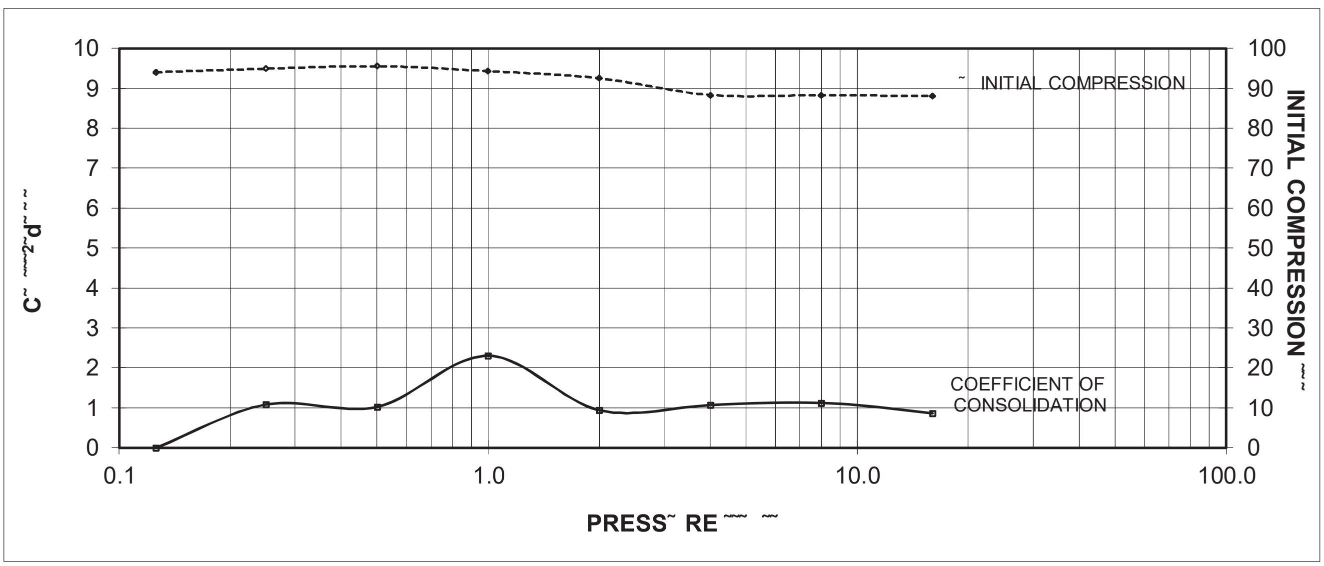
PRESSURE (ksf)	H100 DIAL READING	MACHINE / STONE CORR.	DIAL CHANGE (in)	FITTING TIME (sec) t90	SAMPLE HEIGHT (in)	HEIGHT OF VOIDS Hv	VOID RATIO e	CHANGE IN HEIGHT (accum)	STRAIN %	LENGTH OF DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	H^2 (cm^2)	PERCENT INITIAL COMPRESSION	COEFFICIENT OF CONSOLIDATION (ft^2/day)
0.125	0.0203	0.0000	0.0000	0	0.745	0.4194	1.2880	0.0000	0.0	0.373	0.895	0.0	0.0
0.126	0.0427	0.0000	0.0224	60	0.723	0.3969	1.2191	0.0224	3.0	0.367	0.868	94.0	0.0
0.250	0.0598	0.0000	0.0395	60	0.705	0.3798	1.1665	0.0395	5.3	0.357	0.822	94.9	1.1
0.500	0.0815	0.0000	0.0612	60	0.684	0.3582	1.1000	0.0612	8.2	0.347	0.778	95.5	1.0
1.000	0.0946	0.0000	0.0743	25	0.671	0.3451	1.0599	0.0743	10.0	0.339	0.740	94.3	2.3
2.000	0.1050	0.0000	0.0847	60	0.660	0.3347	1.0279	0.0847	11.4	0.333	0.714	92.5	0.9
4.000	0.1136	0.0000	0.0933	51	0.652	0.3261	1.0015	0.0933	12.5	0.328	0.694	88.3	1.1
8.000	0.1216	0.0000	0.1013	48	0.644	0.3181	0.9769	0.1013	13.6	0.324	0.677	88.3	1.1
16.000	0.1303	0.0000	0.1100	60	0.635	0.3094	0.9502	0.1100	14.8	0.320	0.659	88.0	0.9
4.000	0.1276	0.0000	0.1073	60	0.638	0.3121	0.9586	0.1073	14.4	0.318	0.653	88.7	0.9
1.000	0.1246	0.0000	0.1043	38	0.641	0.3151	0.9678	0.1043	14.0	0.320	0.659	85.6	1.4
0.250	0.1222	0.0000	0.1019	173	0.643	0.3174	0.9749	0.1019	13.7	0.321	0.665	71.0	0.3

FINAL DIAL READING = 0.1222

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B





Remarks: Per client request, sample was targeted for a remolded density of 65 pcf at a moisture content of 20%. Density too low, increased density to 67 pcf. Specimen was not inundated.

SAMPLE ID	SB 1208	LL	-	Dry Unit Weight (pcf)	67.2	80.4
SAMPLE TYPE	Bag	PL	-	Wet Unit Weight (pcf)	80.3	97.9
SAMPLE DEPTH	10.0 - 14.0'	PI	-	Moisture Content	19.6%	21.9%
		Gs	2.46	Void Ratio	1.2880	0.9127
				Degree of Saturation	37.5%	59.0%

(Last two columns: Initial, Final)

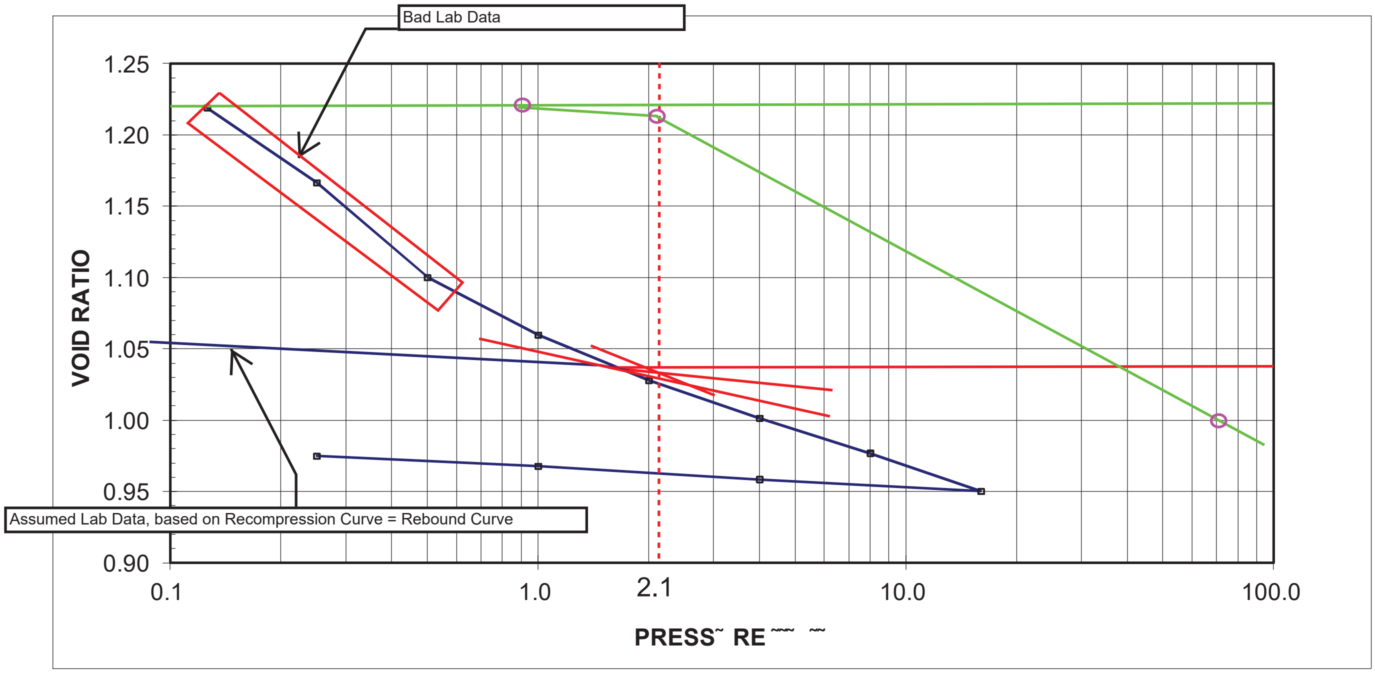
DESCRIPTION: Coal Ash - Dark Gray, SILTY, some fine sand.

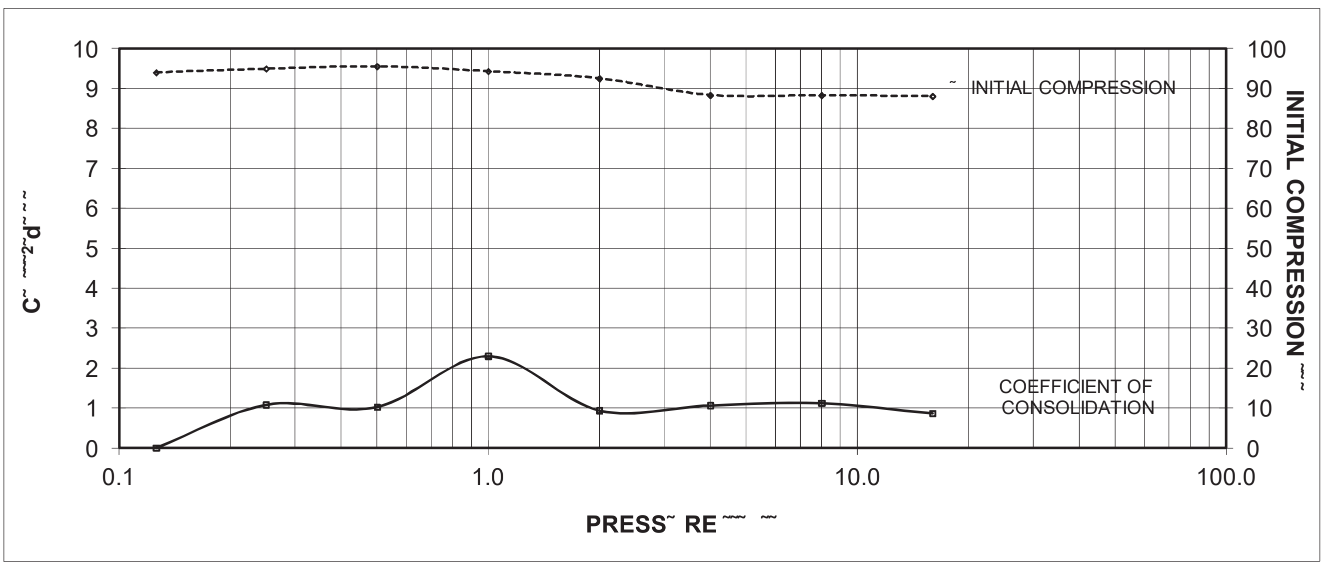
USCS: (ML)

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B





Remarks: Per client request, sample was targeted for a remolded density of 65 pcf at a moisture content of 20%. Density too low, increased density to 67 pcf. Specimen was not inundated.

SAMPLE ID	SB 1208
SAMPLE TYPE	Bag
SAMPLE DEPTH	10.0 - 14.0'

LL	-
PL	-
PI	-
Gs	2.46

	Initial	Final
Dry Unit Weight (pcf)	67.2	80.4
Wet Unit Weight (pcf)	80.3	97.9
Moisture Content	19.6%	21.9%
Void Ratio	1.2880	0.9127
Degree of Saturation	37.5%	59.0%

DESCRIPTION: Coal Ash - Dark Gray, SILTY, some fine sand.

USCS: (ML)

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

Golder Associates Inc.

Soil Compressibilty

Find Preconsolidation Stress Using
Casagrande Procedure

$\sigma_{c'} := 2.1\ ksf$ Assumed Preconsolidation Stress due to poor lab results

Reconstruction Field Consolidation Curve
Using Schmertmann Procedure

$e_a := 1.21$
$e_b := 1.00$
$\sigma'_{za} := 2.1$
$\sigma'_{zb} := 70$

$$C_c := \frac{e_a - e_b}{\log\left(\sigma'_{zb}\right) - \log\left(\sigma'_{za}\right)}$$

$\boxed{C_c = 0.138 \qquad \text{Cc=Compression Index}}$

$e_c := 1.22$
$e_d := 1.21$
$\sigma'_{zc} := 0.9$
$\sigma'_{zd} := 2.1$

$$C_r := \frac{e_c - e_d}{\log\left(\sigma'_{zd}\right) - \log\left(\sigma'_{zc}\right)}$$

$\boxed{C_r = 0.027 \qquad \text{Cr=Recompression Index}}$

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B

PROJECT NAME	EE/CEC CAMPBELL ASH IMPOUNDMENT/MI	DESCRIPTION	Coal Ash - Dark Gray, SILT, some fine sand.	LL	-
PROJECT NUMBER	123-88896			PL	-
SAMPLE ID	SB 1211	CLASSIFICATION	(ML)	PI	-
SAMPLE DEPTH	10.0 - 20.0'			Gs	2.271
SAMPLE TYPE	Bag	CONSOLIDOMETER #	2		
		ASTM D 2435 Method	B		

Sample Data	Trimmings	Before Test	After Test
Tare plus wet soil, g	148.35	142.68	146.41
Tare plus dry soil, g	129.14	129.14	129.14
Tare, g	51.83	76.05	76.05
Water, g	19.21	13.54	17.27
Dry soil, g	77.31	53.09	53.09
Water Content	24.8%	25.5%	32.5%

Diameter (in)	2.498
Height of sample (in)	0.750
Area of sample (in^2)	4.901
Volume of sample (in^3)	3.676
Water Content	25.5%
Sample Wt (wet, g)	66.63
Sample Wt (dry, g)	53.09
Water Wt (g)	13.54

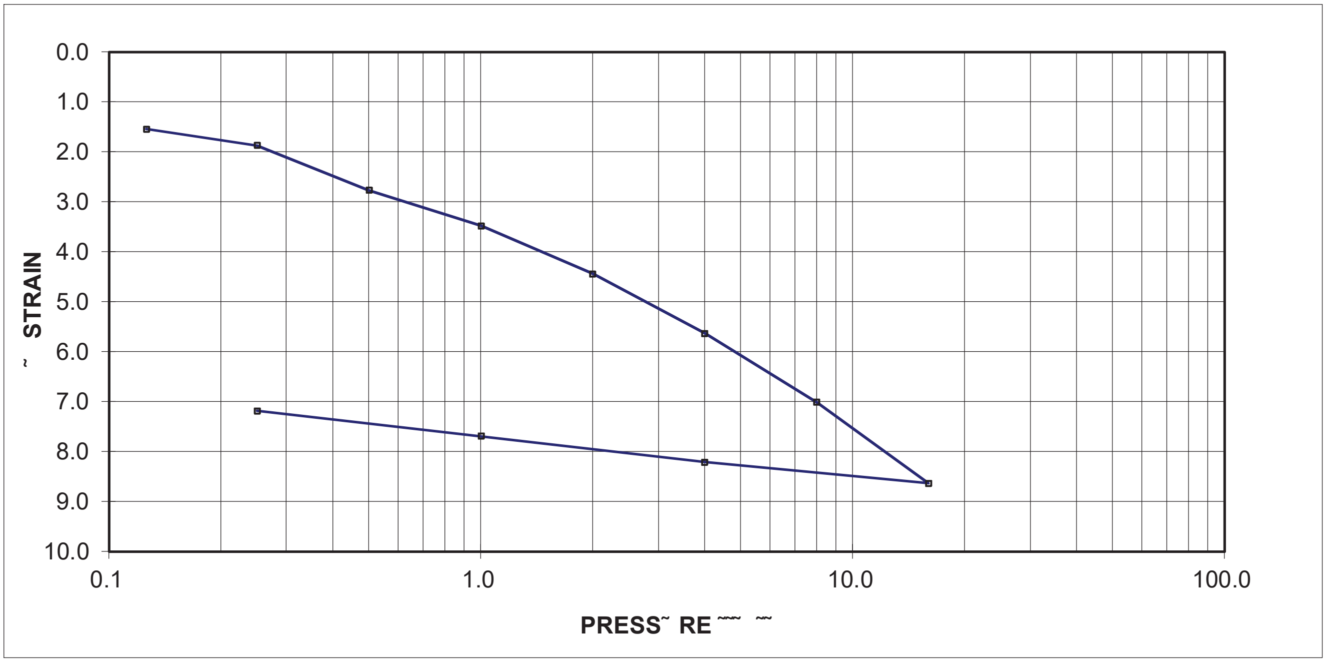
Sample Data	Initial	Final
Total Height (in)	0.750	0.696
Height of solids (in)	0.291	0.291
Height of voids (in)	0.459	0.405
Height of water (in)	0.169	0.215
Void ratio	1.575	1.390
Degree of saturation	36.8%	53.2%
Dry unit wt (pcf)	55.0	59.3
Wet unit wt (pcf)	69.1	78.6

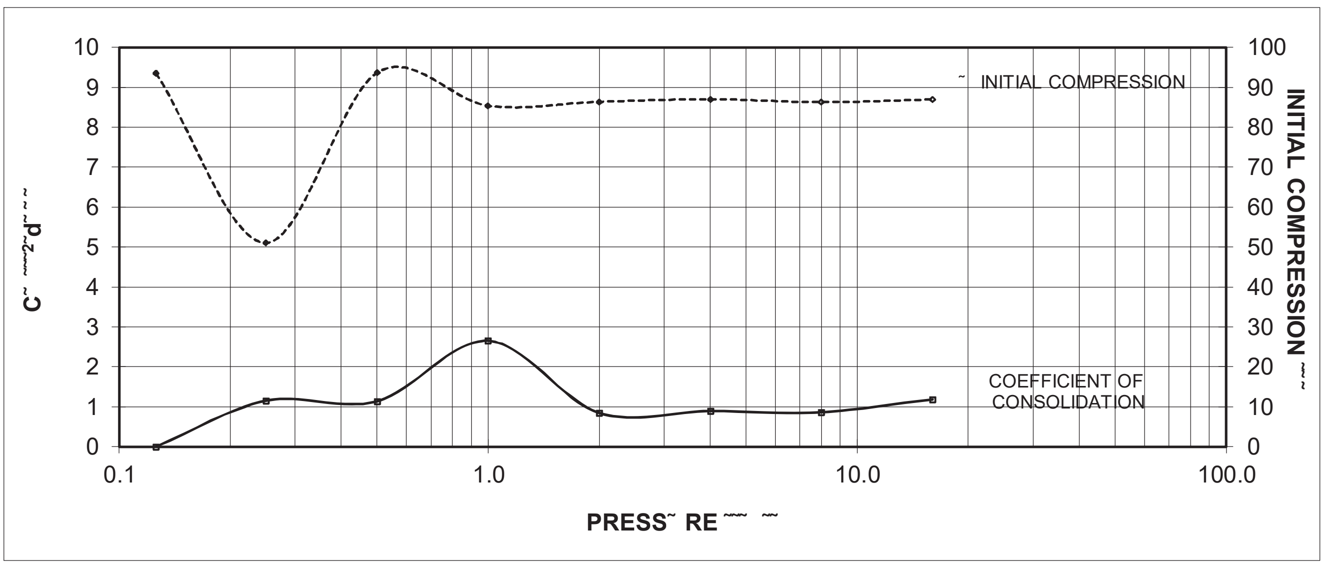
PRESSURE (ksf)	H100 DIAL READING	MACHINE / STONE CORR.	DIAL CHANGE (in)	FITTING TIME (sec) t90	SAMPLE HEIGHT (in)	HEIGHT OF VOIDS Hv	VOID RATIO e	CHANGE IN HEIGHT (accum)	STRAIN %	LENGTH OF DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	H^2 (cm^2)	PERCENT INITIAL COMPRESSION	COEFFICIENT OF CONSOLIDATION (ft^2/day)
0.125	0.0003	0.0000	0.0000	0	0.750	0.4588	1.5755	0.0000	0.0	0.375	0.907	0.0	0.0
0.126	0.0119	0.0000	0.0116	29	0.738	0.4472	1.5357	0.0116	1.5	0.372	0.893	93.5	0.0
0.250	0.0143	0.0000	0.0140	60	0.736	0.4448	1.5273	0.0140	1.9	0.369	0.877	51.0	1.2
0.500	0.0210	0.0000	0.0207	60	0.729	0.4381	1.5042	0.0207	2.8	0.366	0.866	93.6	1.1
1.000	0.0264	0.0000	0.0261	25	0.724	0.4327	1.4859	0.0261	3.5	0.363	0.852	85.3	2.6
2.000	0.0336	0.0000	0.0333	78	0.717	0.4255	1.4611	0.0333	4.4	0.360	0.837	86.4	0.8
4.000	0.0426	0.0000	0.0423	73	0.708	0.4165	1.4304	0.0423	5.6	0.356	0.818	87.0	0.9
8.000	0.0529	0.0000	0.0526	73	0.697	0.4062	1.3949	0.0526	7.0	0.351	0.796	86.3	0.9
16.000	0.0650	0.0000	0.0647	51	0.685	0.3940	1.3531	0.0647	8.6	0.346	0.771	86.9	1.2
4.000	0.0619	0.0000	0.0616	17	0.688	0.3972	1.3640	0.0616	8.2	0.343	0.761	92.3	3.4
1.000	0.0580	0.0000	0.0577	22	0.692	0.4011	1.3774	0.0577	7.7	0.345	0.769	91.9	2.8
0.250	0.0541	0.0000	0.0538	320	0.696	0.4049	1.3906	0.0538	7.2	0.347	0.777	85.1	0.2

FINAL DIAL READING = 0.0541

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Method B





Remarks: Per client request, sample was remolded to a density of 55 pcf at a moisture content of 25%. Specimen was inundated.

SAMPLE ID	SB 1211	LL	-		**Initial**	**Final**
SAMPLE TYPE	Bag	PL	-	Dry Unit Weight (pcf)	55.0	59.3
SAMPLE DEPTH	10.0 - 20.0'	PI	-	Wet Unit Weight (pcf)	69.1	78.6
		Gs	2.27	Moisture Content	25.5%	32.5%
				Void Ratio	1.5755	1.3897
				Degree of Saturation	36.8%	53.2%

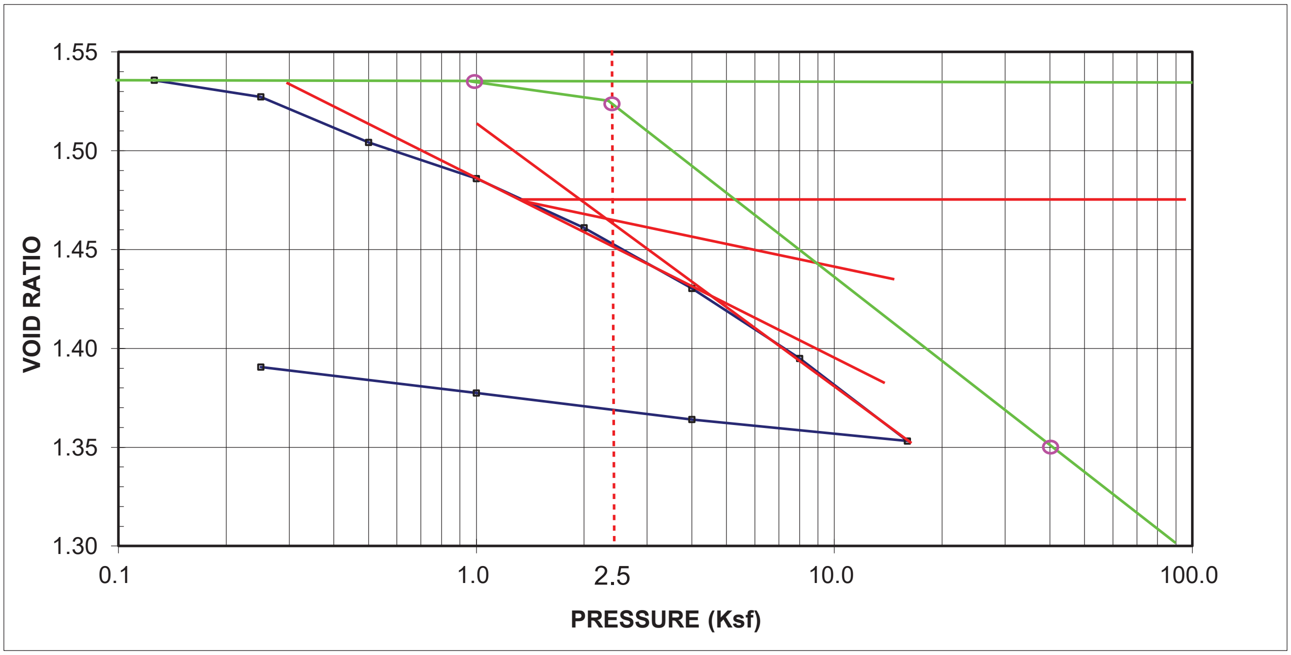
DESCRIPTION: Coal Ash - Dark Gray, SILT, some fine sand.

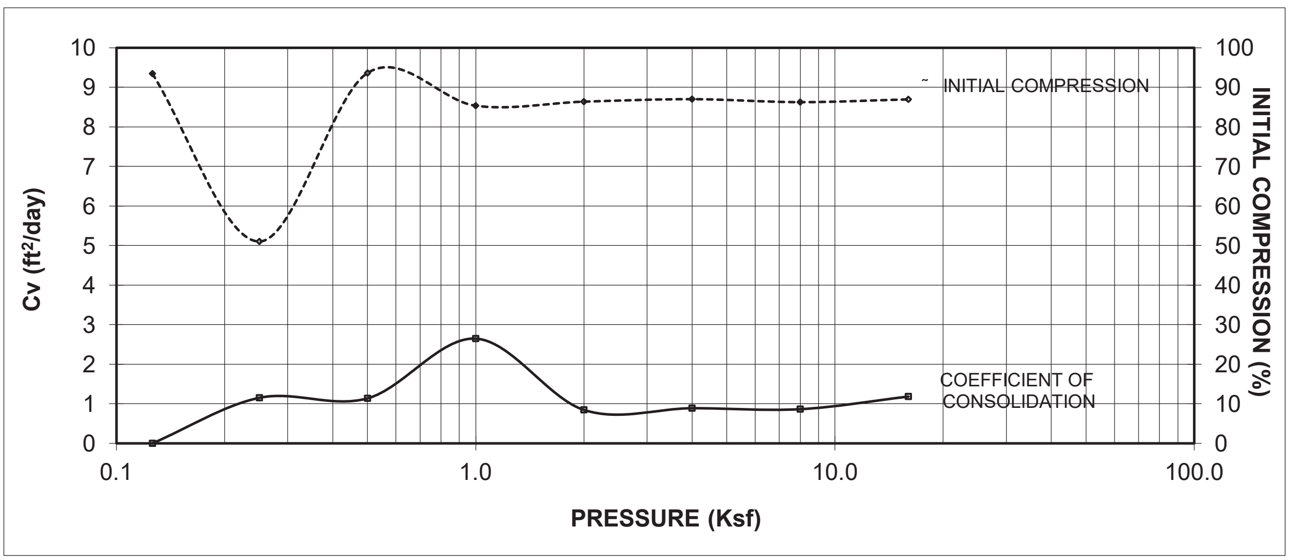
USCS: (ML)

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

ONE - DIMENSIONAL CONSOLIDATION
ASTM D 2435 Met˜ od B





Remarks: Per client re˜ uest˜ sample was remolded to a density of 55 pcf at a moisture content of 25˜ . Sample was conducted inundated.

SAMPLE ID	SB 1211
SAMPLE TYPE	Bag
SAMPLE DEPTH	10.0 - 20.0˜

LL	-
PL	-
PI	-
Gs	2.27

	Initial	Final
Dry Unit Weig˜ t ˜pcf˜	55.0	59.3
Wet Unit Weig˜ t ˜pcf˜	69.1	78.6
Moisture Content	25.5˜	32.5˜
Void Ratio	1.5755	1.3897
Degree of Saturation	36.8˜	53.2˜

DESCRIPTION: Coal As˜ - Dark Gray˜ SILT˜ some fine sand.

USCS: ˜ML˜

EE/CEC CAMPBELL ASH IMPOUNDMENT/MI
123-88896

TECH	TW
DATE	6/26/12
CHECK	
REVIEW	
APPROVE	

Soil Compressibilty

Find Preconsolidation Stress Using Casagrande Procedure

$\sigma_{c'} := 2.5\ ksf$ Preconsolidation Stress

Reconstruction Field Consolidation Curve Using Schmertmann Procedure

$e_a := 1.525$
$e_b := 1.35$
$\sigma'_{za} := 2.5$
$\sigma'_{zb} := 40$

$$C_c := \frac{e_a - e_b}{\log\left(\sigma'_{zb}\right) - \log\left(\sigma'_{za}\right)}$$

$C_c = 0.145$ Cc=Compression Index

$e_c := 1.54$
$e_d := 1.525$
$\sigma'_{zc} := 1.0$
$\sigma'_{zd} := 2.5$

$$C_r := \frac{e_c - e_d}{\log\left(\sigma'_{zd}\right) - \log\left(\sigma'_{zc}\right)}$$

$C_r = 0.038$ Cr=Recompression Index

APPENDIX C

Settlement Calculations

CALCULATIONS

Date:	January 18, 2021	**Made by:**	BB/AK
Project No.	19132873	**Checked by:**	DJS
Short Name:	J.H. Campbell Dry Ash Landfill Vertical Expansion CPA	**Reviewed by:**	TDJ
Subject:	**SETTLEMENT ANALYSIS**		

1.0 OBJECTIVE

Settlement analyses were completed to estimate total and differential settlements for recently constructed Cell 5 and proposed Cells 6 through 9 at the Consumers Energy Company (CEC) J.H. Campbell Dry Ash Landfill. Post settlement slopes were estimated using the calculated settlements to verify that the subgrade slopes along the leachate collection pipes remain greater than 1.0 percent (%).

Settlement analyses were also performed to estimate the total and differential settlement for portions of existing Cells 1, 2, and 4 that would receive additional waste fill from the construction of the vertical expansion. The existing subgrade design and as-constructed leachate collection slopes for Cells 1, 2, and 4 were determined to be 0.25%, 0.28%, and 0.27% respectively from Record Drawings. Post settlement slopes were estimated to verify if the existing leachate collection pipes would remain operational under the loading of the proposed landfill expansion.

2.0 METHODOLOGY

The software program Settle3D (version 4.0) was used to estimate total and differential settlements. The settlement analysis was performed in each cell at the location of the highest fill near the center and near the edge of the landfill / sump. The differential settlement between the two points was calculated and used to calculate the post-settlement pipe slopes. The subsurface conditions generally consist of a sand layer at different densities overlying glacial till. The material types and depths were used from historical boring logs and geotechnical reports (EES, 2012). The groundwater level was assumed to be at 604 feet above mean sea level (EES, 2012). The vertical datum used in this analysis is National Geodetic Vertical Survey of 1929 (NGVD29 – "Plant Datum").

2.1 Material Properties

Historical boring logs with Standard Penetration test (SPT) results and laboratory testing data were used to estimate the material properties for the sand. Material properties for the glacial till were assumed to be the same as those presented in the historical engineering calculations (EES, 2012). Material properties are summarized in Table 1.

Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, MI 48906 USA
Tel: (517) 482-2262 Fax: (517) 482-2460 www.golder.com

Project No.:	19132873	Made by:	BB/AK
Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

Table 1.0: Material Properties

Material Properties								
Material	**Total Unit Weight (pcf)**	**E_s (tsf)**	**v_s**	**C_c**	**C_r**	**e_o**	**OCR**	**Approximate Elevation (ft-msl)**
Medium Dense Foundation Sand (Fill)	130	150	0.25	-	-	-	-	Subgrade to 610
Loose Foundation Sand	125	85	0.21	-	-	-	-	610 to 590
Medium Dense Foundation Sand	130	150	0.25	-	-	-	-	590 to 570
Glacial Till (EES , 2017)	141	-	-	0.225	0.023	0.5	3	570 to 470

Notes:
pcf = pounds per cubic foot, tsf = tons per square foot
ft-msl= feet above mean sea level
Es=Elastic modulus, C_c=compression Index, C_r=recompression Index, e_0=void ratio, OCR= overconsolidation ratio, v_s= Poison's ratio

For these analyses, a typical Poisson's ratio for the loose sand and the medium dense sand was selected (Reference 2). The elastic modulus for the sand was estimated based on conservative N_{60} values, assuming N_{60}=2 for loose sand and N_{60}=15 for medium dense sand (EES, 2012). The following equation was used to calculate the elastic modulus based on the conservative N values:

$$E_s = 500 * (N_{60} + 15) \qquad (Bowles, 1996)$$

Where:

N_{60}=SPT N-value corrected to 60% of the theoretical free-fall hammer energy
E_s= the elastic modulus (kPa)

For example for the Loose Foundation Sand: $Es = 500 * (2 + 15) = 8{,}500\ kPa = 85\ tsf$

2.2 Hand Calculation

A settlement calculation was performed for the center of proposed Cell 5 where the loading is maximum, using hand calculations to verify the results from the computer models. The subsurface conditions at this location consist of the following layers:

- 7-feet thick Medium Dense Sand (Fill)
- 20-feet thick Loose Sand

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Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

- 40-feet thick Medium Dense Sand
- 100-feet thick Glacial Till

The total settlement was calculated as the sum of the elastic settlements of the sand layers and the consolidation settlement of the glacial till.

The elastic settlement of the sand layers was calculated using the following equations (Ref. 3):

$$S_e = \left(\frac{\Delta\sigma}{M_s}\right) * H_0$$

$$M_s = \frac{E_s(1 - \nu_s)}{(1 + \nu_s)(1 - 2 * \nu_s)}$$

Where;

S_e= Elastic settlement of soil layer (ft)

H_0=initial thickness of soil layer (ft)

$\Delta\sigma$=increment of vertical effective stress (tsf)

M_s=constrained modulus of soil (tsf)

ν_s=Poisson's ratio of soil

<u>Loose sand:</u>

Assuming $\nu_s = 0.21$ and $E_s = 85\ tsf \quad \rightarrow\ M_s = 95\ tsf$

<u>Medium dense sand:</u>

Assuming $\nu_s = 0.25$ and $E_s = 150\ tsf \quad \rightarrow\ M_s = 180\ tsf$

For settlement in Cell 5 the following hand calculations were completed:

$$H = 89\ feet$$

$$Q = (\Upsilon * H) * (B * L) = (95 * 89) * (300 * 900) = 1{,}141{,}425\ tons$$

$$\Delta\sigma \quad = \frac{Q}{(B + Z)(L + Z)} = \frac{1{,}141{,}425}{(300 + 3.5)(900 + 3.5)} = 4.16\ tsf$$

Where:
ϒ= fly ash unit weight (pcf)
H=maximum fly ash (waste) height (ft)
B=cell width (ft)
L=cell Length (ft)
Z=depth from the ground surface (ft)

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Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

Q= load at the ground surface (tons)

Using the 2:1 stress distribution method the increment of vertical effective stress will be:

- At 3.5 feet below the ground surface (bgs) at the middle of the 7-feet thick Medium Dense Sand (Fill): 4.16 tsf
- At 17 feet below the ground surface (bgs) at the middle of the 20-feet thick Loose Sand: 3.93 tsf
- At 40 feet bgs at the middle of the 40-feet thick Medium Dense Sand: 3.57 tsf
- At 90 feet bgs at the middle of the 100-feet thick Glacial Till: 2.96 tsf

$$S_e = \left(\frac{4.16}{180}\right) * 7 + \left(\frac{3.93}{95}\right) * 20 + \left(\frac{3.57}{180}\right) * 40 = 1.78\ feet$$

The primary consolidation of the slightly over-consolidated glacial till (OCR=3) can be calculated using the following equation (Reference 4):

$$S_c = \frac{C_r * H}{1 + e_0} \log\left(\frac{\sigma_o' + \Delta\sigma}{\sigma_o'}\right)$$

Where

σ'_o=initial vertical effective stress (psf)
C_r=recompression Index
e_0=void ratio
H=thickness of the layer (feet or inch)
S_c= primary consolidation settlement

In the middle of the glacial till layer:

$$\sigma_o' = 7 * 130 + 20 * 125 + 40 * 130 + 50 * 141 - 84 * 62.4 = 5.21\ tsf$$

$$S_c = \frac{0.023 * 100}{1 + 0.5} \log\left(\frac{5.21 + 2.96}{5.21}\right) = 0.3\ feet$$

Total settlement will be:

$$S = S_e + S_c = 2.08\ feet$$

Project No.:	19132873	Made by:	BB/AK
Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

3.0 RESULTS

The settlement analysis was primarily performed using Settle3D. Hand calculations were also performed to verify the computer model results. The settle 3D model results are summarized in Table 2 and the Settle 3D output for Cell 5 is shown on Figure 1.

Table 2.0 Settlement Calculation Results

Cell #	Length (ft)	Location	Subgrade Elevation (ft-amsl NGVD29)	Top of Waste Elevation (ft-amsl NGVD29)	Total Settlement (feet)	Design Slope	Post Settlement Slope
1	531	Center	609.38	700.41	1.97	0.25%	-0.05%
		Sump	608.05	623.00	0.35		
2	243	West End	610.82	700.21	1.93	0.28%	0.14%
		Transition	610.14	683.09	1.59		
4	682	Center	607.04	705.1	1.96	0.27%	0.12%
		Sump	605.2	649	0.91		
5	687	Center	616.5	705.1	2.10	1.50%	1.34%
		Sump	606.2	648.0	1.00		
6	691	Center	617.7	705.2	2.11	1.50%	1.34%
		Sump	607.3	648.0	1.00		
7	753	Center	622.8	704.4	2.09	1.50%	1.25%
		Sump	611.5	618.0	0.24		
8	651	Center	620.9	702.4	2.02	1.50%	1.23%
		Sump	611.1	618.0	0.23		
9	342	Center	615.3	695.7	1.86	1.50%	1.02%
		Sump	610.2	618.0	0.24		

Notes:

1. The pipe was evaluated at the center of the total length. The center location was used because the normal loading due to waste height is maximum at the center, resulting in the maximum settlement achieved for each pipe and each cell.

4.0 RESULTS AND CONCLUSIONS

4.1 Cells 5 through 9

Hand calculations performed for the center of proposed Cell 5 estimated a total settlement of 2.08 feet. Therefore, the total settlement of 2.10 feet (as calculated by Settle3D) is a reasonable expectation. This analysis indicates that loading from the ash in the proposed cells will cause approximately 1.86 to 2.11 feet

Project No.:	19132873	Made by:	BB/AK
Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

of total settlement at the center of the landfill and 0.23 to 1.0 feet of total settlement near the sump. Therefore, differential settlement ranging between 1.1 to 1.62 feet is anticipated. The minimum post settlement slope for Cells 5 through 9 was calculated to be 1.02%. This is greater than the minimum slope of 1.0% required by the design criteria, as stated in Section 1.0. Therefore, the design of the proposed pipe slope is adequate for post-settlement conditions.

4.2 Cells 1, 2, and 4

The analysis indicates that loading from the vertical expansion over the existing Cells 1, 2, and 4 will result in approximately 1.93 to 1.97 feet of total settlement at the center of the landfill and 0.35 to 1.59 feet of total settlement near the sump. Therefore, differential settlement ranging between 0.34 to 1.62 feet is anticipated. Cells 2 and 4 will maintain a positive slope in post-settlement conditions. However, the leachate collection pipes in Cell 1 are expected to have a negative to flat slope in post-settlement conditions. It is assumed that the pipes within Cells 1, 2, and 4 have already experienced the majority of this settlement as they are filled to final grades as of this permit submittal. To avoid new leachate from Cells 5 through 9 reporting to Cells 1 2, or 4, an overliner will be included with this vertical expansion design. A 12-inch sand or bottom ash layer will be placed along the existing sideslopes of Cells 1, 2, and 4 which will direct leachate to the new Cells 6 through Cell 9 leachate collection system. This would resolve the potential leachate collection issues from Cell 1, 2, or 4 in post-settlement conditions.

5.0 ATTACHMENTS

Figure 1 – Settlement Points Plan
Attachment 1 – Settle 3D Output

6.0 REFERENCES

1. Engineering and Environmental Solutions (EES), LLC. December 2012. Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation -2012. J.H. Campbell Solid Waste Disposal Area.

2. National Cooperative Highway Research Program, 1999, “NCHRP Measuring In Situ Mechanical Properties of Pavement Subgrade Soils”.

3. Qian, X., Koerner, R. M., and Gray, D. H., (2002). Geotechnical Aspects of Landfill Design and Construction. Prentice-Hall, Inc., New Jersey.

4. Das, B.M., 2014, “Principle of Geotechnical Engineering”.

Project No.:	19132873	Made by:	BB/AK
Site Name:	JH Campbell Dry Ash Landfill	Checked by:	DJS
Date:	January 18, 2021	Reviewed by:	TDJ

5. Bowles, J.E., 1996, “Foundation Analysis and Design”.

SIGNATURE
NAME
MICHIGAN P.E. No.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

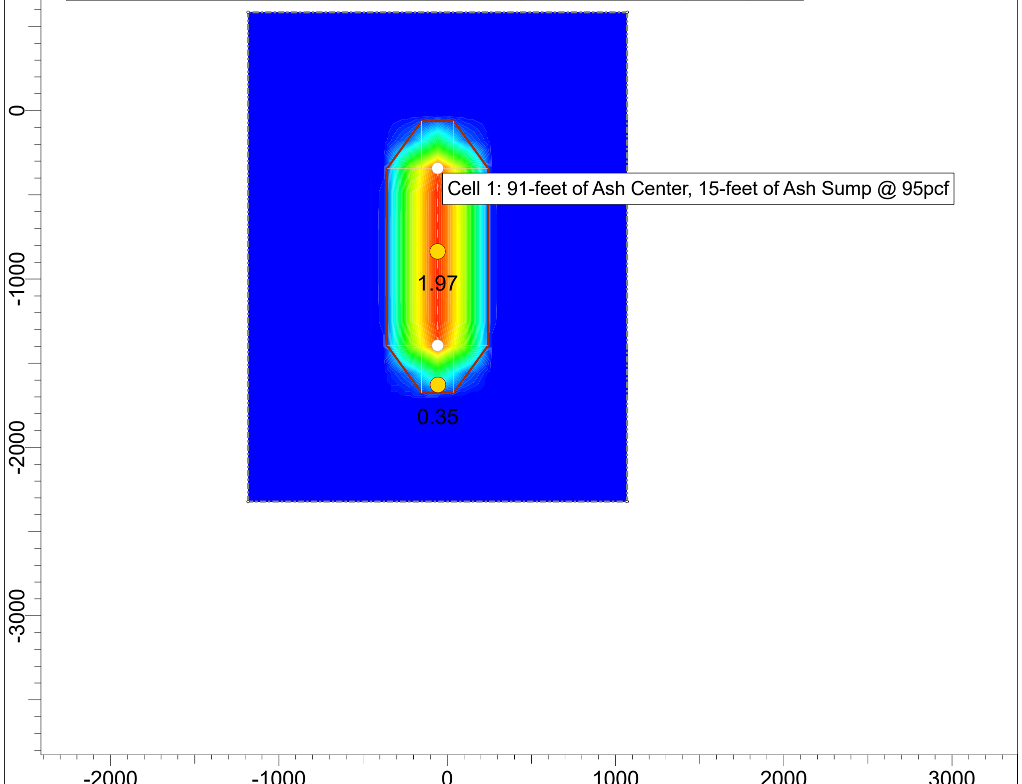
Consumers Energy

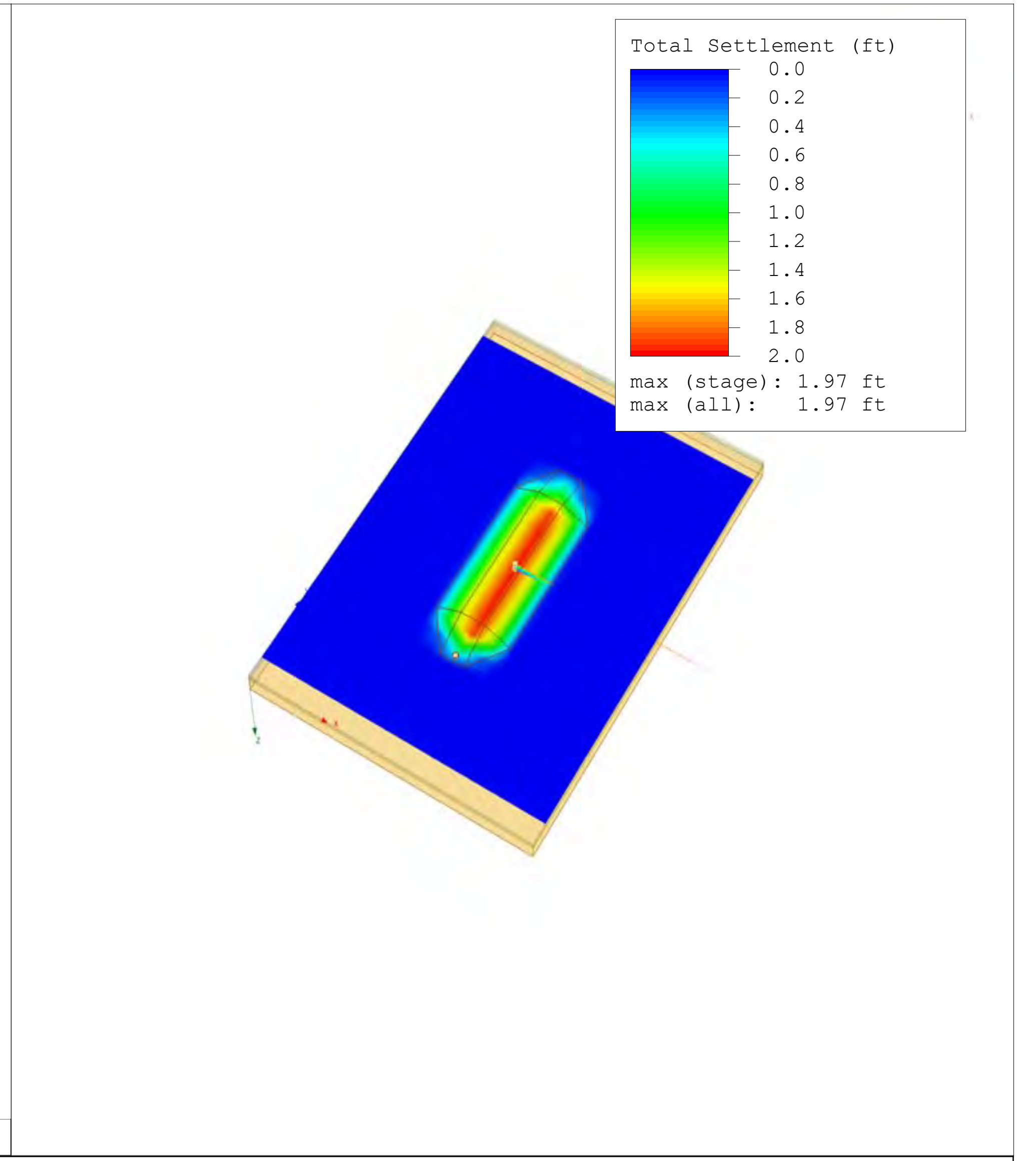
J.H. CAMPBELL PLANT
WEST OLIVE, MI

FIGURE 1
SETTLEMENT POINTS PLAN

SCALE: 1" = 100'
JOB:
DRAWING NO.
FIGURE
REV.

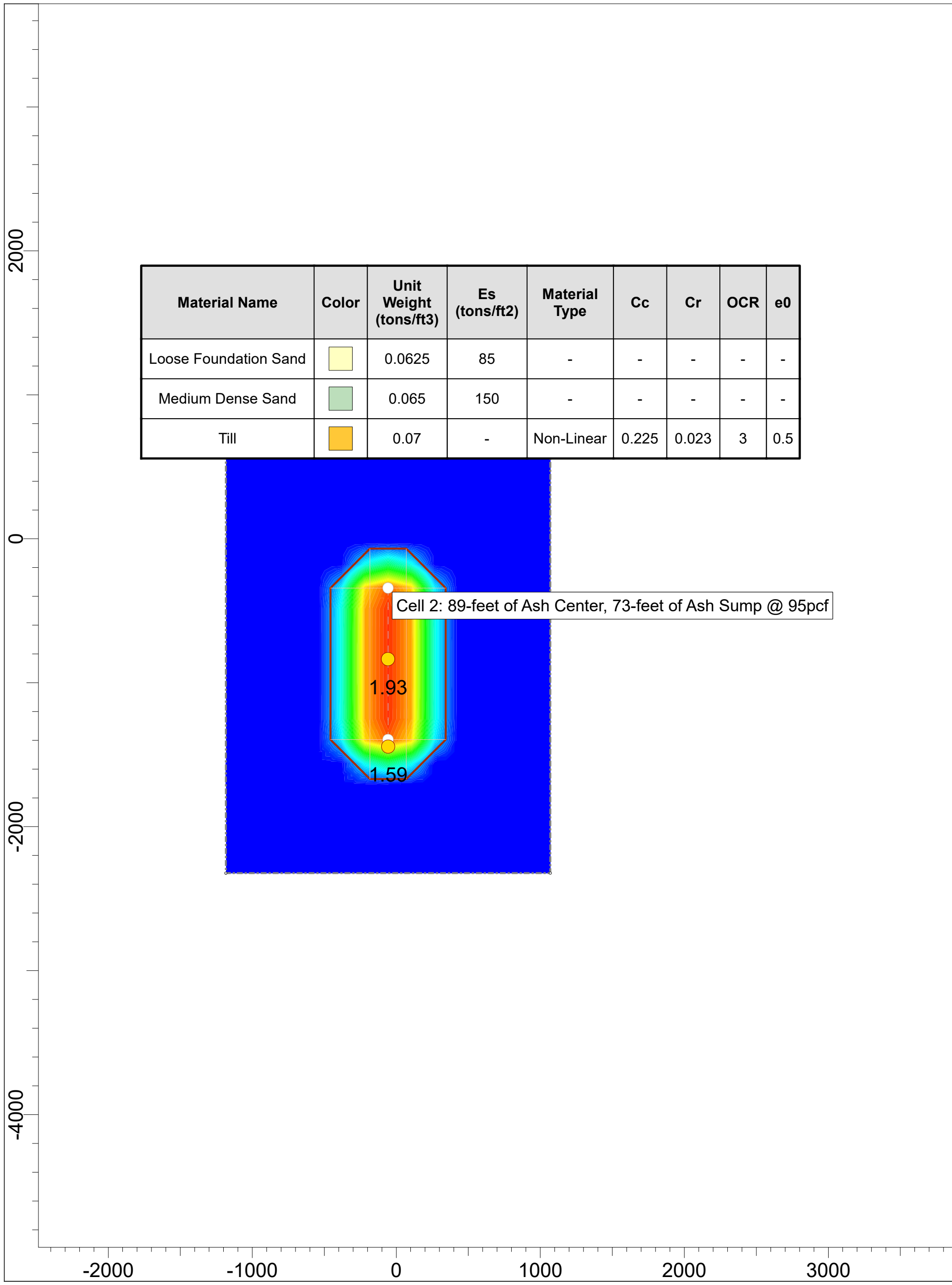
Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR
Loose Foundation Sand		0.0625	85	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3

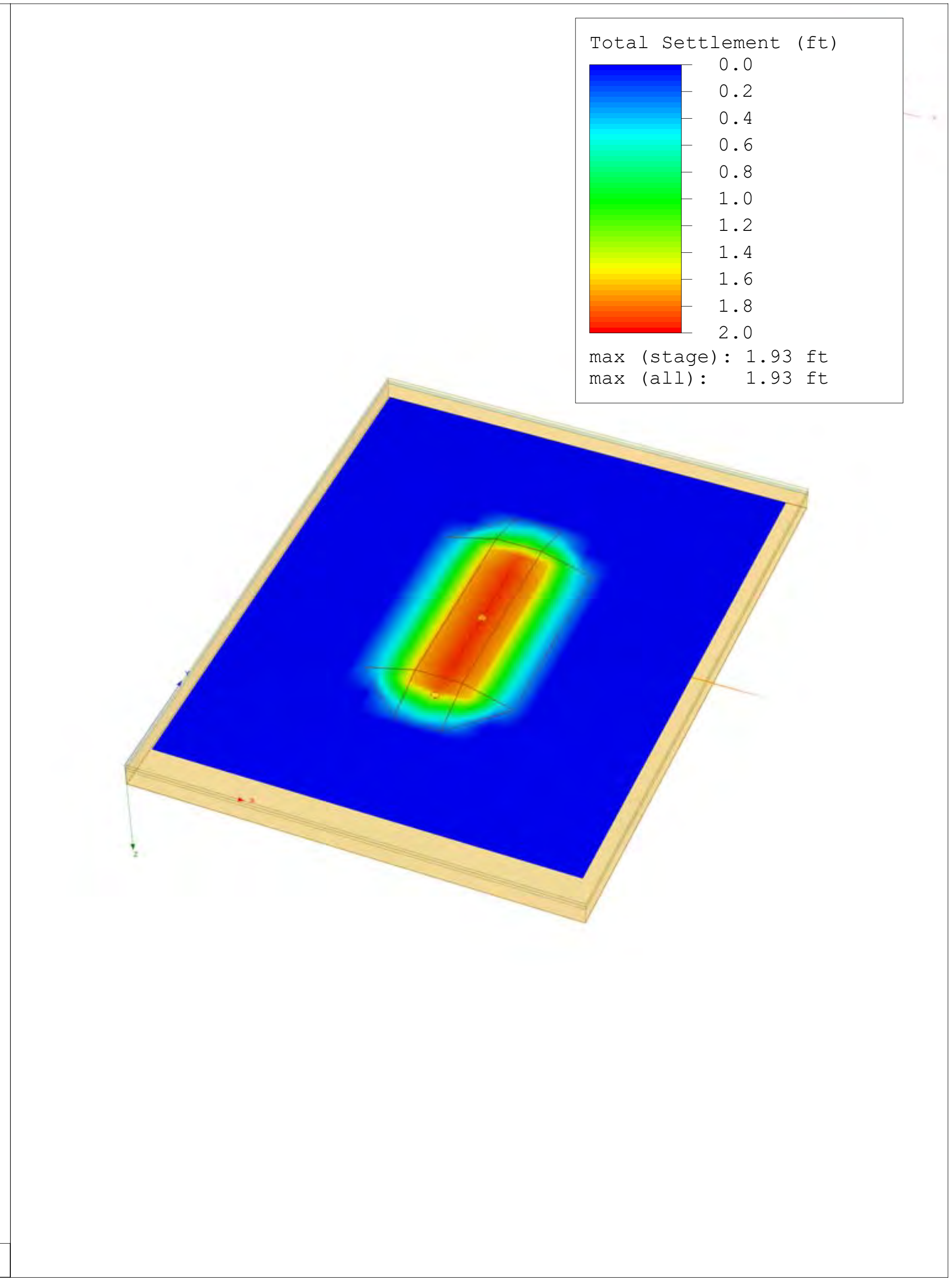




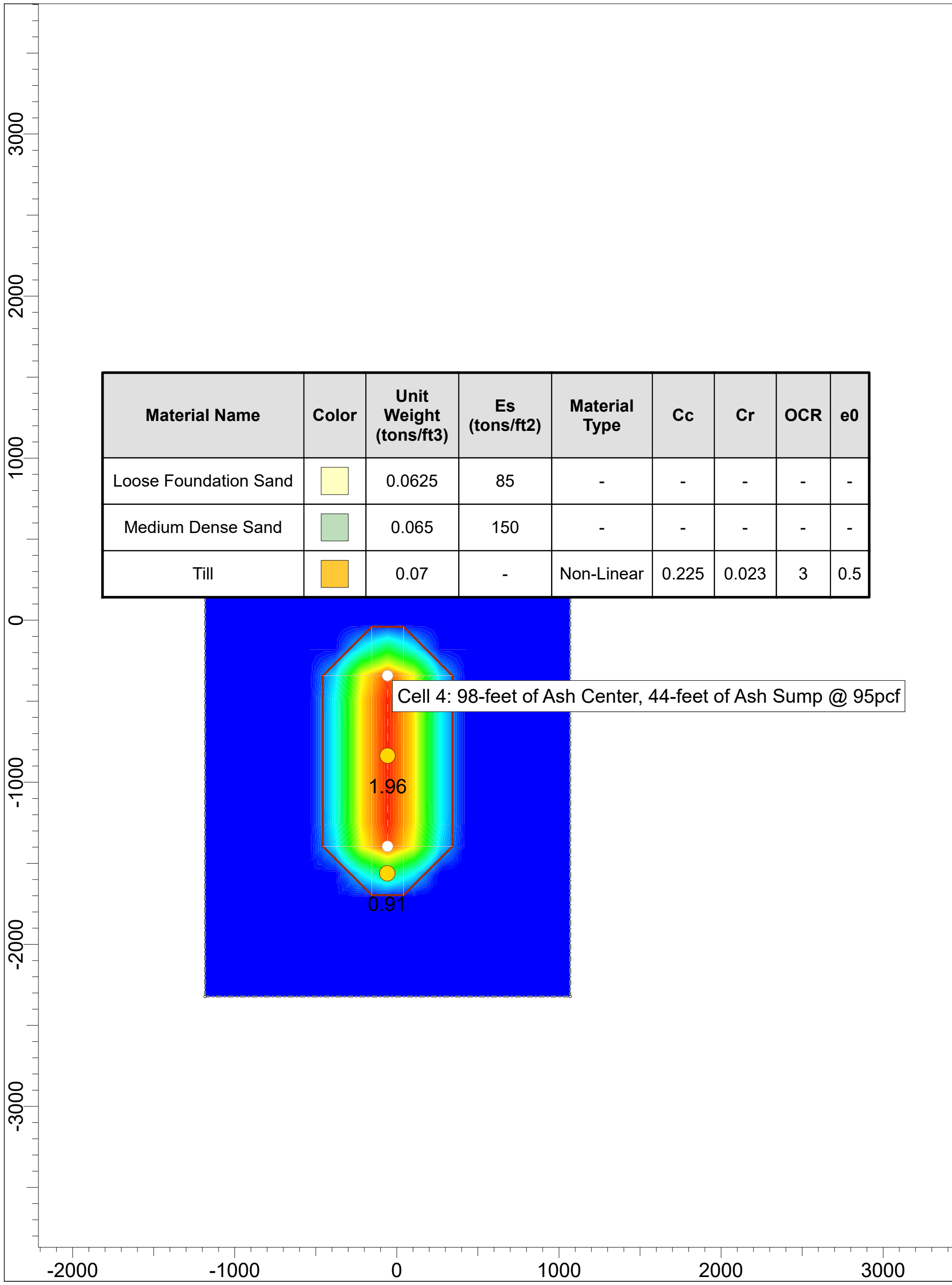
JHC Settlement Cell 1

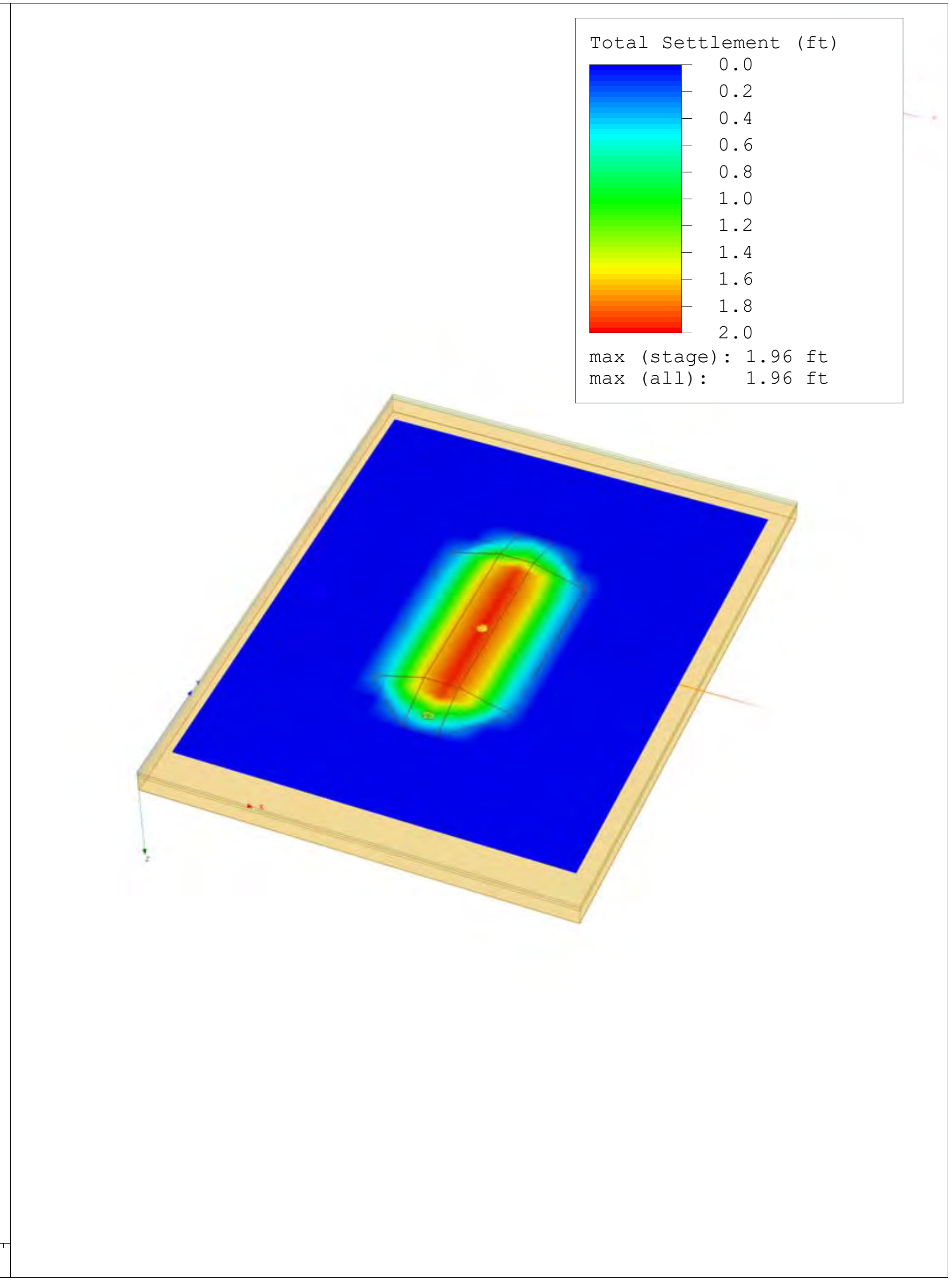
Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5

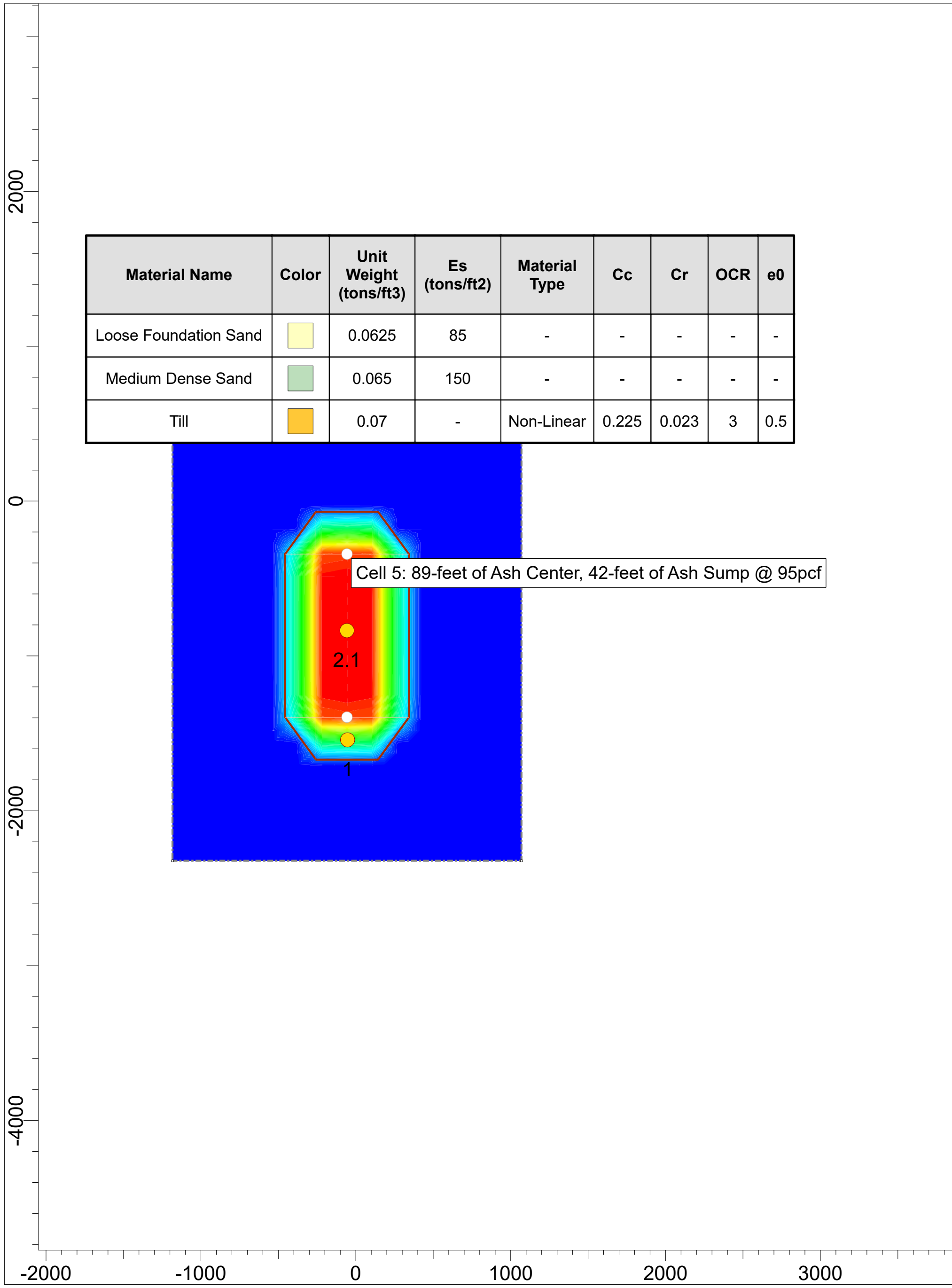




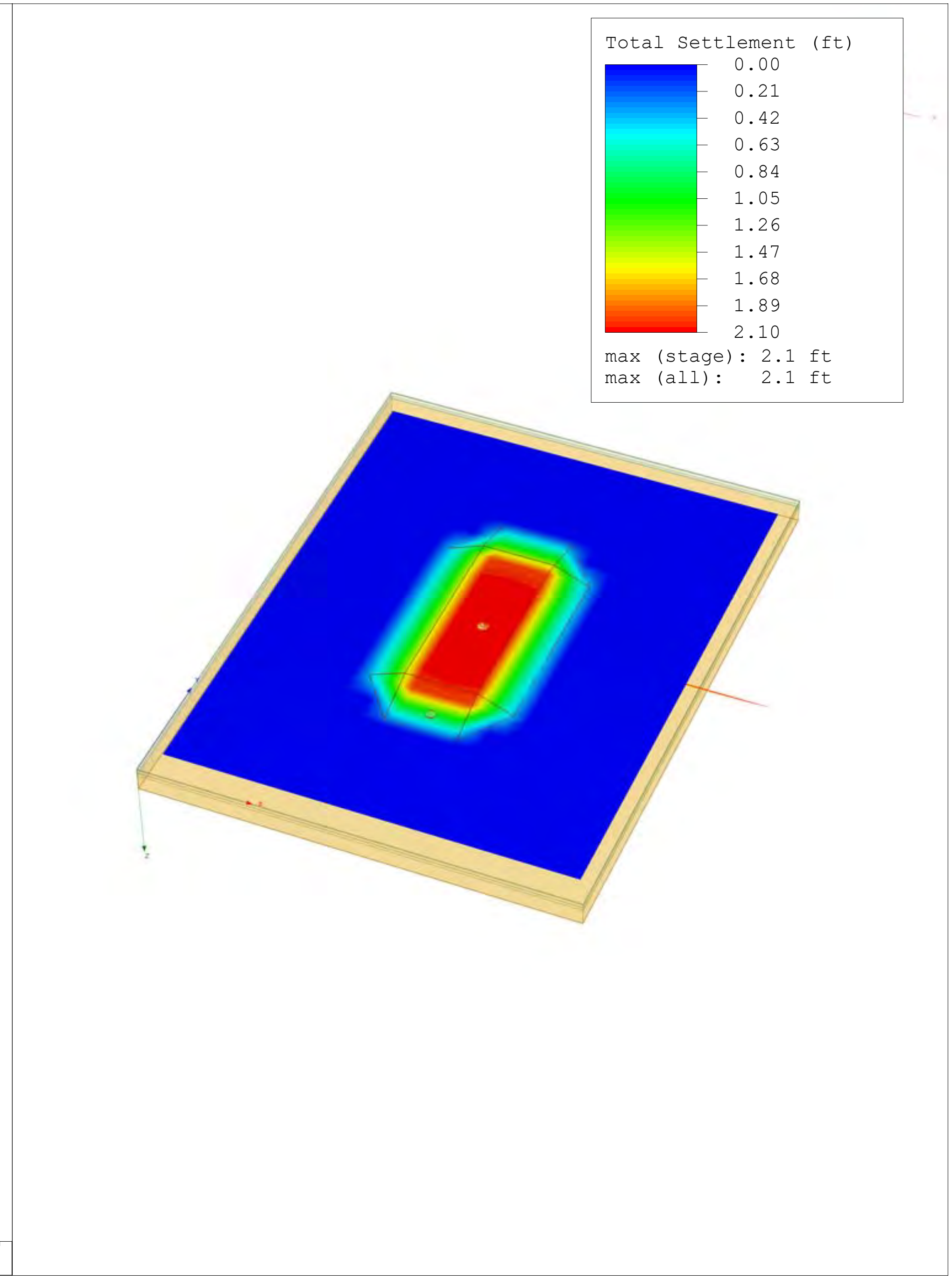
Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5



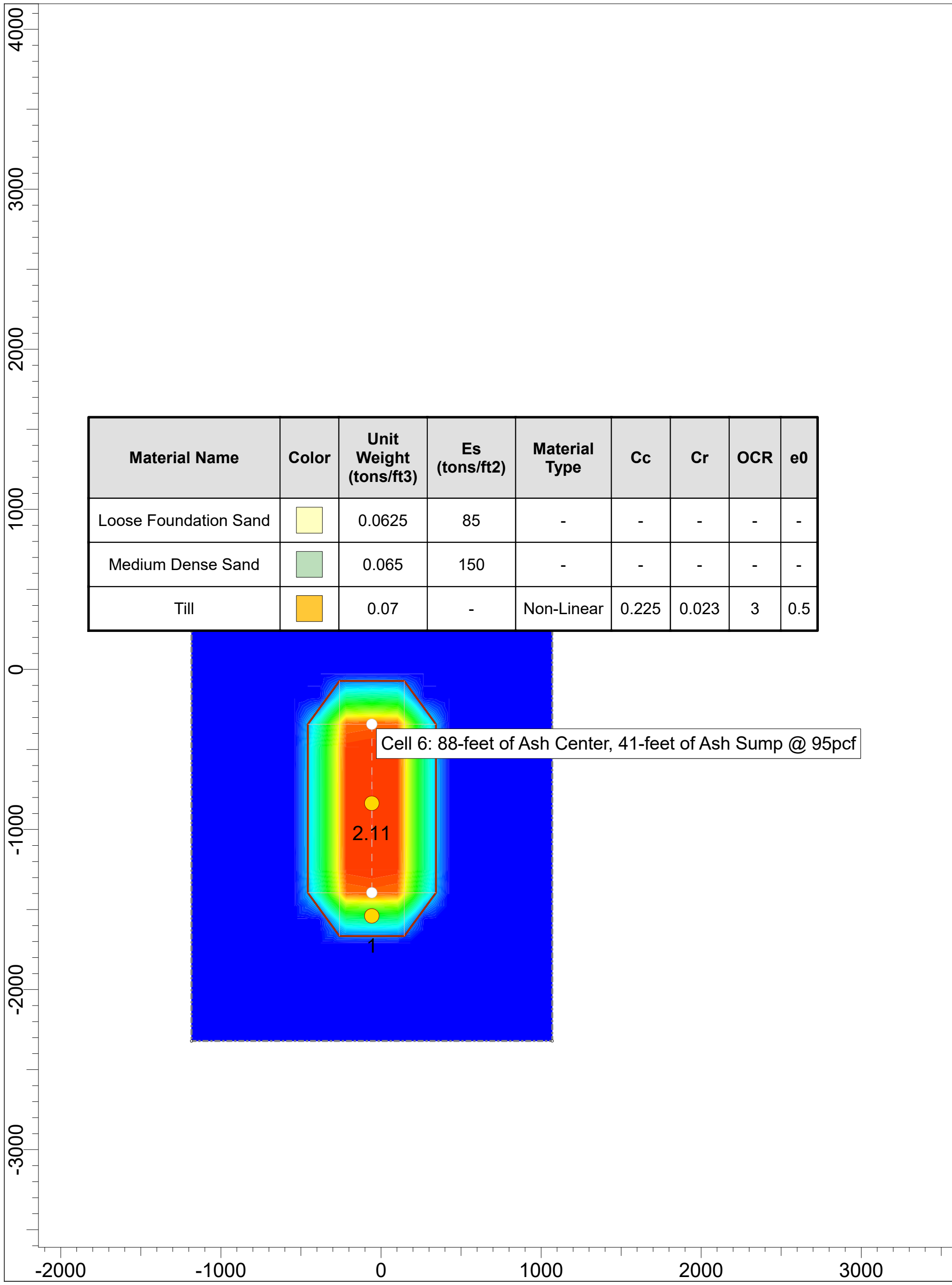


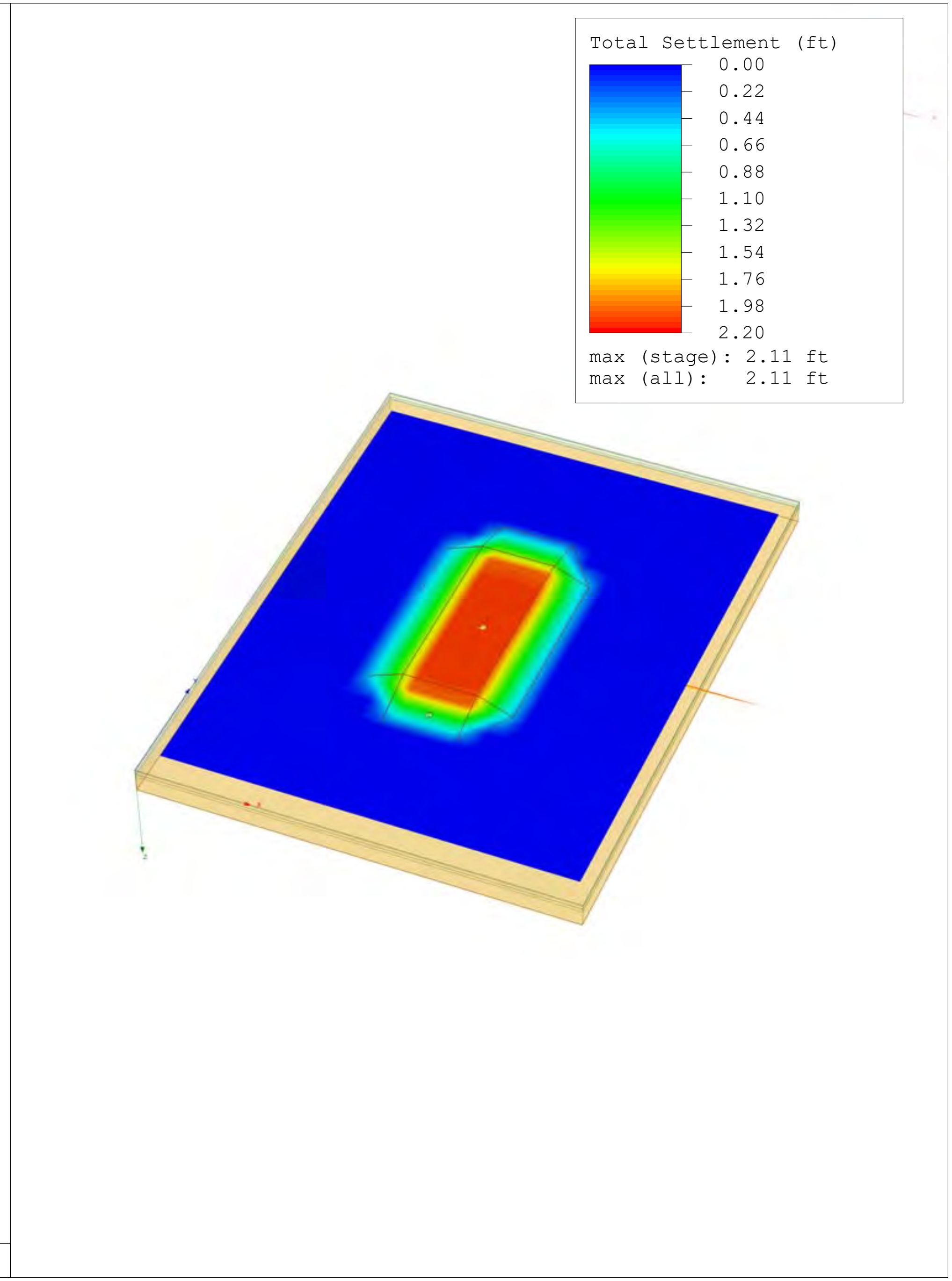


Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5

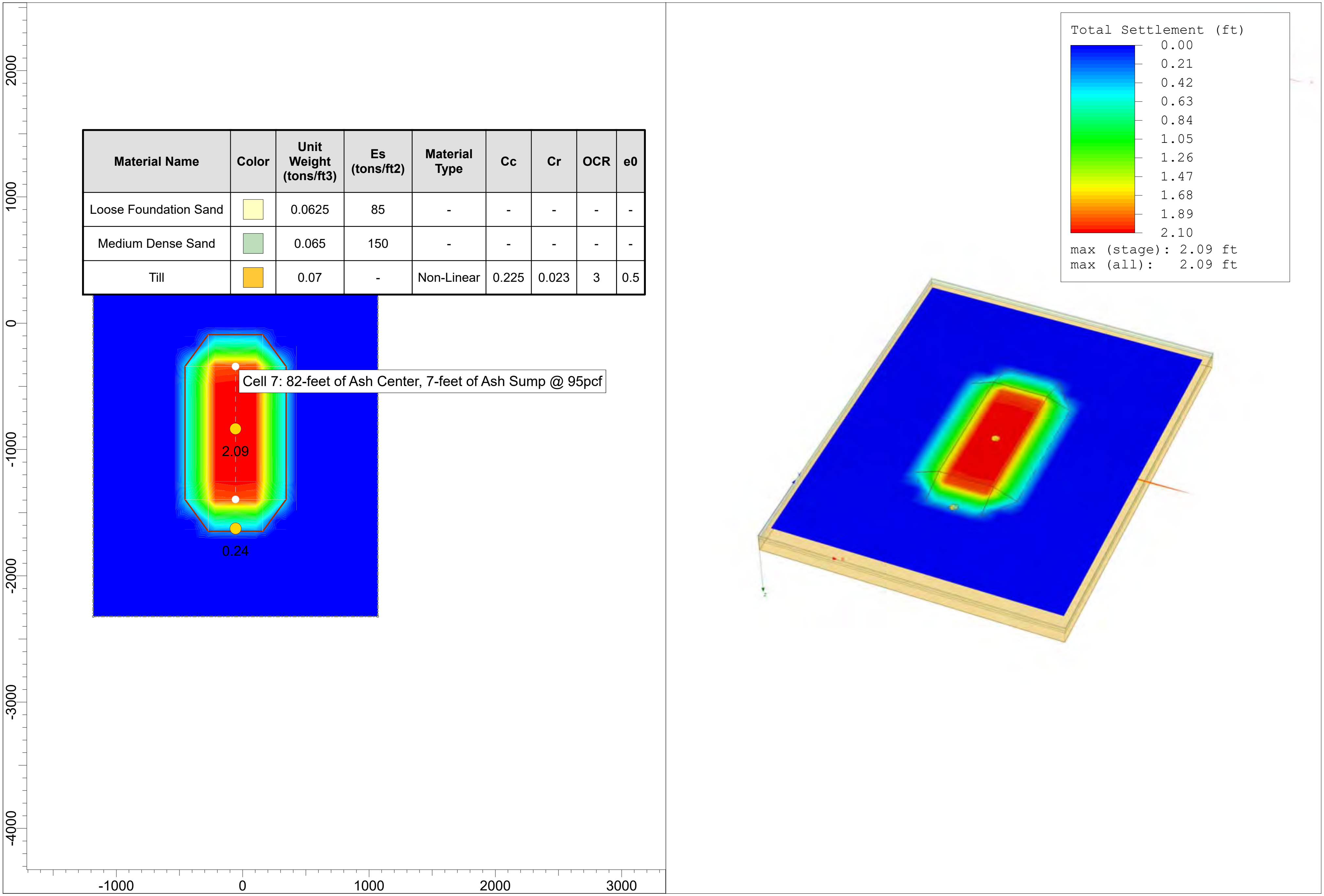


Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5

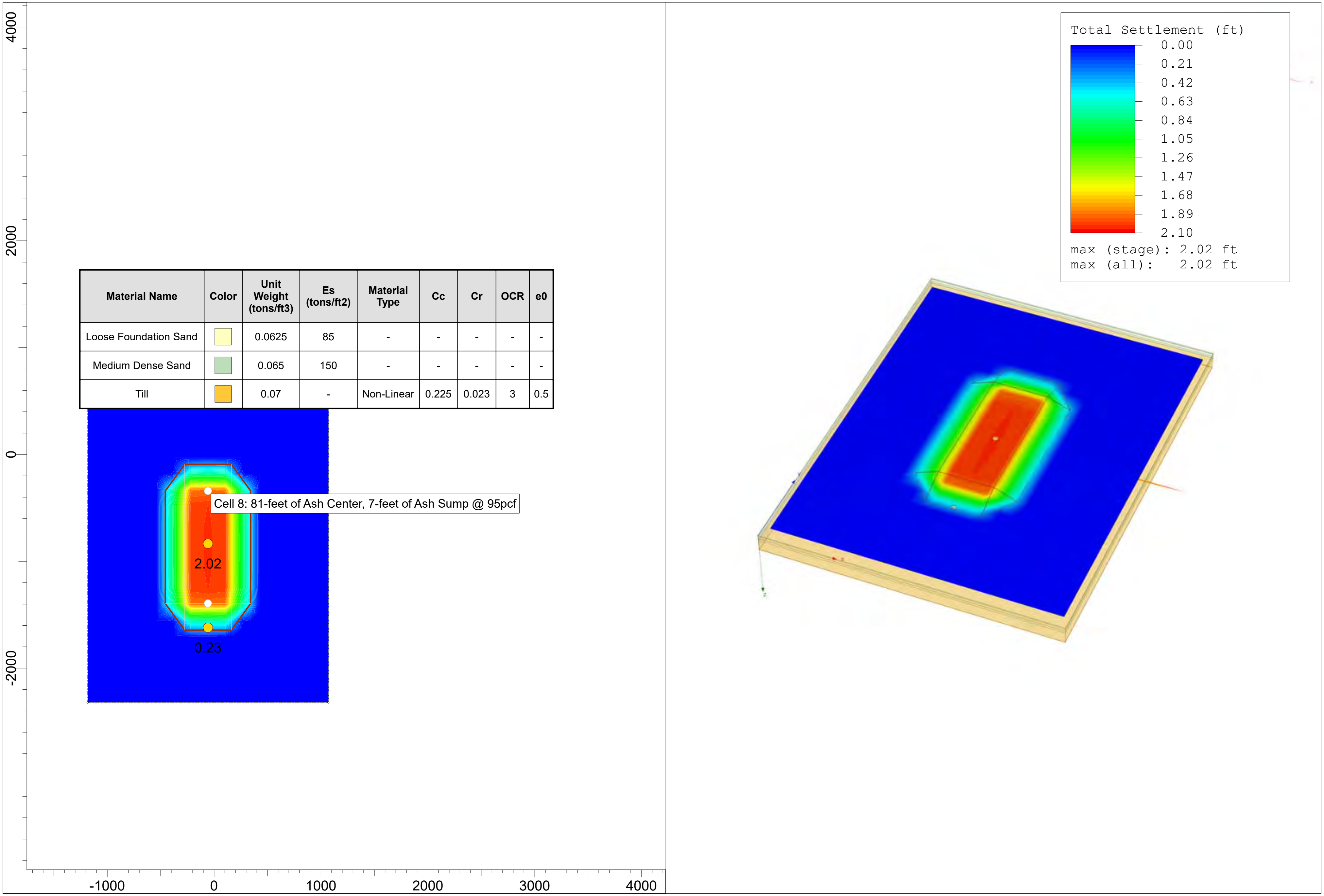




JHC Settlement Cell 6



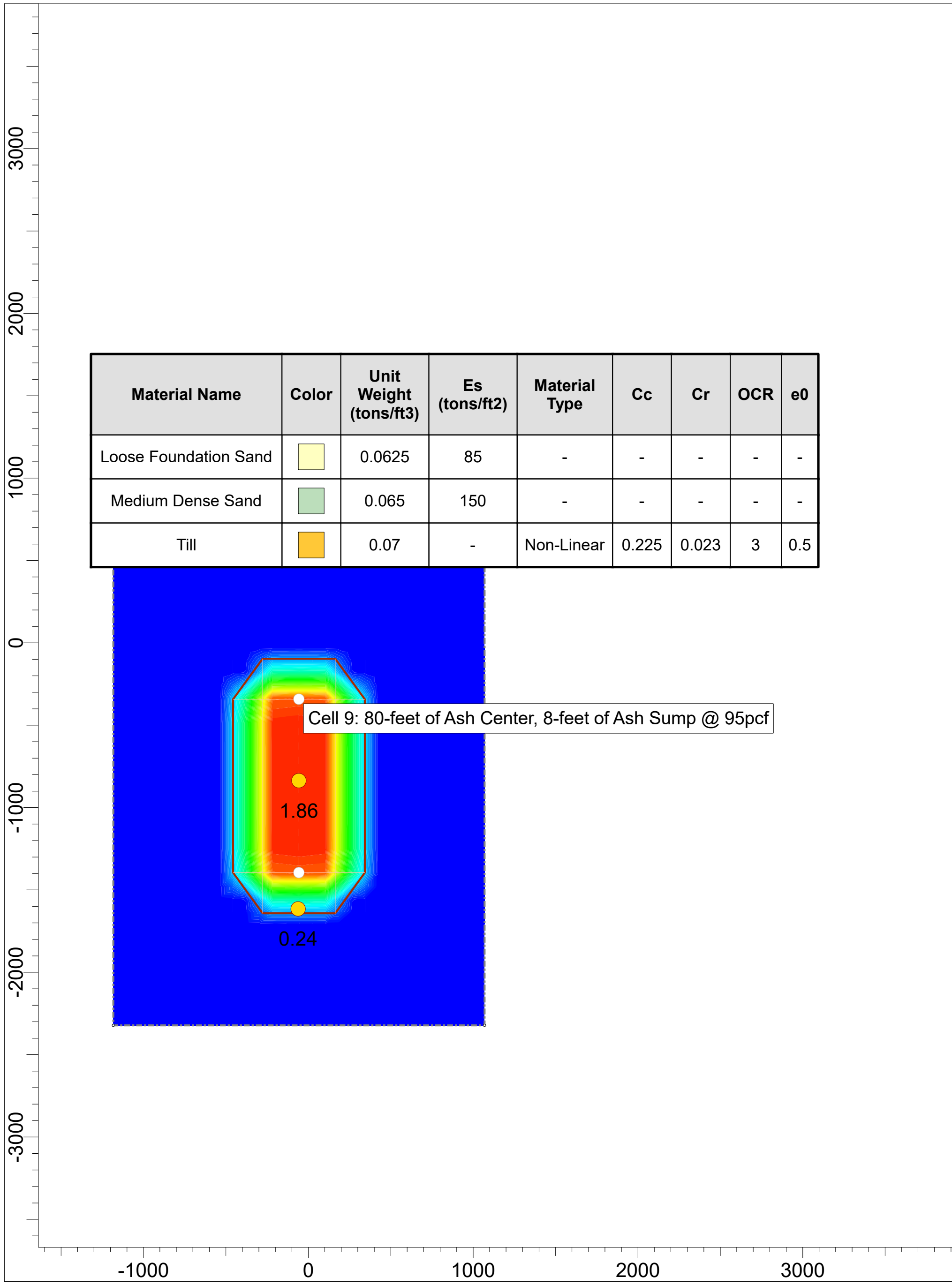
Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5

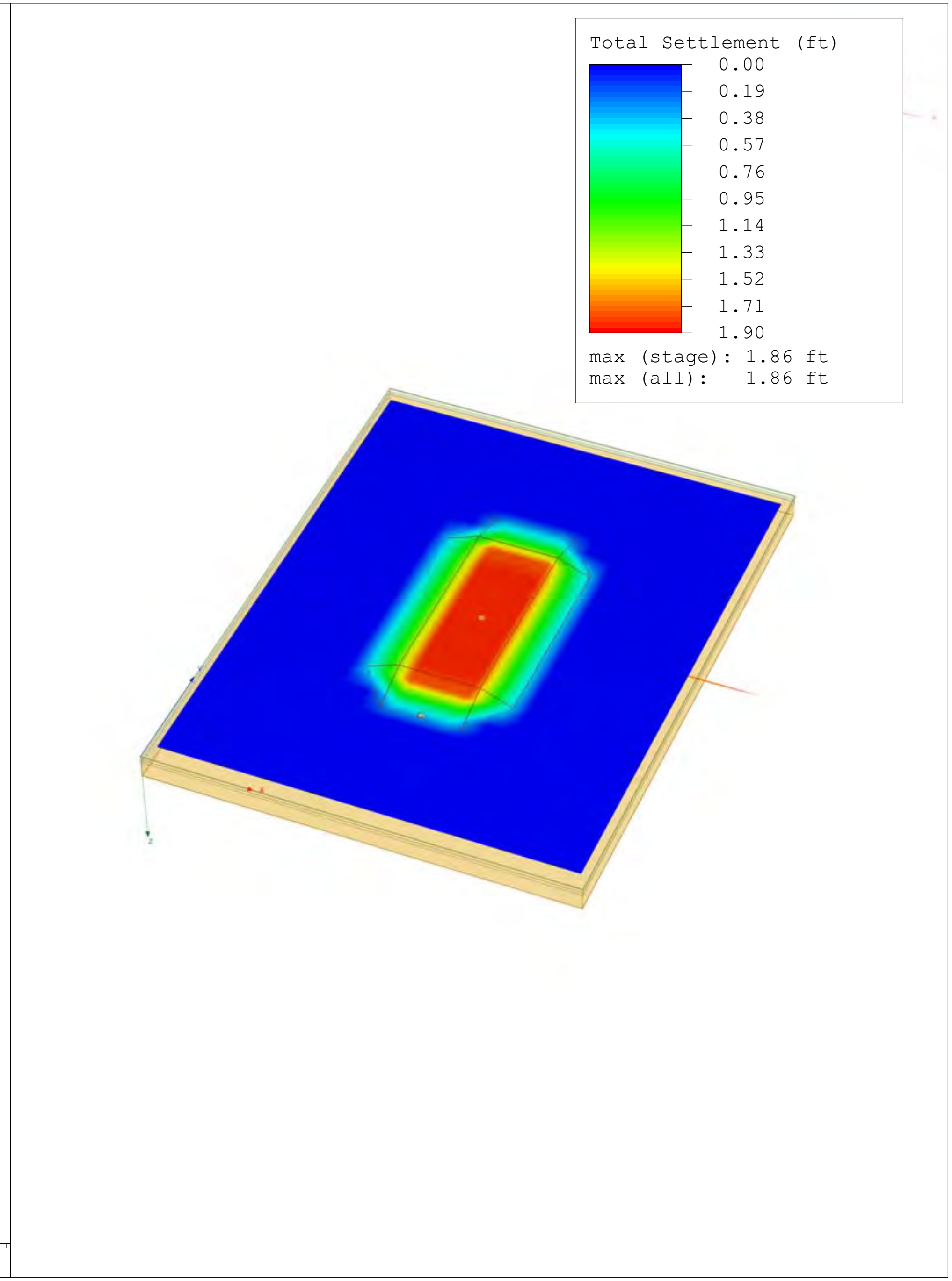


Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5

JHC Settlement Cell 8

Material Name	Color	Unit Weight (tons/ft3)	Es (tons/ft2)	Material Type	Cc	Cr	OCR	e0
Loose Foundation Sand		0.0625	85	-	-	-	-	-
Medium Dense Sand		0.065	150	-	-	-	-	-
Till		0.07	-	Non-Linear	0.225	0.023	3	0.5





APPENDIX D

Veneer Slope Stability Calculations

CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	ANCHOR TRENCH STABILITY	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

1.0 OBJECTIVE

Evaluate anchor trench stability under static condition and seismic loading, for the following situation:

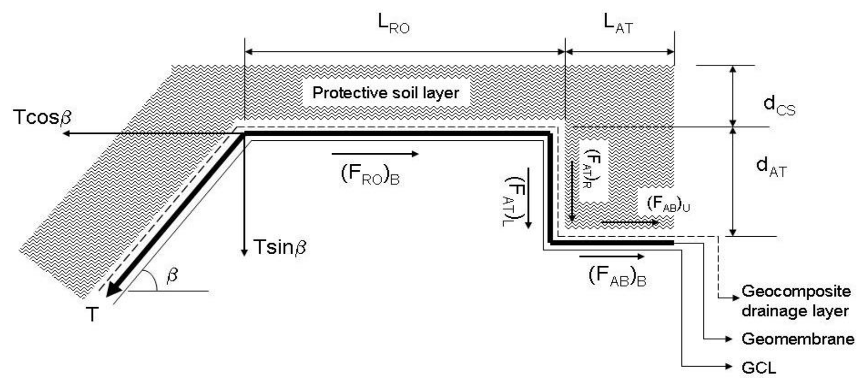
Placement of geosynthetics on the slope and the anchor trench is backfilled with 2-feet of soil and 2-feet of cover soil at the crest to protect the anchor trench.

2.0 METHOD

Determine the tensile force able to be held by the anchor trench due to the weight of the soil backfilled over the liner in the trench and the resultant frictional resistance to pullout.
The anchor trench design should allow pullout of the geomembrane before tension failure. Thus, the design anchor resistance capacity should fall between the ultimate strength and the allowable strength of the geosynthetic liner (Qian et al, 2002). That is,

Ultimate Strength > **Anchor Resistance Capacity** > Allowable Strength

GEOMETRY:
The following figure shows an illustrative design for a geomembrane in a L-shaped rectangular anchor trench.



Note: Drawing not in scale.

Legend:
T = geomembrane tensile force
L_{RO} = runout length
L_{AT} = anchor trench width
d_{CS} = depth of cover soil
d_{AT} = anchor trench depth

$(F_{RO})_B$ = friction force beneath runout geomembrane
$(F_{AT})_L$ = friction force between the left side of the geomembrane and the side wall of the anchor trench
$(F_{AT})_R$ = friction force between the right side of the geomembrane and the side wall of the anchor trench
$(F_{AB})_B$ = friction force between the geomembrane and the underlying soil at the bottom of the anchor trench
$(F_{AB})_U$ = friction force between the geomembrane and the overlying soil at the bottom of the anchor trench

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	ANCHOR TRENCH STABILITY	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

2.0 METHOD CONT.

Anchor resistance capacity = T / t

Where,

T = geomembrane tensile force (i.e., anchor trench resistance force) per unit width; and
t = geomembrane thickness.

Under Static Conditions:

According to Qian et.al (2002), the tensile force for a geomembrane in a L-shaped rectangular anchor trench design can be estimated applying the following equations:

$$T = \frac{q_B \times L_{RO} \times \tan \delta c + [K_o \times (\sigma v)_{ave} \times d_{AT} + \sigma_{vB} \times L_{AT}] \times (\tan \delta c + \tan \delta_F)}{\cos\beta - \sin\beta \times \tan \delta c}$$

$q_B = \gamma s \times d_{CS}$

$K_o = 1 - \sin\phi$

$(\sigma_h)_{ave} = K_o \times (\sigma_v)_{ave}$

$(\sigma_v)_{ave} = \gamma s \times (d_{CS} + 0.5 d_{AT})$

$\sigma_{vB} = \gamma s \times (d_{CS} + d_{AT})$

Where,

T = geomembrane tensile force (i.e., anchor trench resistance force) per unit width;
q_B = cover soil pressure on the runout length;
L_{RO} = runout length;
L_{AT} = anchor trench width;
d_{CS} = depth of cover soil;
d_{AT} = anchor trench depth;
δc = friction angle between the geomembrane and the underlying soil;
δ_F = friction angle between the geomembrane and the backfill soil;
ϕ = friction angle of the backfill soil in anchor trench;
K_o = coefficient of at-rest earth pressure;
β = side slope angle; and
σ_v = vertical stress in anchor trench.

Considering Seismic Forces:

$$T = \frac{q_B * L_{RO} * \tan \delta c + [K_o * (\sigma v)_{ave} * d_{AT} + \sigma_{vB} * L_{AT}] * (\tan \delta c + \tan \delta_F)}{\cos\beta - \sin\beta \times \tan \delta c} - \text{Seismic Forces}$$

Seismic Forces = $Cs * \gamma\,(d_{AT} + d_{CS})$

Where,

Cs = seismic coefficient.

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	ANCHOR TRENCH STABILITY	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

3.0 CALCULATIONS

1) 60 mil Textured HDPE Geomembrane in anchor trench:

Geomembrane thickness, t = 0.06 in

Ultimate strength (at yield) = 126 lb/in = 2100 lb/in^2

Factor of safety for geomembrane against tension response = 3

The allowable stress, σ_{allow} = the ultimate strength / FS

$$\sigma_{allow} = \frac{2100}{3}$$

σ_{allow} = 700 lb/in^2

2) The side slope angle (β), measured from the horizontal 3H:1V = 18.43 degrees

3) The runout length, L_{RO} (ft) = 3

4) Anchor trench depth, d_{AT} (ft) = 2 See Detail 3 on Engineering Drawing Sheet 500-4

5) Anchor trench width, L_{AT} (ft) = 2

6) Dry unit weight of protective soil, γs(pcf) = 130

7) Friction angles (see attached Table 1- Global material properties):

Interface	Symbol	Friction angle, degrees
Protective Sand	ϕ	32
60-mil TGM vs. GCL	δc	23
GCL vs. GC	δF	20

8) Ko = coefficient of at-rest earth pressure = 1-sin ϕ = 1 - sin (32°) = 0.47

9) Depth of cover soil,

d_{CS} (ft) = 2

10) Cover soil pressure on the runout length, q_B (psf) = γs x d_{CS} =

q_B (psf) = 260

note: the weight of the drainage geocomposite is considered negligible.

11) Average vertical stress in anchor trench, $(\sigma v)_{ave} = \gamma \times H_{ave}$

H_{ave} (ft) = the average depth of anchor trench = dcs + (d_{AT}/2)

H_{ave} (ft) = 3

$(\sigma_v)_{ave}$ = 390 lb/ft^2

CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	ANCHOR TRENCH STABILITY	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

3.0 CALCULATIONS CONT.

12) The vertical stress acting at the bottom of anchor trench(σ_{vB}), which is caused by filling soil weight.

σ_{vB} (lb/ft^2) = γs * (d_{CS} + d_{AT}) = 520 lb/ft^2

13) The horizontal acceleration for a 2% in 50 years probability (from USGS) is ~ 0.0394 (See Table 1)

The geomembrane tensile force:

I - Under Static Conditions

T = 1768.13 lb/ft = 147.3 lb/in

So, **anchor resistance capacity** = T / t = 2,455.73 lb/in^2

Ultimate Strength > **Anchor Resistance Capacity** > Allowable Strength

2,100 lb/in^2 > 2,455.73 lb/in^2 > 700 lb/in^2

FS = 3.5

II - Considering Seismic Forces

Seismic Forces = Cs * γ (d_{AT} + d_{CS}) = 20.49 lb/ft Cs = 0.039 g

T = 1747.64 lb/ft = 145.64 lb/in

So, **anchor resistance capacity** = T / t = 2,427.28 lb/in^2

Ultimate Strength > **Anchor Resistance Capacity** > Allowable Strength

2,100 lb/in^2 > 2,427.28 lb/in^2 > 700 lb/in^2

FS = 3.5

The results indicate the design anchor resistance capacity under static conditions and considering seismic forces fall between the yield stress and the allowable stress of a geomembrane. Therefore, the anchor trench dimensions are acceptable.

4.0 CONCLUSION

The results indicate a factor of safety of 3.5 under static conditions and a factor of safety of 3.5 considering seismic forces. Therefore, the anchor trench dimensions are acceptable with factors. of safety $\geq$ 1.5.

5.0 REFERENCES

1) Qian, X., Koerner, R. M., and Gray, D. H., (2002). Geotechnical Aspects of Landfill Design and Construction. Prentice-Hall, Inc., New Jersey, pg 104-118.

2.) USGS, Beta version of the U.S. Seismic Design Maps application, 2015

3) GSE, Textured Geomembrane Specifications, 2013.

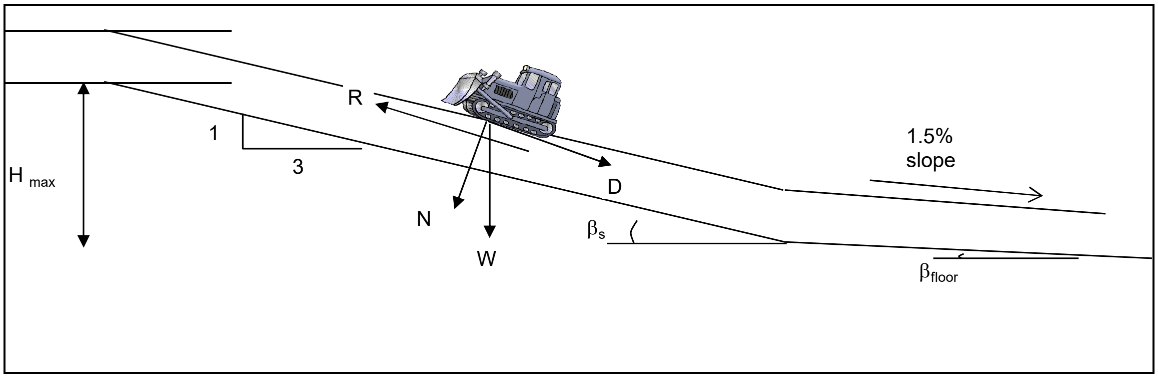
CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	SOIL DRAINAGE/PROTECTION LAYER STABILITY ON 3H:1V SLOPE WITH EQUIPMENT FORCES	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

1.0 OBJECTIVE

To analyze the stability of the 24-inch thick sand layer for the designed side slopes at the J.H. Campbell Landfill.

2.0 GEOMETRY



2.0 ASSUMPTIONS/GIVENS

1.) The proposed sideslope liner system consists of (from top to bottom):
<u>JHC Landfill</u>
2-foot thick soil drainage layer
Primary textured 60-mil HDPE geomembrane (TGM)
****Primary GCL**
****Secondary Geocomposite Double Sided**
Secondary 60-mil HDPE TGM
Subgrade **** Critical interface friction angle = 17 degrees**

2.) Material Properties:

Material Properties used for the analysis are shown on TABLE 1 in the Permit Upgrade Report.

3.0 METHODS:

1.) **Use method outlined in R.M. Koerner and T. Soong's method, Reference 2. Please see Figure 1 for Equations and Parameter definitions for the calculations performed below.**

2.) Allow a minimum interim factor of safety of 1.3, when saturated conditions are considered, and peak interface friction angles are used. Calculate the maximum safe slope length to place sand for each condition.

3.) Interface friction angles were taken as averages of representative lab data for similar materials, peak strengths. (These friction angels are conservative and for design purposes, the owner may choose to purchase materials with interface friction angles greater than those used in the design.)

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	SOIL DRAINAGE/PROTECTION LAYER STABILITY ON 3H:1V SLOPE WITH EQUIPMENT FORCES	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

4.0 CALCULATIONS:

STATIC CONDITIONS

1.) Calculate Factor of Safety using Koerner's Method for soil slope stability with equipment loads.

Uniform Soil Thickness
with the Incorporation of Equipment Loads

thickness of drainage layer =	h =	2	ft				
	β =	18.43	degrees	Slope = 3H : 1V			
length of slope measured along the geosynthetics =	L =	20	ft - maximum sand to place at once				
weighted unit wt. of drainage layer =	γ_t =	130	pcf	Assume saturated conditions			
min. friction angle of drainage layer =	ϕ =	32	degrees				
min. cohesion of drainage layer =	c =	0	psf		C =	0	lb
min. interface frict. =	δ =	20	degrees				
min. interface adhesion =	ca =	0	psf		Ca =	0.00	lb

From CAT Handbook		(Ref 3)	
D6 LGP Track- type tractor	39,985	lb	
Track	128	inches long	
	104	inches wide	

				Force from the Dozer - Ref 4
thickness of drainage layer =	h =	2	ft	b/h= 4.3
equipment ground pressure (=wt. of equip./(2*w*b)) =	q =	216	psf	We = q*w*I = 2306.8
length of equipment track =	w =	10.67	ft	Ne = Wecosb = 2188.5
width of equipment track (track influence) =	b =	8.67	ft	Fe=We*a/g*I= 161.5
influence factor at FML interface =	I =	1	from Ref. 1	
acceleration of bulldozer =	a =	0.07	g	Assume Cat D6T Track dozer accelerating to 3 mph in approx. 2 sec. (accel. = 0.07 g)

W_A	3552.91	lb	See Figure 1
N_A	3370.68	lb	
W_p	866.87	lb	

a	1910.71	
b	-2859.15	(Ref 2)
c	399.72	

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

FS	**1.3**

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	SOIL DRAINAGE/PROTECTION LAYER STABILITY ON 3H:1V SLOPE WITH EQUIPMENT FORCES	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

4.0 CALCULATIONS CONT.:

2.) Calculate Factor of Safety using Koerner's Method for soil slope stability with wet conditions (i.e. water on the liner); (See attached Figure 1).

Uniform Cover Soil Thickness
Seepage Forces with Parallel-to-Slope Buildup

thickness of drainage layer =	h =	2	ft	
	β =	18.43	degrees	Slope = 4H : 1V
length of slope measured along the geosynthetics =	L =	20	ft - maximum sand to place at once	
vertical height of slope measured from toe =	H =	*6.3*	ft	
depth of water over FML =	h_w =	0.50	ft	(Assume GC 200-mil)
parallel submergence ratio =	*PSR* =	*0.3*		*PSR* = depth of water on FML / thickness of cover soil
weighted unit wt. of drainage layer =	γ_d =	115	pcf	
saturated unit wt. of drainage layer =	γ_{sat} =	130	pcf	
unit wt. of water =	γ_w =	62.4	pcf	
min. friction angle of drainage layer =	ϕ =	32	degrees	
min. interface frict. =	δ =	20	degrees peak	

W_A	4030.25	lb
Un	567.32	lb
Uh	7.80	lb
N_A	3258.68	lb
W_p	773.09	lb
Uv	23.41	lb

See Figure 1

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a	1209.58
b	-1843.93
c	234.31

(Ref 2)

FS	**1.4**

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	AK
Subject:	SOIL DRAINAGE/PROTECTION LAYER STABILITY ON 3H:1V SLOPE WITH EQUIPMENT FORCES	**Reviewed by:**	DML
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

5.0 RESULTS:

	STATIC CONDITION	
	F.S	**Max. Slope Length**
3H:1V Soil Slope w/ Equip. Loads-------	**1.3**	20
3H:1V Soil Slope w/ 6-inches of head--------	**1.4**	20

6.0 CONCLUSIONS:

As the results show, the maximum slope length is governed by the factor of safety for the side slope stability. To maintain a reasonable factor of safety, the maximum slope length for the placement of granular drainage material is 20-ft along the slope. Also, the slope will be stable under seepage conditions for the greatest slope length design of 20-feet.

7.0 REFERENCES:

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

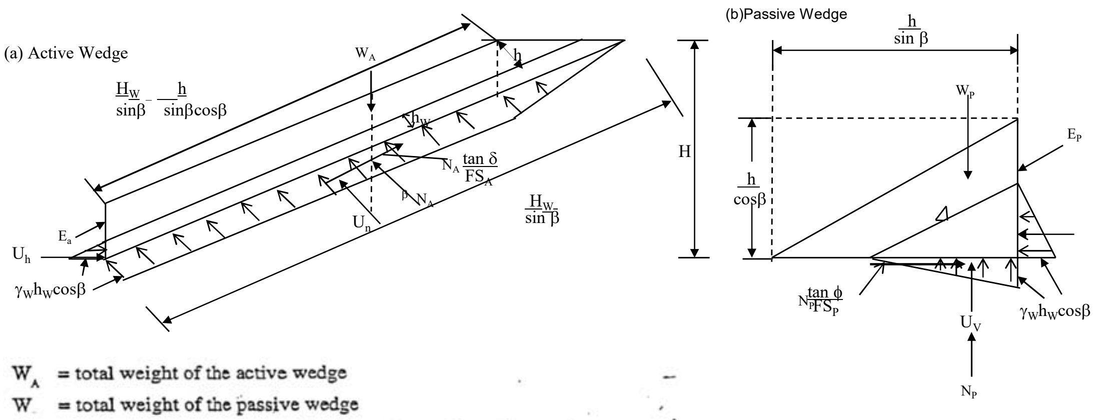
3.) Table 1 Global Material Properties contained in this report.

4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

FIGURE 1

Uniform Cover Soil Thickness
Seepage Forces with Parallel-to-Slope Buildup

JAB
JBF



W_A = total weight of the active wedge
W = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane

C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor-of-safety against cover soil sliding on the geomembrane

$$W_A = \gamma h^2\left(\frac{L}{h}\cdot\frac{1}{\sin 2\beta}-\frac{1}{2\tan\beta}\right)$$

$$a(FS)^2 + b(FS) + c = 0$$

$$N_A = W_A \cos\beta$$

$$a = \left(W_A - N_A\cos\beta\right)\cos\beta$$

$$W_P = \frac{\gamma h^2}{\sin 2\beta}$$

$$b = -[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_p\tan\phi)]$$

$$N_p = W_P + E_P\sin\beta$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi$$

$$C = \frac{(c)(h)}{\sin\beta}$$

AND:

$$E_P\cos\beta = \frac{C + N_p\tan\phi}{FS}$$

$$FS = \frac{-b+\sqrt{b^2-4ac}}{2a}$$

a factor of safety ≥ 1.0.

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill - Expansion CPA

1.0 OBJECTIVE

To analyze a "worst case" scenario and determine the long-term stability of final cover system in the 4H to 1V slope areas considering post-peak (residual) low normal load shear strengths with regards to wedge/block failure and sliding due water seepage forces within the erosion layer and considering seismic forces.

2.0 ASSUMPTIONS

1.) The proposed cover system consists of (from top to bottom):

2.5-feet of Vegetative/Erosion Layer
****Textured 40-mil Linear Low-Density Polyethylene (LLDPE) Geomembrane**
Ash Waste

**** Critical interface angle = 25 degrees (post peak)**
Adhesion for post-peak = 108 pounds per square foot (psf)

2.) Material Properties:

Material Properties used for the analysis are shown on TABLE 1, attached and in reference 5.

3.) The final cover slopes are designed to be 4 horizontal to 1 vertical (4H:1V) maximum.

4.) Maximum slope length along the 4H:1V slope is approximately 150-feet (ft), (36 feet vertical).

5.) For interface friction angle the residual (post-peak) strength under low normal stress was used.

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill - Expansion CPA

3.0 METHODS

1.) **Use method outlined in R.M. Koerner and T. Soong's method, Reference 2. Please see Figure 1 for Equations and Parameter definitions for the calculations performed below.**

2.) Allow a minimum interim factor of safety of 1.0, with seismic when saturated conditions are considered, and residual interface friction angles are used and calculate the maximum safe slope length for each condition. All other conditions, allow a minimum factor of safety of 1.3.

3.) Interface friction angles were taken as averages of representative lab data for similar materials, residual strengths. (These friction angels are conservative and for design purposes, the owner may choose to purchase materials with interface friction angles greater than those used in the design.)

4.0 CALCULATIONS

Calculate Factor of Safety using Koerner's Method for long term stability with wet conditions (i.e. water on the liner); (See attached GRI Report #18)

Uniform Cover Soil Thickness
Seismic and Seepage Forces with Parallel-to-Slope Buildup
(See attached Figure 1 depicting seepage forces with parallel-to-slope buildup)

1. GRAVITY ONLY

Interface Friction Angle, δ	25	degrees	$\sin\beta$ =	0.24	W_A =	45,398	lb/ft
Interface Adhesion, c_a	108	psf	$\tan\beta$ =	0.25	W_P =	1,727	lb/ft
Soil Friction Angle, ϕ	32	degrees	$\cos\beta$ =	0.97	N_A =	44,043	lb/ft
Soil Cohesion, c	0	psf	$\sin 2\beta$ =	0.47	C_a =	15,120	lb/ft
Slope	4	H:1V	$\tan\phi'$ =	0.62	C =	0	lb/ft
Soil Unit Weight (wet), γ	130	pcf	$\tan\delta'$ =	0.47			
Cover Depth, h	2.5	ft			a =	2,591	lb/ft
Slope Length, L	150	ft			b =	-9,056	lb/ft
					c =	1,311	lb/ft
FACTOR OF SAFETY =	**3.3**	**acceptable**					

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

2. EQUIPMENT PUSHING SOIL UP FINAL COVER SLOPE

Weight of Equipment, W_b	39,895	lb	W_e =	2,256	lb/ft		
Length of Equipment Track, w	10.7	ft	N_e =	2,188	lb/ft	From CAT Handbook	(Ref. 3)
Width of Equipment Track, b	8.7	ft				D6T LGP Track- type tractor	
Width-to-Thickness Ratio, b/h	3.5						
Influence Factor, I	0.98	See Ref. 1					
			a =	11,213	lb/ft		
			b =	-38,413	lb/ft		
			c =	5,559	lb/ft		
FACTOR OF SAFETY =	**3.3**	**acceptable**					

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill - Expansion CPA

3. SEISMIC FORCES

Seismic Coefficient, C_S	0.05		a =	12,649	lb/ft
			b =	-36,570	lb/ft
			c =	5,243	lb/ft
FACTOR OF SAFETY =	**2.7**	**acceptable**			

4. PARALLEL-TO-SLOPE SEEPAGE BUILDUP

Assumed Saturated Soil Unit Weight, γ_{sat}	132	pcf	W_A =	46,753	lb/ft	a =	11,001	lb/ft
Cover Depth	2.5	ft	U_N =	178	lb/ft	b =	-37,386	lb/ft
Head Buildup	0.02	ft	U_h =	0	lb/ft	c =	5,484	lb/ft
Vertical Height	36	ft	W_P =	1,727	lb/ft			
			U_v =	829	lb/ft			
			N_A =	45,179	lb/ft			
FACTOR OF SAFETY =	**3.2**	**acceptable**						

5.0 CONCLUSIONS

Considering the use of seismic loading, post-peak (residual) low normal load shear strengths, and saturated conditions, the long-term "worst case" stability evaluation results for each lateral drainage layer option is considered acceptable with a factor of safety $\geq$ 1.0 for seepage and seismic cases and $\geq$ 1.3 for the other cases.

6.0 REFERENCES

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

3.) Table 1 Global Material Properties contained in this report.

4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

5.) Koerner, G.R., and Dhani Harejo, "Direct Shear Database of Geosynthetic to Geosynthetic and Geosynthetic to Soil Interfaces". GRI Report #30, June 14, 2005.

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CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES UNDER IMPROVED DOWNCHUTES	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

1.0 OBJECTIVE

To analyze a "worst case" scenario and determine the long-term stability of final cover system in the area of the improved downchute, including a geocomposite, considering post-peak (residual) low normal load shear strengths with regards to wedge/block failure and sliding due water seepage forces within the lateral drainage layer (geocomposite) and considering seismic forces.

2.0 ASSUMPTIONS

1.) The proposed cover system consists of (from top to bottom):

2.5-feet of Vegetative/Erosion Layer
**** Double-sided Geocomposite**
****Textured 40-mil Linear Low-Density Polyethylene (LLDPE) Geomembrane**
Ash Waste

**** Critical interface angle = 17 degrees (post peak)**
Adhesion for post-peak = 195 pounds per square foot (psf)

2.) Material Properties:

Material Properties used for the analysis are shown on TABLE 1, attached and in reference 5.

3.) The final cover slopes are designed to be 4 horizontal to 1 vertical (4H:1V) maximum.

4.) Maximum slope length along the 4H:1V slope is approximately 150-feet (ft), (36 feet vertical).

5.) For interface friction angle the residual (post-peak) strength under low normal stress was used.

6.) Maximum head is equal to the geocomposite thickness, geonet component = 200-mil.

CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES UNDER IMPROVED DOWNCHUTES	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

3.0 METHODS

1.) **Use method outlined in R.M. Koerner and T. Soong's method, Reference 2. Please see Figure 1 for Equations and Parameter definitions for the calculations performed below.**

2.) Allow a minimum interim factor of safety of 1.0, with seismic when saturated conditions are considered, and residual interface friction angles are used and calculate the maximum safe slope length for each condition. All other conditions, allow a minimum factor of safety of 1.3.

3.) Interface friction angles were taken as averages of representative lab data for similar materials, residual strengths. (These friction angels are conservative and for design purposes, the owner may choose to purchase materials with interface friction angles greater than those used in the design.)

4.0 CALCULATIONS

Calculate Factor of Safety using Koerner's Method for long term stability with wet conditions (i.e. water on the liner); (See attached GRI Report #18)

Uniform Cover Soil Thickness
Seismic and Seepage Forces with Parallel-to-Slope Buildup
(See attached Figure 1 depicting seepage forces with parallel-to-slope buildup)

1. GRAVITY ONLY

Interface Friction Angle, δ	17	degrees	$\sin\beta$ =	0.24	W_A =	45,398	lb/ft
Interface Adhesion, c_a	195	psf	$\tan\beta$ =	0.25	W_P =	1,727	lb/ft
Soil Friction Angle, ϕ	32	degrees	$\cos\beta$ =	0.97	N_A =	44,043	lb/ft
Soil Cohesion, c	0	psf	$\sin 2\beta$ =	0.47	C_a =	27,300	lb/ft
Slope	4	H:1V	$\tan\phi'$ =	0.62	C =	0	lb/ft
Soil Unit Weight (wet), γ	130	pcf	$\tan\delta'$ =	0.31			
Cover Depth, h	2.5	ft			a =	2,591	lb/ft
Slope Length, L	150	ft	$FS=\dfrac{-b+\sqrt{b^2-4ac}}{2a}$		b =	-10,258	lb/ft
					c =	1,498	lb/ft
FACTOR OF SAFETY =	**3.8**	**acceptable**					

2. EQUIPMENT PUSHING SOIL UP FINAL COVER SLOPE

Weight of Equipment, W_b	39,895	lb	W_e =	2,256	lb/ft		
Length of Equipment Track, w	10.7	ft	N_e =	2,188	lb/ft	From CAT Handbook	(Ref. 3)
Width of Equipment Track, b	8.7	ft				D6T LGP Track- type tractor	
Width-to-Thickness Ratio, b/h	3.5						
Influence Factor, I	0.98	See Ref. 1					
			a =	11,213	lb/ft		
			b =	-43,028	lb/ft		
			c =	6,279	lb/ft		
FACTOR OF SAFETY =	**3.7**	**acceptable**					

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	ACB
Subject:	4H:1V FINAL COVER STABILITY - LONG TERM WITH SEEPAGE FORCES UNDER IMPROVED DOWNCHUTES	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill - Expansion CPA		

3. SEISMIC FORCES

Seismic Coefficient, C_S	0.05		a =	12,649	lb/ft
			b =	-41,377	lb/ft
			c =	5,994	lb/ft
FACTOR OF SAFETY =	**3.1**	**acceptable**			

4. PARALLEL-TO-SLOPE SEEPAGE BUILDUP

Assumed Saturated Soil Unit Weight, γ_{sat}	130	pcf	W_A =	46,747	lb/ft	a =	10,999	lb/ft
Cover Depth	2.5	ft	U_N =	178	lb/ft	b =	-42,163	lb/ft
Head Buildup	0.02	ft	U_h =	0	lb/ft	c =	6,230	lb/ft
Vertical Height	36	ft	W_P =	1,727	lb/ft			
			U_v =	829	lb/ft			
			N_A =	45,173	lb/ft			
FACTOR OF SAFETY =	**3.7**	**acceptable**						

5.0 CONCLUSIONS

Considering the use of seismic loading, post-peak (residual) low normal load shear strengths, and saturated conditions, the long-term "worst case" stability evaluation results for each lateral drainage layer option is considered acceptable with a factor of safety $\geq$ 1.0 for seepage and seismic cases and $\geq$ 1.3 for the other cases.

6.0 REFERENCES

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

3.) Table 1 Global Material Properties contained in this report.

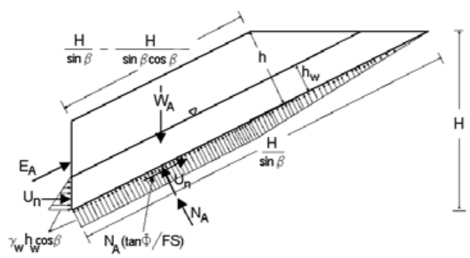
4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

5.) Koerner, G.R., and Dhani Harejo, "Direct Shear Database of Geosynthetic to Geosynthetic and Geosynthetic to Soil Interfaces". GRI Report #30, June 14, 2005.

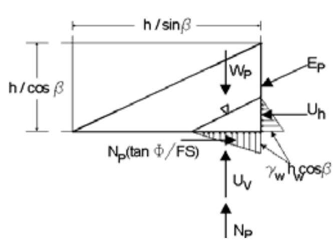
FIGURE 1

Uniform Cover Soil Thickness
Seepage Forces with Parallel-to-Slope Buildup

(A) Active Wedge



(B) Passive Wedge



(C) Units & Definitions

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane

Allow a minimum interim factor of safety of 1.0, with seismic when saturated conditions are considered, and:

C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor-of-safety against cover soil sliding on the geomembrane

a factor of safety ≥ 1.0.

(D) Equation Sets

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin 2\beta} - \frac{1}{2\tan\beta}\right)$$

$$N_A = W_A \cos\beta$$

$$W_P = \frac{\gamma h^2}{\sin 2\beta}$$

$$N_P = W_P + E_P \sin\beta$$

$$C = \frac{(c)(h)}{\sin\beta}$$

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS}$$

$$a(FS)^2 + b(FS) + c = 0$$

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi$$

AND:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

APPENDIX E

Global Slope Stability Calculations (SLIDE)

CALCULATIONS

Date:	May-21	**Made by:**	Amin Kandi and David Falish
Project No.:	19132873	**Checked by:**	Gary Daniels
Subject:	**Slope Stability Analysis**	**Reviewed by:**	Tiffany Johnson
Project Short Title:	**JHC Campbell - Dry Ash Landfill Expansion CPA**		

1.0 OBJECTIVE

To analyze the stability of the JH Campbell Dry Ash Landfill Expansion CPA.

2.0 ASSUMPTIONS

1) Material Properties used for the analysis are shown on TABLE 1 of this Construction Permit Application. The material properties for the Coal Combustion Residuals (CCR) were obtained from the historical laboratory results (Reference 1 and 2). A drained friction angle of 30 degrees with no cohesion was selected for the CCR. The unit weight of CCR was selected to be 95 pounds per cubic feet (pcf).

2) No excessive surcharges are present.

3) The water level was estimated from historical information (Reference 2).

4) Material types represent simplified subsurface conditions. Material boundaries are approximated.

5) No excess pore-pressure will be generated because of relatively high permeability.

6) The cross-section locations used for this analysis are shown on Figures 1 and 2.

7) The Final Cover veneer stability is included in Appendix D.

3.0 METHODS

1) Slope stability is performed using Rocscience's slope stability program, *SLIDE2* version 9.

2) *SLIDE2* is a 2D slope stability program for evaluating the safety factor or probability of failure, of circular or non-circular failure surfaces in soil or rock slopes.

3) *SLIDE2* analyzes the stability of slip surfaces using vertical slice limit equilibrium methods (e.g. GLE/Morgenstern-Price, Janbu, Spencer, etc.). Individual slip surfaces can be analyzed, or search methods can be applied to locate the critical slip surface for a given slope.

4) Seismic coefficient of 0.05 was selected for the pseudo-static analysis (Reference 3).

5) Slope stability analyses were conducted for two cases for an east to west cross section and five cases for a north to south cross section:

East to West Cross Section
- **1 Global Stability**
- **2 Geosynthetics Interface with 3H:1V Operational Slope**

North to South Cross Section
- **1 Global Stability**
- **2 Geosynthetics Interface with 3H:1V Operational Slope**
- **3 Geosynthetic Interface Failure**
- **4 Deep Soils Failure**
- **5 Drainage Ditch Stability**

6) Each of these scenarios was analyzed for rotational (circular) and/or translational block failures using GLE/Morgenstern-Price and Spencer Methods. These methods are based on the principle of limiting equilibrium, i.e. the method calculates the shear strengths that would be required to just maintain equilibrium and then computes a factor of safety by dividing the available shear strength by the shear strength required to maintain stability. A critical surface search routing is used to determine the least stable failure surface, i.e. SLIDE iterates through a large number of potential failure surfaces and calculates the factor of safety of each surface – the lowest factor of safety is reported. Two different methods are used to verify the results are consistent with the estimated factor of safety.

6) Safety factors in excess of 1.0 indicate stability and the greater the mathematical difference between a safety factor and 1.0, the larger the margin of safety. However, to account for uncertainties and variability, the acceptance criteria are 1.5 for permanent loading conditions (long-term, drained), 1.3 for temporary loading conditions (end of construction, undrained), and 1.0 for pseudo-static conditions.

The minimum acceptable safety factors were design criteria based on Golder's experience with similar projects. These requirements are appropriate for this application and have been approved by the EGLE on similar projects.

7) Geosynthetics Interface with the 3H:1V Operational Slope case was considered to be a short-term operational condition.

8) The short-term undrained condition was not analyzed because the foundation material and the CCR have relatively high permeability (granular in nature).

CALCULATIONS

Date:	May-21	**Made by:**	Amin Kandi and David Falish
Project No.:	19132873	**Checked by:**	Gary Daniels
Subject:	**Slope Stability Analysis**	**Reviewed by:**	Tiffany Johnson
Project Short Title:	**JHC Campbell - Dry Ash Landfill Expansion CPA**		

4.0 RESULTS

The results of the slope stability analysis are summarized in Table 2, and the SLIDE outputs are attached.

Table 2: SLIDE Results

	Factor of Safety (GLE/Morgenstern Price)		**Properties Used**
East to West Analysis	**CALCULATED**	**Minimum Required**	
Global Stability			
Static	2.3	1.5	Drained parameters
Pseudo-static	1.9	1.0	Drained parameters
Geosynthetics Interface with 3H:1V Operational Slope			
Static	1.6	1.3	Drained parameters
Pseudo-static	1.4	1.0	Drained parameters
North to South Analysis	**CALCULATED**	**Minimum Required**	**Properties Used**
Global Stability			
Static	2.2	1.5	Drained parameters
Pseudo-static	1.8	1.0	Drained parameters
Geosynthetics Interface with 3H:1V Operational Slope			
Static	1.4	1.3	Drained parameters
Pseudo-static	1.2	1.0	Drained parameters
Geosynthetic Interface Failure			
Static	2.7	1.5	Drained parameters
Pseudo-static	2.1	1.0	Drained parameters
Deep Soils Failure			
Static	3.4	1.5	Drained parameters
Pseudo-static	2.7	1.0	Drained parameters
Drainage Ditch Stability			
Static	1.8	1.5	Drained parameters
Pseudo-static	1.6	1.0	Drained parameters

5.0 CONCLUSIONS

Using the strength parameters that were conservatively estimated or assumed, the J.H. Campbell Dry Ash Landfill Cells 5 through 9 upgraded design slopes meet the Acceptance Criteria for the conditions analyzed.

6.0 REFERENCES

1.) Golder Associates, July 2017, "J.H. Campbell Landfill Test Fill Report".

2.) Engineering & Environmental Solutions, LLC (EES), 2012. Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation – December 2012.

3.) Golder Associates, October 2016, "J.H. Campbell Generating Facility Pond A Structural Stability and Safety Factor Assessment Report".

4.) Rocscience Inc. (2020) "SLIDE2" ver. 9, 2D Limit Equilibrium Slope Stability for Soil.

5.) Golder Associates, January 2021, "Table 1: Global Material Properties Used for Calculations - JH Campbell Vertical Expansion".

<u>Attachments or Enclosures:</u>

Figure 1- Slope Stability East to West Cross Section Location
Figure 2 - Slope Stability North to South Cross Section Location
SLIDE Outputs

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
									0	03-02-18	SUBMITTED TO MDEQ	DS	GD	DL	TJ	

SIGNATURE

NAME: TIFFANY D. JOHNSON

MICHIGAN P.E. No. 6201049160

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

Slope Stability Cross Section Location A-A'

SCALE: 1" = 100'
JOB: PT-01891
DRAWING NO.
SHEET 1
REV. 0

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
0	XX-XX-XX	SUBMITTED TO EGLE	--	--	--	--	

SIGNATURE

NAME: TIFFANY D. JOHNSON

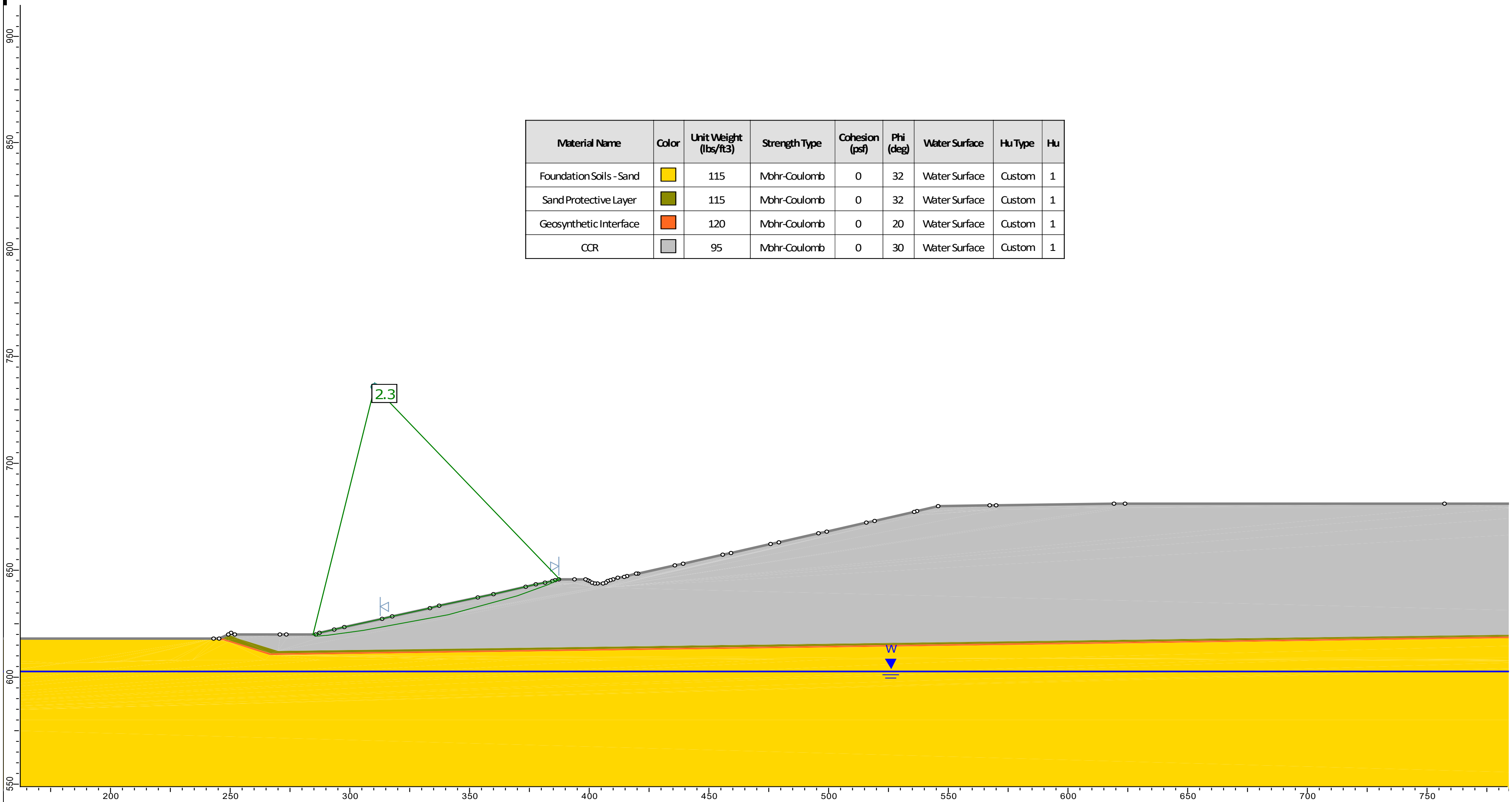
MICHIGAN P.E. No. 6201049160

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

Slope Stability Cross Section Location B-B'

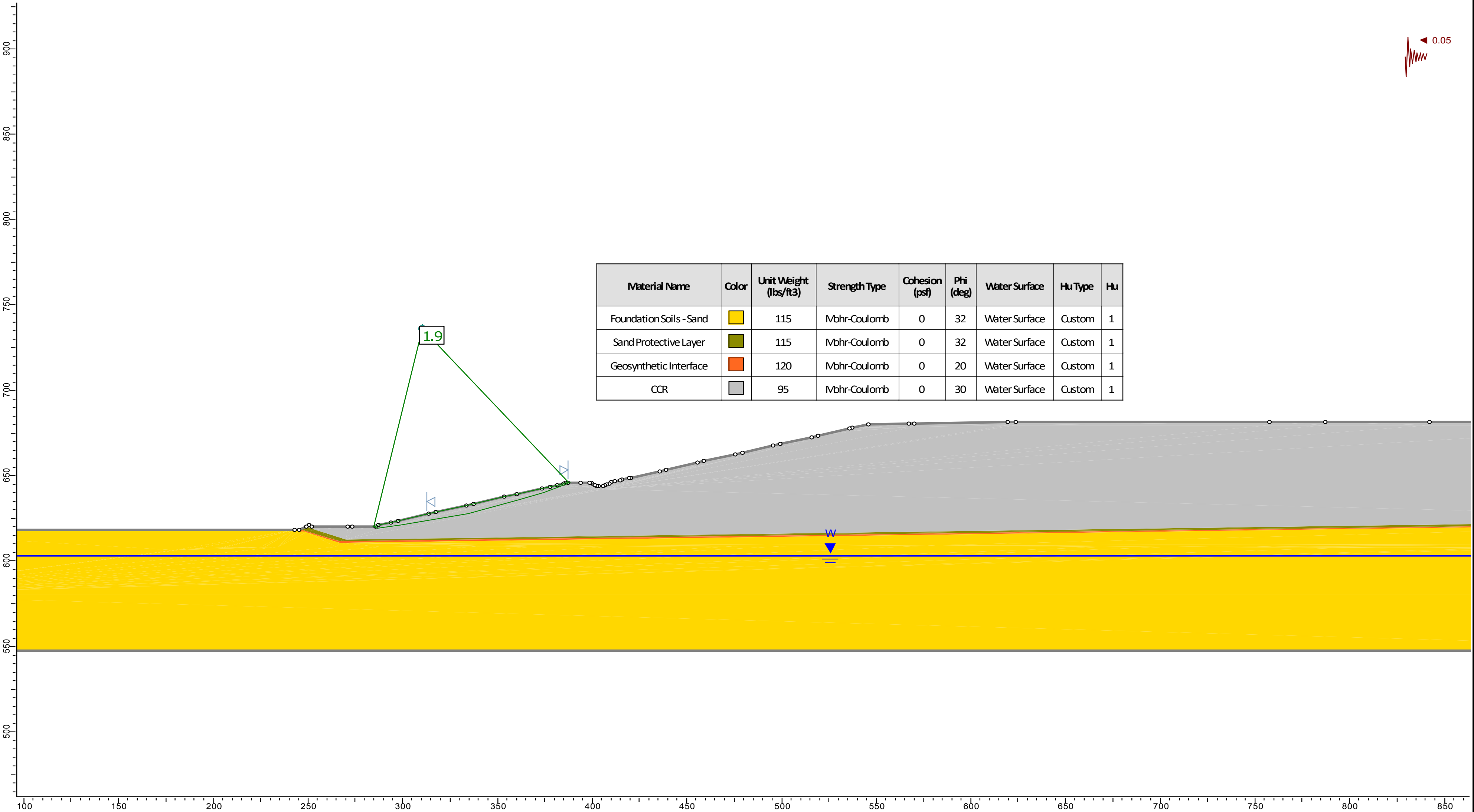
SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO. ---
SHEET 2
REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Foundation Soils - Sand		115	Mohr-Coulomb	0	32	Water Surface	Custom	1
Sand Protective Layer		115	Mohr-Coulomb	0	32	Water Surface	Custom	1
Geosynthetic Interface		120	Mohr-Coulomb	0	20	Water Surface	Custom	1
CCR		95	Mohr-Coulomb	0	30	Water Surface	Custom	1

EAST TO WEST CROSS-SECTION

GOLDER	SCALE: AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
	DATE: Jan 2021	TITLE	Global Stability- Static
	MADE BY: AK		
	CAD: -		
FILE: STABILITY	CHECK: TDJ	CLIENT	Consumers Energy Company
PROJECT No. 19132873 / REV. 0	REVIEW	FIGURE	1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Foundation Soils - Sand		115	Mohr-Coulomb	0	32	Water Surface	Custom	1
Sand Protective Layer		115	Mohr-Coulomb	0	32	Water Surface	Custom	1
Geosynthetic Interface		120	Mohr-Coulomb	0	20	Water Surface	Custom	1
CCR		95	Mohr-Coulomb	0	30	Water Surface	Custom	1

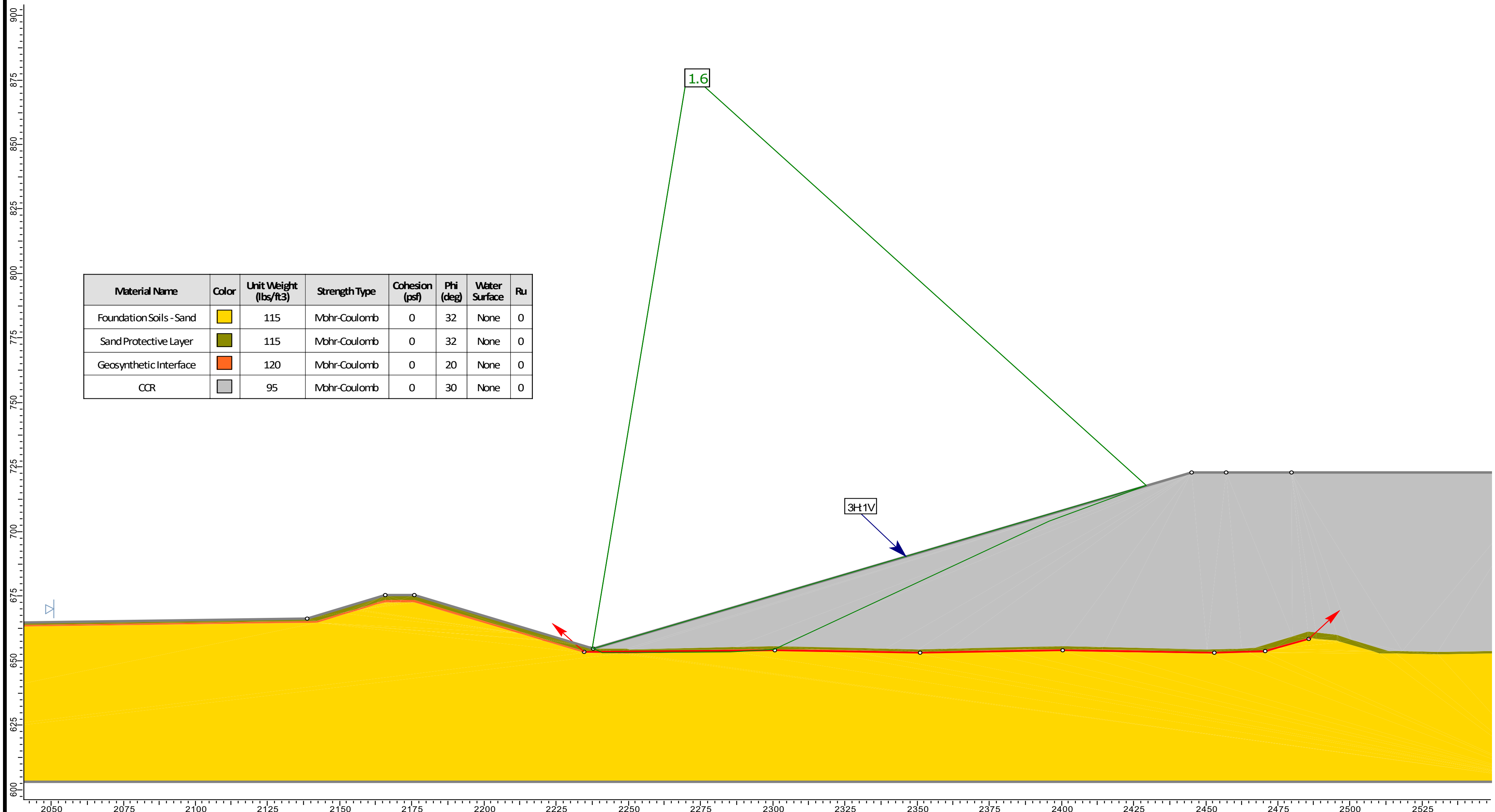
EAST TO WEST CROSS-SECTION

GOLDER

SCALE	AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
DATE	Jan 2021	TITLE	Global Stability- PseudoStatic
MADE BY	AK		
CAD	-		
CHECK	TDJ	CLIENT	Consumers Energy Company
REVIEW		FIGURE	2

FILE STABILITY

PROJECT No. 19132873 REV. 0

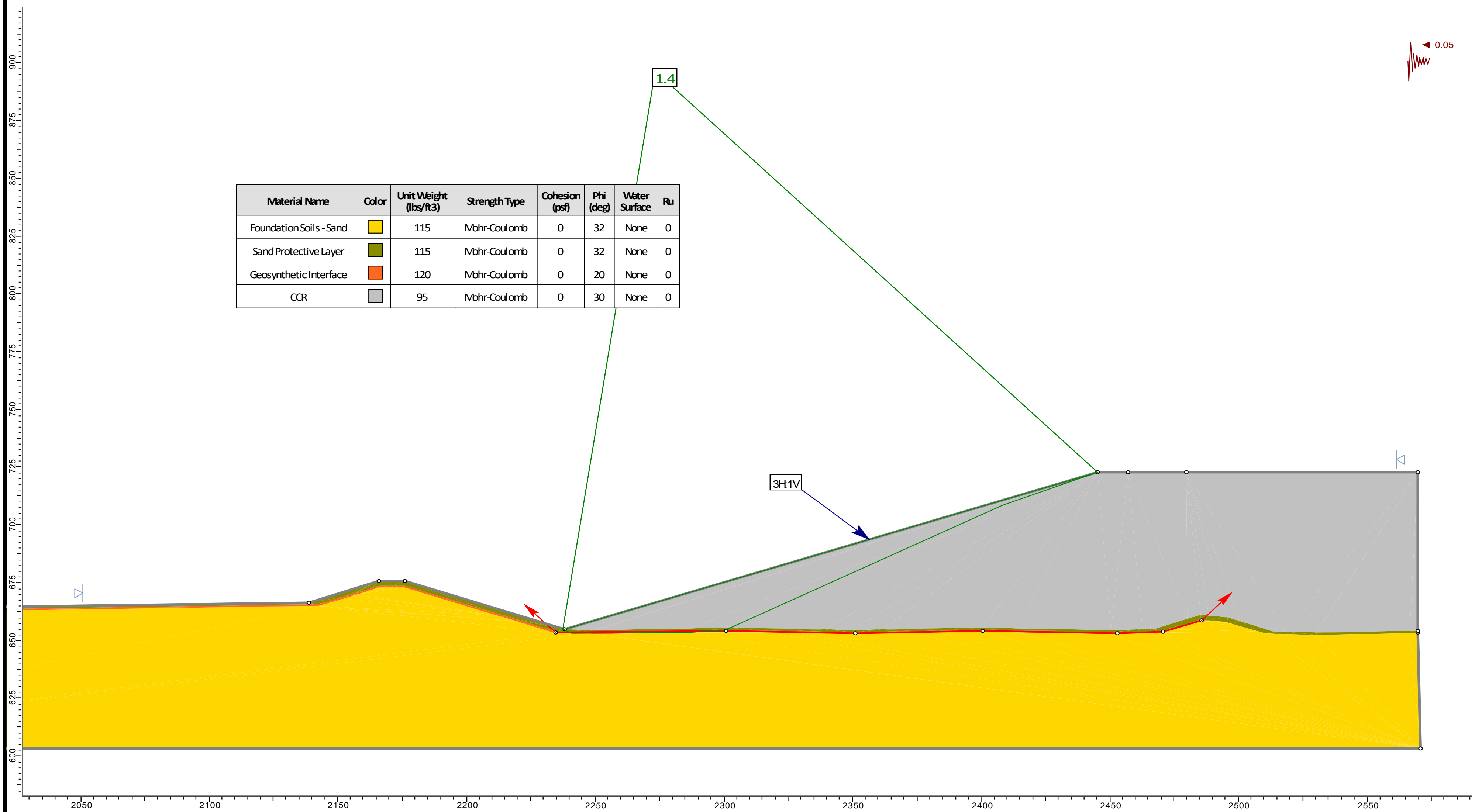


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soils - Sand		115	Mohr-Coulomb	0	32	None	0
Sand Protective Layer		115	Mohr-Coulomb	0	32	None	0
Geosynthetic Interface		120	Mohr-Coulomb	0	20	None	0
CCR		95	Mohr-Coulomb	0	30	None	0

EAST TO WEST CROSS-SECTION

GOLDER

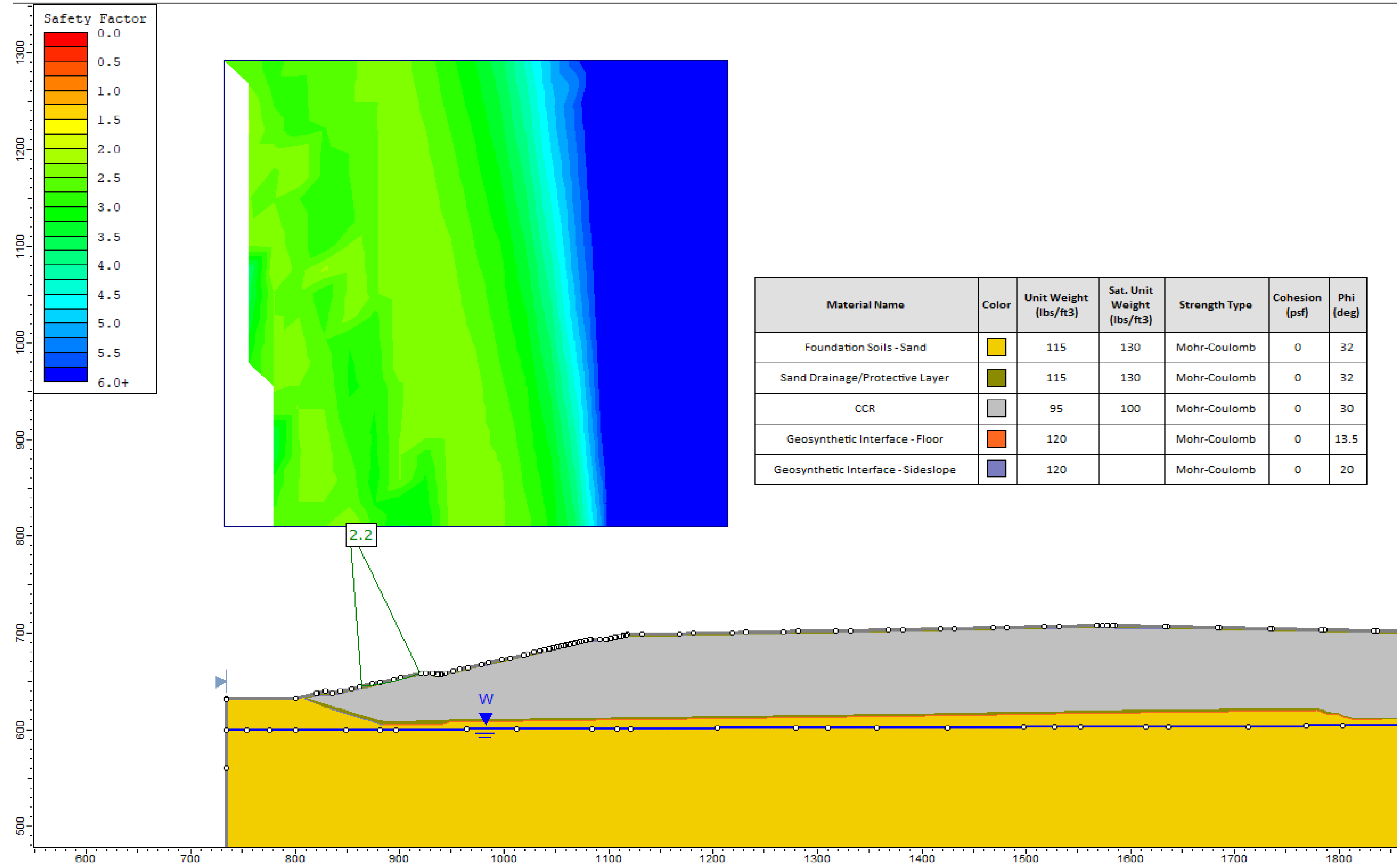
SCALE	AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
DATE	Jan 2021	TITLE	**Geosynthetic Interface- Static**
MADE BY	AK		
CAD	-		
FILE	STABILITY	CHECK	TDJ
PROJECT No.	19132873	REV.	0
REVIEW		CLIENT	**Consumers Energy Company**
FIGURE	3		



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soils - Sand		115	Mohr-Coulomb	0	32	None	0
Sand Protective Layer		115	Mohr-Coulomb	0	32	None	0
Geosynthetic Interface		120	Mohr-Coulomb	0	20	None	0
CCR		95	Mohr-Coulomb	0	30	None	0

EAST TO WEST CROSS-SECTION

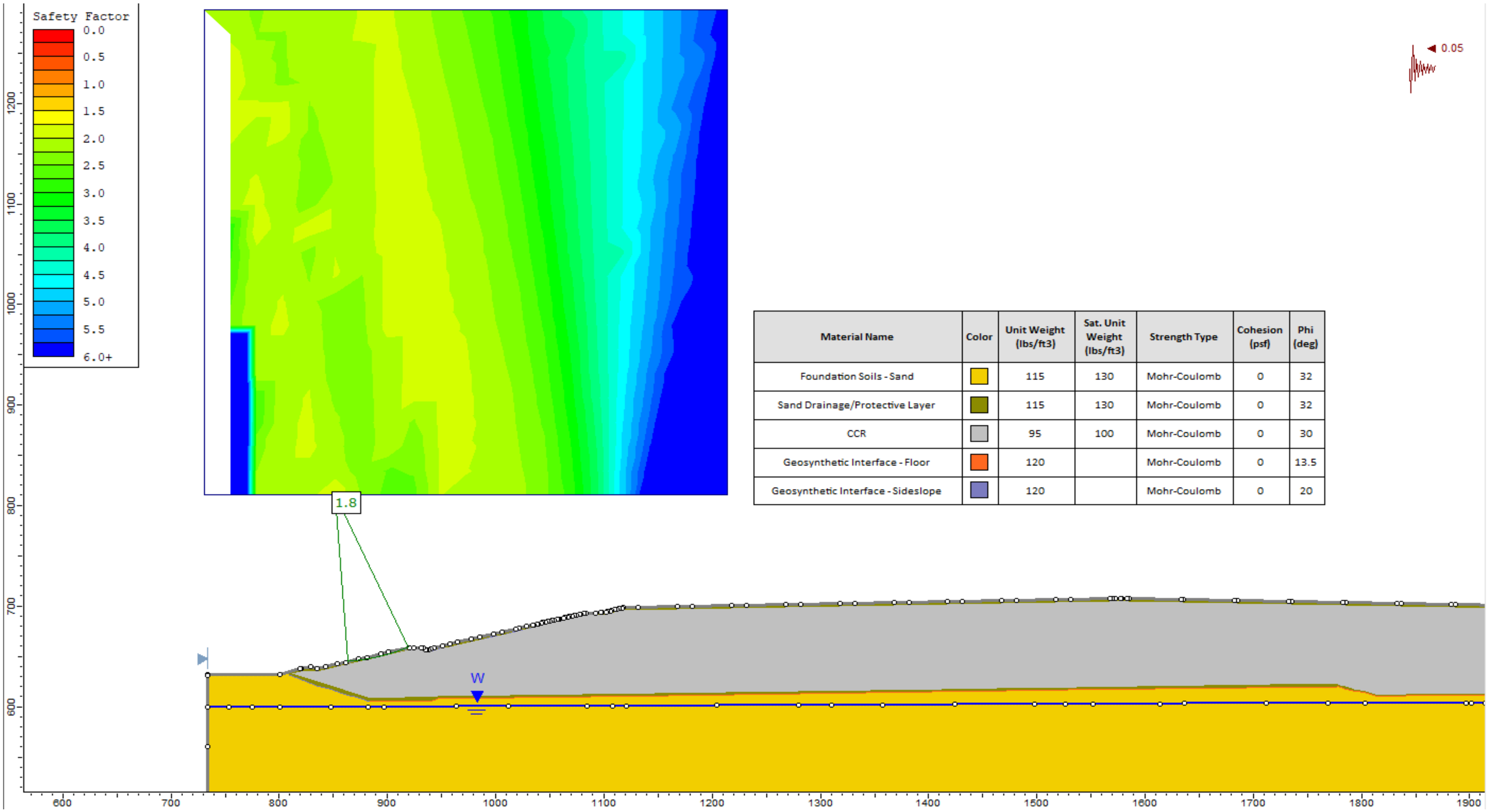
GOLDER	SCALE: AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
	DATE: Jan 2021	TITLE	**Geosynthetic Interface- PseudoStatic**
	MADE BY: AK		
	CAD: -		
FILE: STABILITY	CHECK: TDJ	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 / REV. 0	REVIEW	FIGURE	**4**



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER	SCALE AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
	DATE Jan 2021	TITLE	**Global Stability- Static**
	MADE BY DF		
	CAD -		
FILE STABILITY	CHECK	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 REV. 0	REVIEW	FIGURE	5

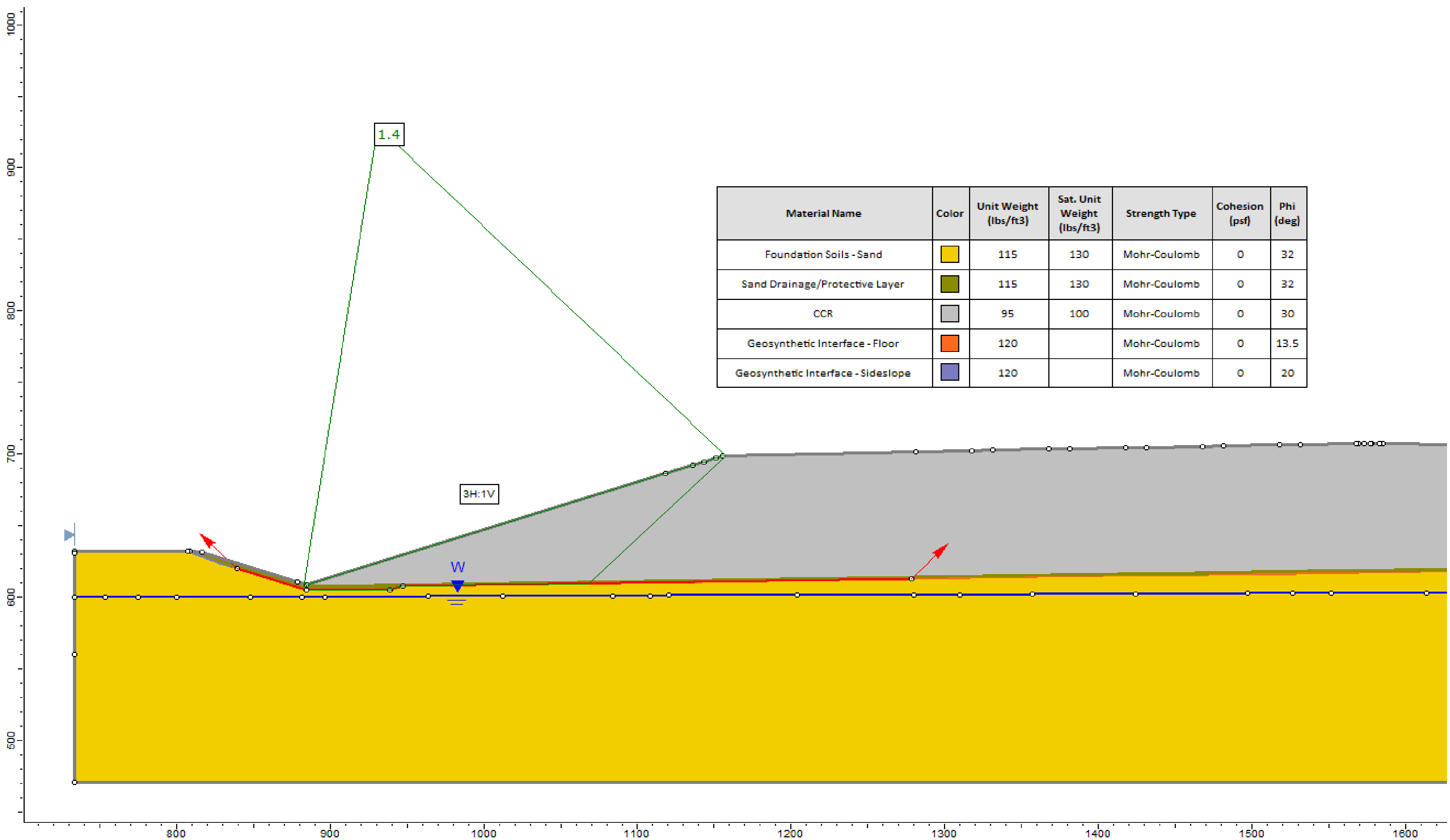


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER

SCALE	AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
DATE	Jan 2021	TITLE	**Global Stability- PseudoStatic**
MADE BY	DF		
CAD	-		
FILE: STABILITY	CHECK	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 REV. 0	REVIEW	FIGURE	6

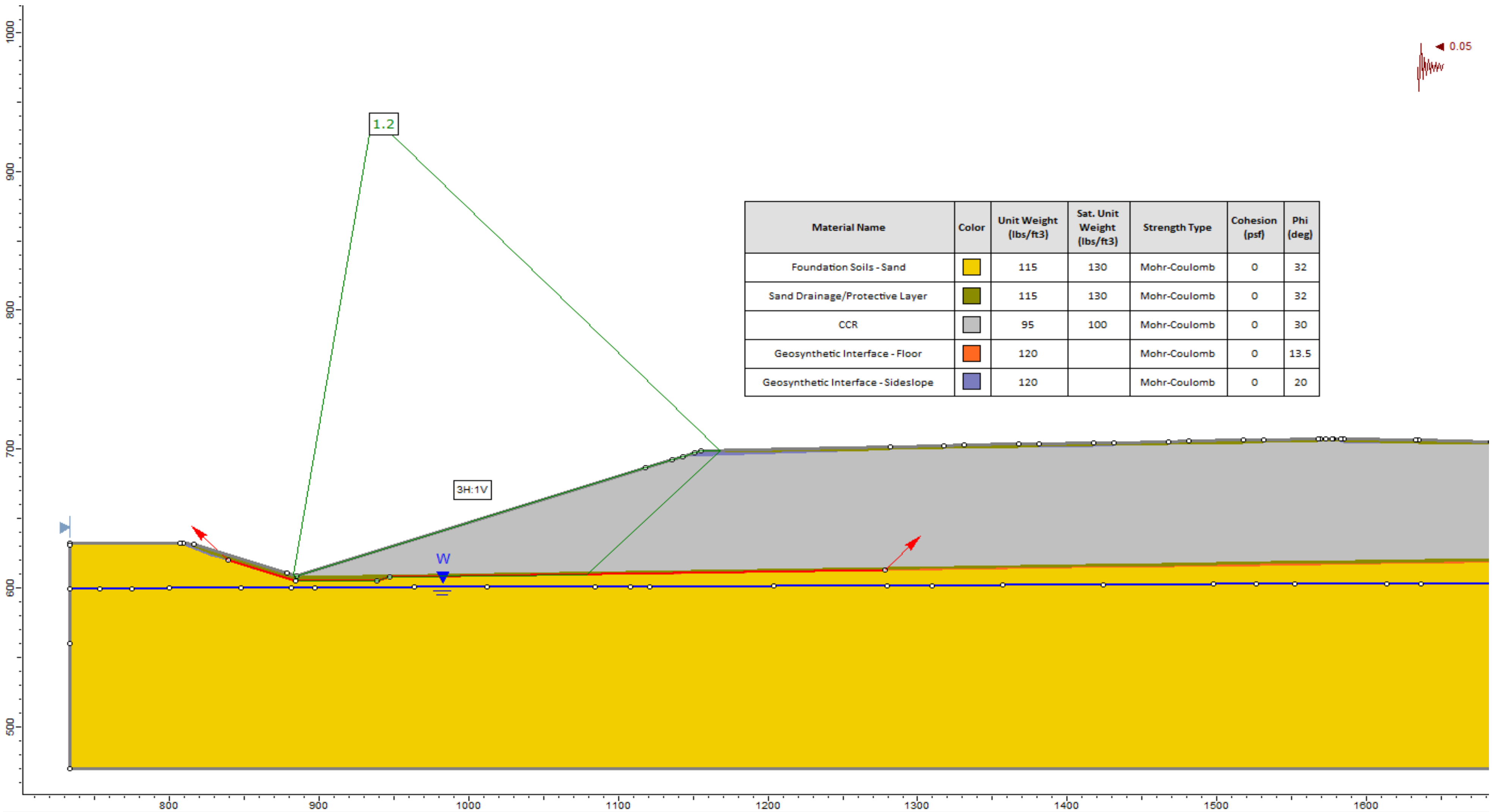


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER

SCALE	AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
DATE	Jan 2021	TITLE	Geosynthetic Interface with 3H:1V Operational Slope- Static
MADE BY	DF		
CAD	-		
FILE	STABILITY	CHECK	
PROJECT No. 19132873	REV. 0	REVIEW	
CLIENT	Consumers Energy Company	FIGURE	7

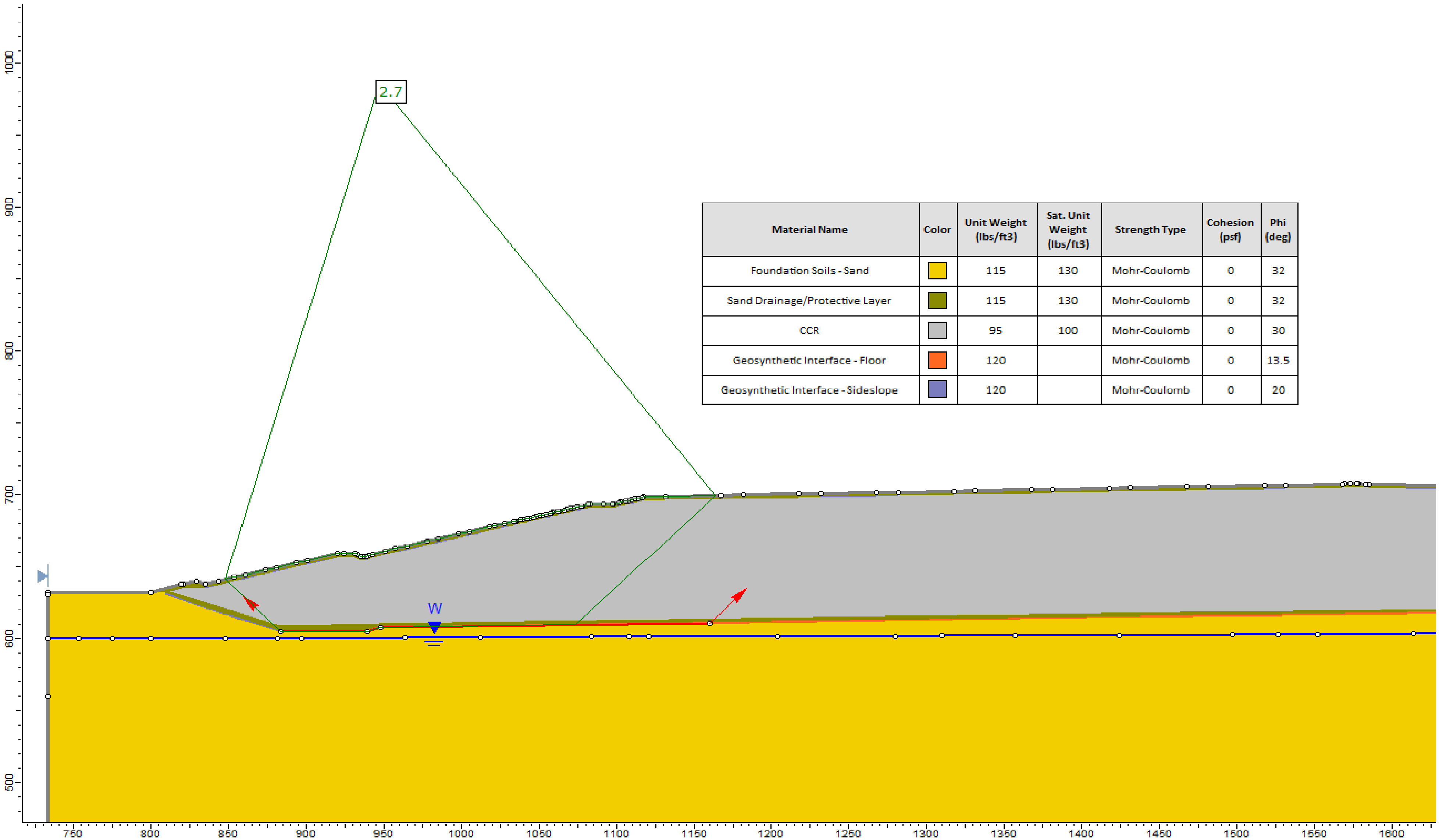


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER

SCALE	AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
DATE	Jan 2021	TITLE	Geosynthetic Interface with 3H:1V Operational Slope- PseudoStatic
MADE BY	DF		
CAD	-		
FILE	STABILITY	CLIENT	Consumers Energy Company
CHECK		FIGURE	8
PROJECT No.	19132873	REV.	0
REVIEW			

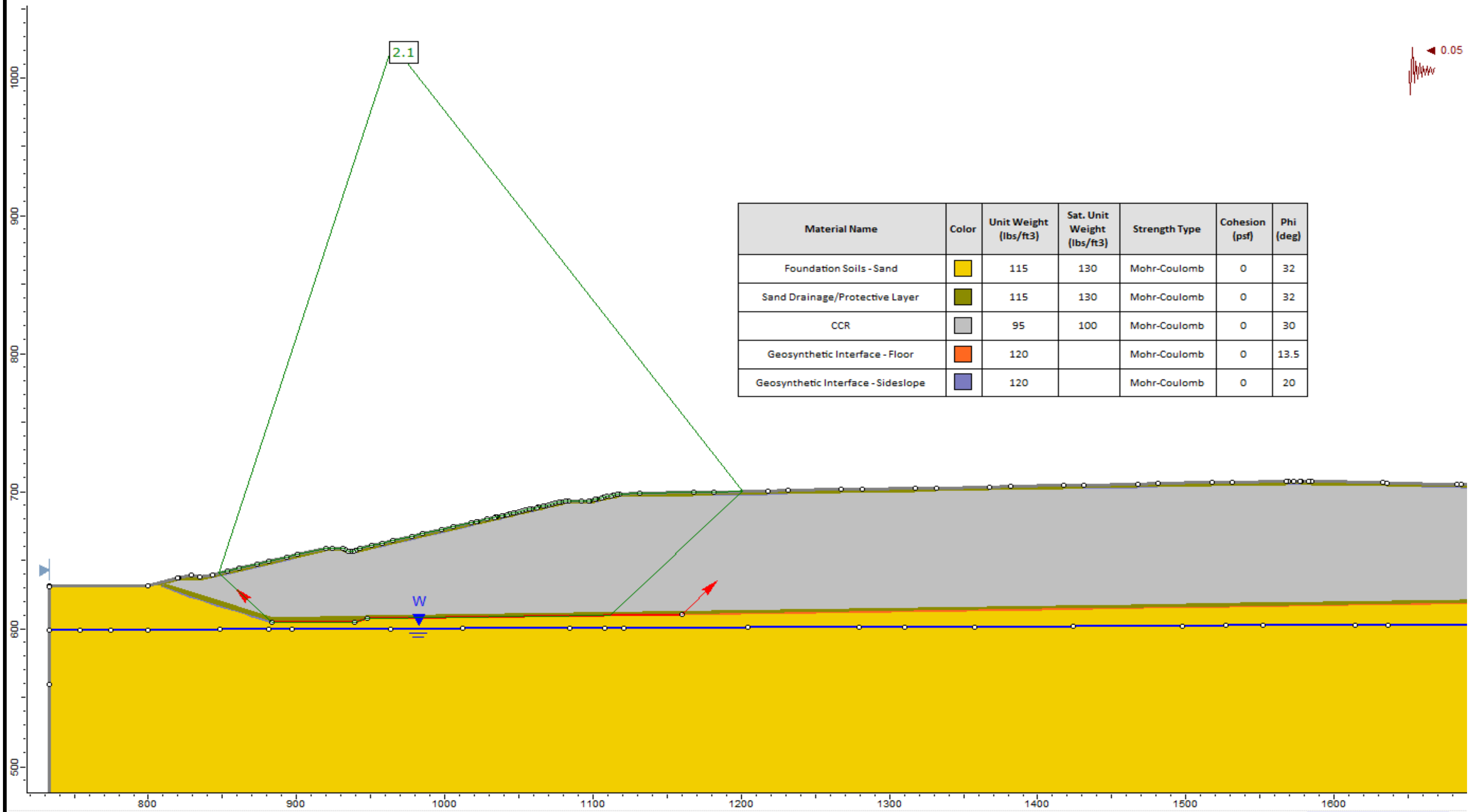


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER

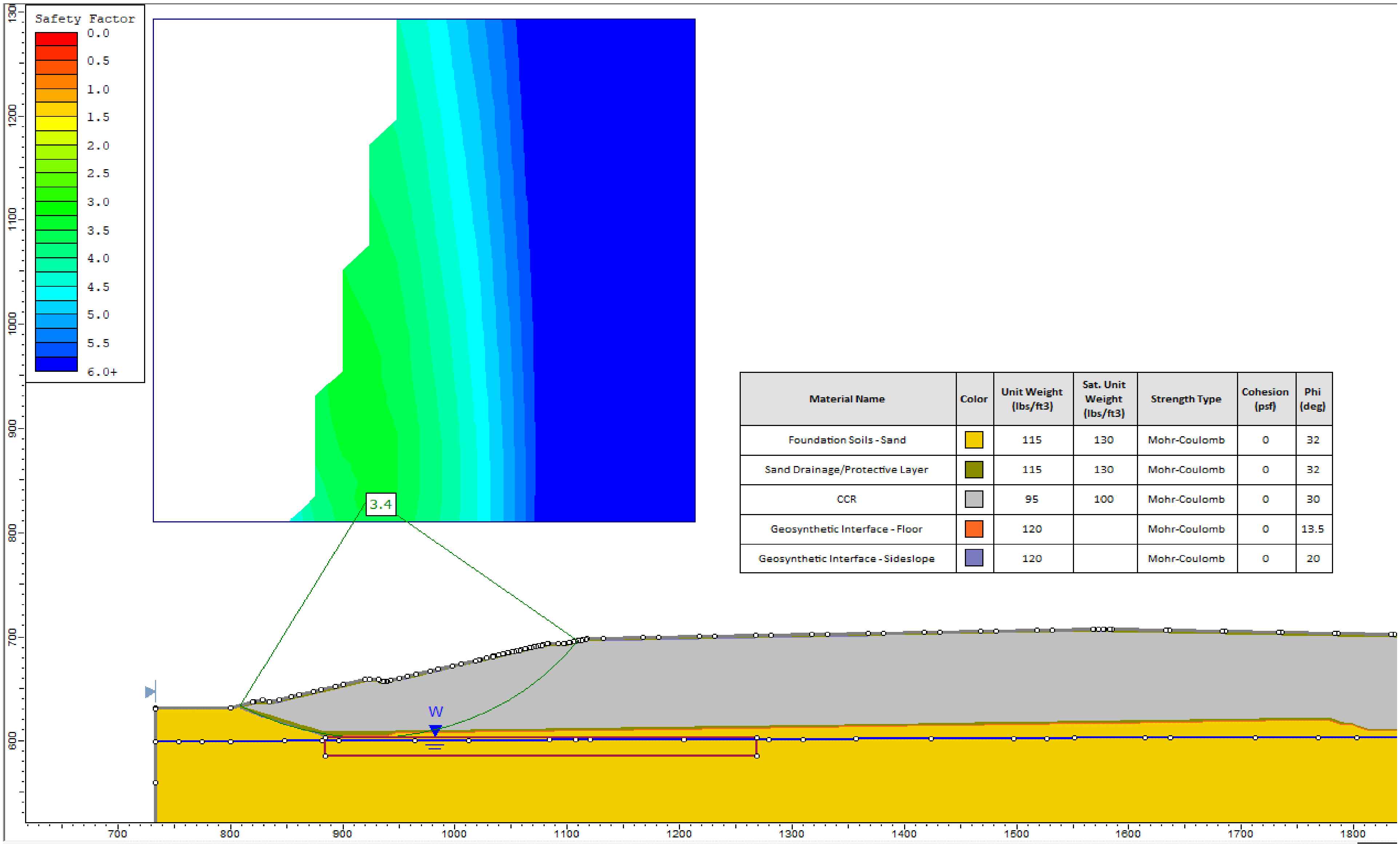
SCALE	AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
DATE	Jan 2021	TITLE	Geosynthetic Interface Failure- Static
MADE BY	DF		
CAD	-		
FILE	STABILITY	CHECK	CLIENT: Consumers Energy Company
PROJECT No. 19132873	REV. 0	REVIEW	FIGURE 9



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER	SCALE: AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
	DATE: Jan 2021	TITLE	**Geosynthetic Interface Failure- PseudoStatic**
	MADE BY: DF		
	CAD: -		
FILE: STABILITY	CHECK	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 REV. 0	REVIEW	FIGURE	10

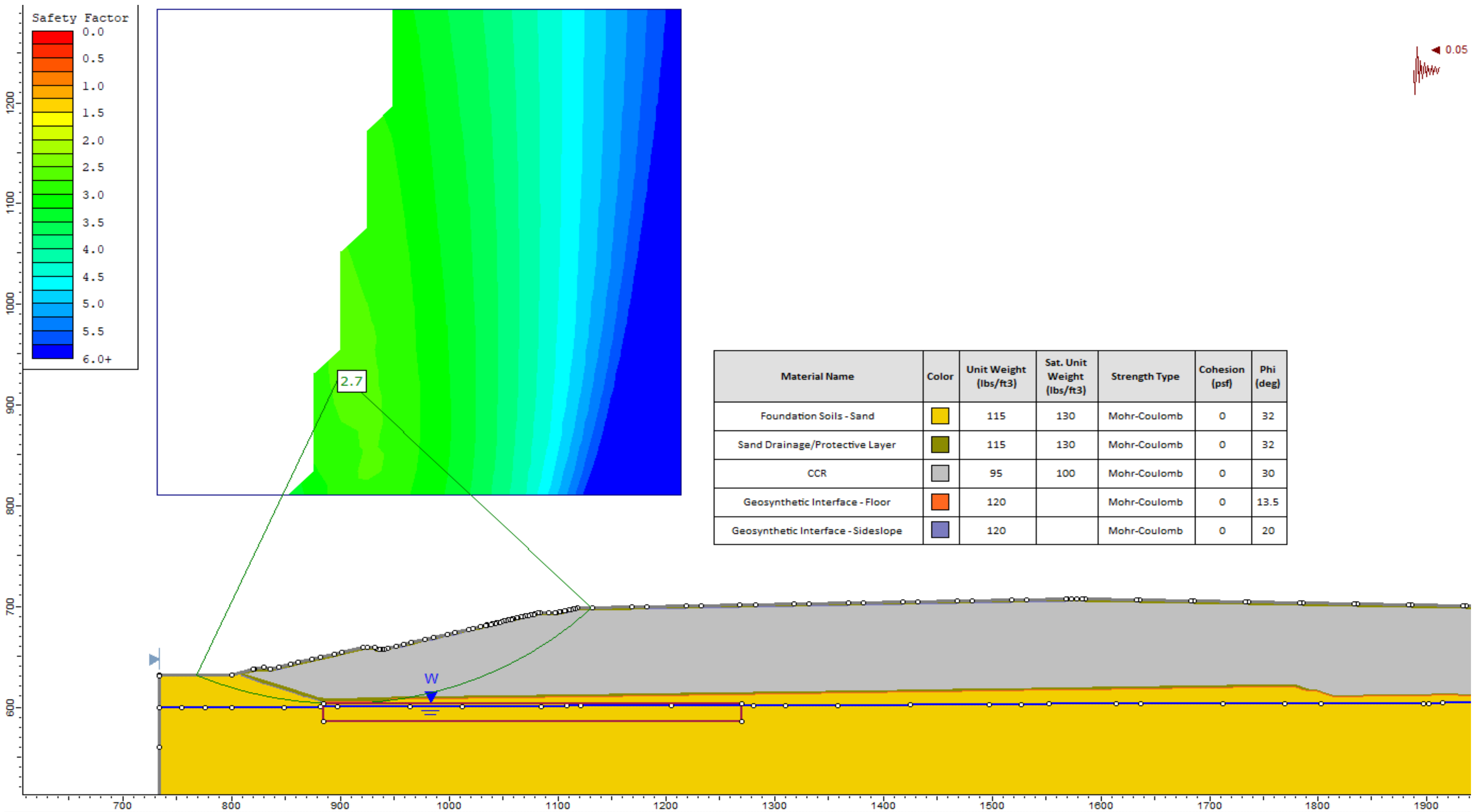


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER

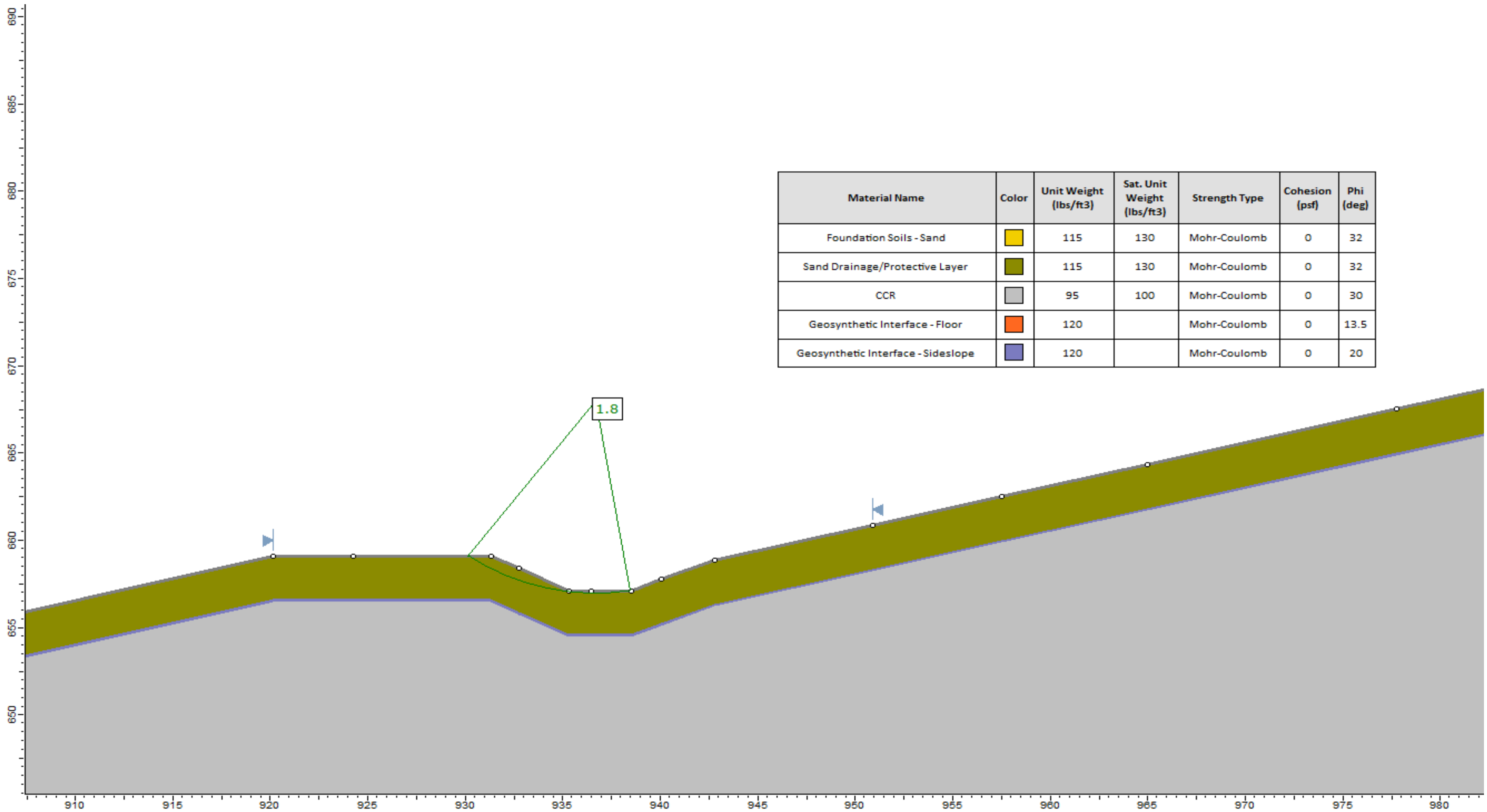
SCALE	AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
DATE	Jan 2021	TITLE	**Deep Soils Failure- Static**
MADE BY	DF		
CAD	-		
FILE: STABILITY	CHECK	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 / REV. 0	REVIEW	FIGURE	**11**



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

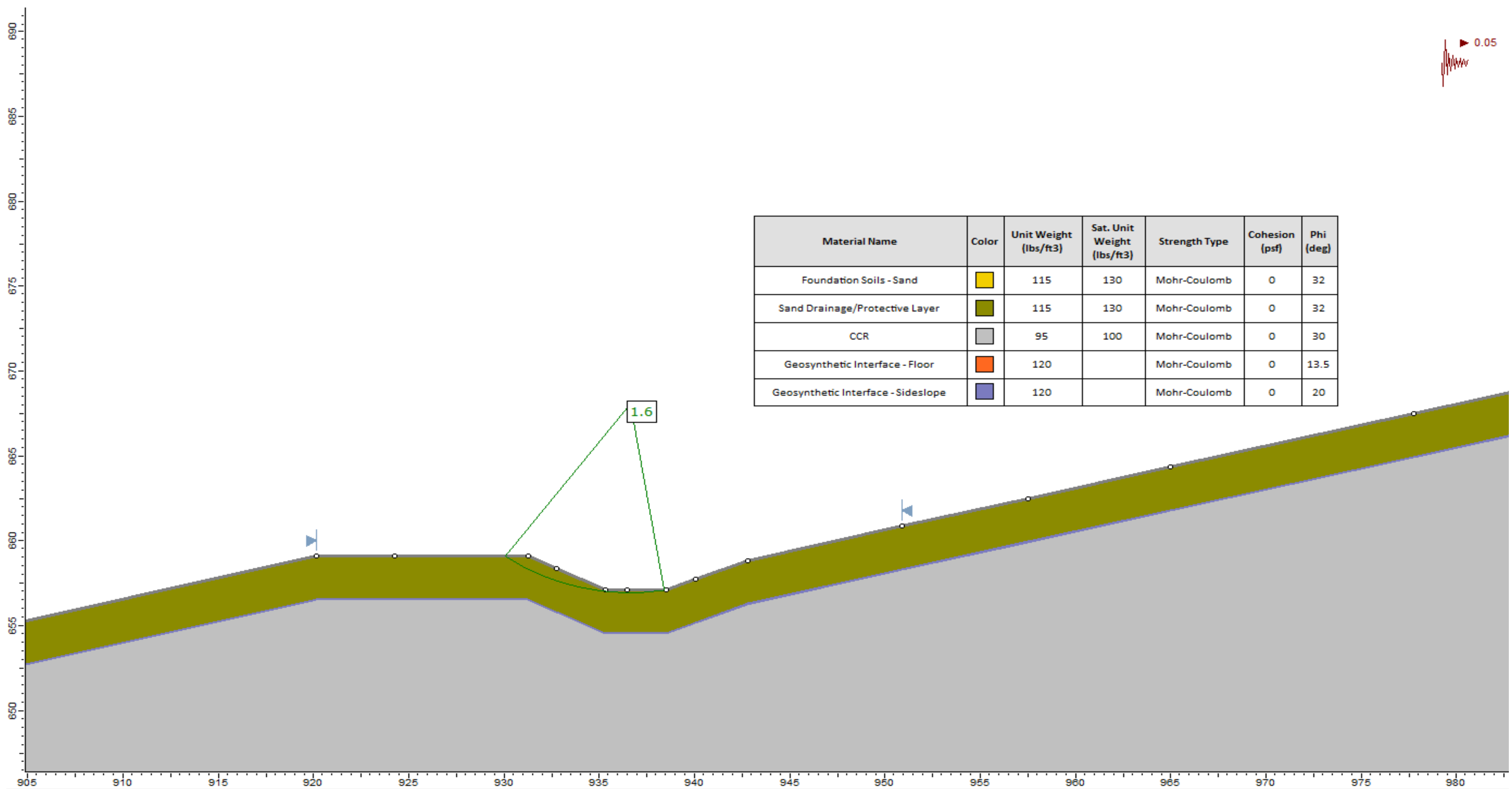
GOLDER	SCALE: AS SHOWN	PROJECT	JH Campbell - Dry Ash Landfill Vertical Expansion
	DATE: Jan 2021	TITLE	Deep Soils Failure- Static
	MADE BY: DF		
	CAD: -		
FILE: STABILITY	CHECK	CLIENT: Consumers Energy Company	FIGURE: 12
PROJECT No.: 19132873 / REV.: 0	REVIEW		



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER	SCALE AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
	DATE Jan 2021	TITLE	**Drainage Ditch Stability- Static**
	MADE BY DF		
	CAD -		
FILE STABILITY	CHECK	CLIENT **Consumers Energy Company**	FIGURE **13**
PROJECT No. 19132873 REV. 0	REVIEW		



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Foundation Soils - Sand		115	130	Mohr-Coulomb	0	32
Sand Drainage/Protective Layer		115	130	Mohr-Coulomb	0	32
CCR		95	100	Mohr-Coulomb	0	30
Geosynthetic Interface - Floor		120		Mohr-Coulomb	0	13.5
Geosynthetic Interface - Sideslope		120		Mohr-Coulomb	0	20

NORTH TO SOUTH CROSS-SECTION

GOLDER	SCALE AS SHOWN	PROJECT	**JH Campbell - Dry Ash Landfill Vertical Expansion**
	DATE Jan 2021	TITLE	**Drainage Ditch Stability- PseudoStatic**
	MADE BY DF		
	CAD -		
FILE STABILITY	CHECK	CLIENT	**Consumers Energy Company**
PROJECT No. 19132873 REV. 0	REVIEW	FIGURE	**14**

APPENDIX F

Puncture Resistance Calculation

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	PUNCTURE RESISTANCE OF GEOMEMBRANE, with Geotextile	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

To evaluate the puncture resistance of 60 mil thick HDPE smooth or textured geomembrane when overlain by a geotextile protection (or cushion) layer of 6 ounces per square yard (oz/sy) nonwoven needle punched as part of a single sided geocomposite.

2.0 METHOD

There are many situations where geomembranes are placed on or beneath soils containing relatively large-sized stones. For example, poorly prepared soil subgrade with stones protruding from the surface, and cases where crushed-stoned drainage layers are to be placed above the geomembrane.
In all of these situations, a nonwoven needle-punched geotextile can provide significant puncture protection to the geomembrane (Ref 1).

The method presented herein (Koerner, 2005) focuses on the protection of 60 mil (1.5 mm) thick HDPE geomembrane. The method uses the design by function approach.

$$FS = \frac{P_{allow}}{P_{actual}}$$

where:
FS = factor of safety against geomembrane puncture.
P_{actual} = actual pressure due to the landfill contents or surface impoundment.
P_{allow} = allowable pressure using different types of geotextiles and site specific conditions.

The allowable pressure, P_{allow} is determined by the following equation:

$$P_{allow} = \left[50 + 0.00045\left(\frac{M}{H^2}\right)\right] * \left[\frac{1}{(MF_S * MF_{PD} * MF_A)}\right] * \left[\frac{1}{(RF_{CR} * RF_{CBD})}\right]$$

where:

P_{allow} = allowable pressure (kPa)
M = geotextile mass per unit area (g/m^2)
H = protrusion height (m)
MF_S = modification factor for protrusion shape
MF_{PD} = modification factor for packing density
MF_A = modification factor for arching in solids
RF_{CR} = reduction factor for long-term creep
RF_{CBD} = reduction factor for long-term chemical/biological degradation

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	PUNCTURE RESISTANCE OF GEOMEMBRANE, with Geotextile	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

3.0 CALCULATIONS

Evaluate the factor of safety against geomembrane puncture when a 6 oz/sy nonwoven geotextile (as part of a geocomposite) overlies the geomembrane of the base liner system.

Table 1 - Modification Factors and Reduction Factors for Geomembrane Protection Design (reference 1).

MF_S		MF_{PD}		MF_A	
Angular:	1	Isolated	1	Hydrostatic	1
Subrounded:	0.5	Dense, 38 mm	0.83	Geostatic, shallow	0.75
Rounded:	0.25	Dense, 25 mm	0.67	Geostatic, mod.	0.5
		Dense, 12mm	0.5	Geostatic, deep	0.25

RF_{CBD}		RF_{CR}			
		Mass per unit area (g/m^2)	Protrusion (mm)		
			38	25	12
Mild leachate	1.1	Geomembrane alone	N/R	N/R	N/R
Moderate leachate	1.3	270	N/R	N/R	>1.5
Harsh leachate	1.5	550	N/R	1.5	1.3
		1100	1.3	1.2	1.1
		>1100	1.2	1.1	1

- Geotextile mass per unit area, M = 200 g/m^2 (6 oz/sy).
- Depth of material on top of geomembrane, d = 38.1 m (Max. height ≈ 125-feet)
- Unit weight of material on top of geomembrane, γ = 14.9 kN/m^3 (95 pcf)
- Protrusion height, H = 0.0127 m (0.5 inches max.)
- Modification and Reduction Factors:

MF_S = 0.25
MF_{PD} = 0.83
MF_A = 0.75
RF_{CR} = 1.5
RF_{CBD} = 1.5

P_{allow} = {50 + 0.00045*[200/**0.0127**^{2}]} * [1/(**0.25*****0.83*****0.75**]*[1/(**1.5*****1.5**)]
P_{allow} = 1,644 kPa

P_{actual} = d * γ = 38.1 x 14.9230286 = 569 kPa

$$FS = \frac{1{,}644}{569} = 2.9$$ **(OK)**

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	PUNCTURE RESISTANCE OF GEOMEMBRANE, with Geotextile	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CONCLUSION

The results show a factor of safety against geomembrane puncture of 2.9, when the geomembrane is overlain by a 6 oz/sy non-woven, needle punched geotextile. It should be noted that the geomembrane will be overlain by a geocomposite, which consists of 1 layer of 6 oz/sy geotextile heat bonded to the top of a geonet.

5.0 REFERENCES

1- Koerner, R.M. (2005), *Designing with Geosynthetics*, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 5th edition.
2- GSE manufacturer data sheet for nonwoven geotextile, 2014.

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CALCULATIONS

Date:	June 2020	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Geomembrane Puncture - No Geotextile	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

To evaluate the puncture resistance of a 60-mil thick textured high density polyethylene (HDPE) geomembrane on the side slope of Cells 5 through 9 for the J.H. Campbell Dry Ash Landfill Expansion.

2.0 GIVENS/ASSUMPTIONS

1) The proposed side slope liner system consists of:

   -Ash Waste, ~125 feet (ft) thick
   -Geomembrane, 60-mil Textured HDPE
   -Smooth drum rolled subgrade soils

2) In place unit weight of the ash waste is assumed to be 95 pounds per cubic foot (pcf).
3) The subgrade material of the upgraded Cells 5 through 9 is composed of sandy structural fill which will be rock-picked and compacted with smooth drum roller prior to liner installation. The largest protrusion expected in the subgrade is a 0.5-inch diameter subangular particle.

3.0 METHODS

Use the following methods presented in *Theoretical Analysis of Geomembrane Puncture* (Reference 1), to determine the puncture resistance of the 60-mil HDPE in the proposed side slope liner system for Cells 5 through 9 at the J.H. Campbell Dry Ash Landfill.

$$F_P = \pi \, d_p \, \sigma_{peak} \, t_{GM} \, Z_{\varepsilon\, peak}$$ (Equation 1)

Where:

F_p=	force exerted by a probe on the geomembrane when geomembrane puncture occurs (Newtons);
d_p=	assumed circular diameter of the contact area between the probe and the geomembrane (square meters)
σ_{peak}=	peak tensile stress in the geomembrane
t_{GM}=	nominal thickness of geomembrane (millimeters)
$Z\varepsilon_{peak}$=	value of Z_ε for $\varepsilon=\varepsilon_{peak}$ (unitless)

$$\frac{\lambda \, d_s^2 \, p_P}{d_{cs} \, t_{GMs}} = \frac{F_P}{d_p \, t_{GMp}}$$ (Equation 2)

Where:

d_{cs}=	assumed circular diameter of the contact area between the stone and the geomembrane (square meters)
d_s=	diameter of stone (meters)
P_p=	average pressure at the contact between geomembrane and stones when puncture occurs (Pa)
λ=	unitless term that is a function of the stone arrangement (Dense arrangement= 0.87 , Loose arrangement=1.0)
t_{GMs}=	thickness of geomembrane at contact with stone (meters)
t_{GMp}=	thickness of geomembrane used in probe test (meters)

GOLDER
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CALCULATIONS

Date:	June 2020	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Geomembrane Puncture - No Geotextile	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CALCULATIONS

Probe Calculations

d_p=	0.00635	meters (m)	(6.35 millimeter probe)
σ_{peak}=	14,750,000	Pascals (Pa)	(From Attachment 2, Table 2)
t_{GMp}=	0.002	m	(60-mil HDPE)
$Z\varepsilon_{peak}$=	0.728	unitless	(From Attachment 1, Table 1 assuming ε_{peak}= 12%)

Design Geomembrane Calculations

t_{GMs}=	0.002	m	(60-mil HDPE)

"To use [Equation 2], it is necessary to make an assumption regarding the value of d_{cs}. The contact area, hence the value of d_{cs}, depends on several parameters including the angularity of the stones, the thickness and modulus of the geomembrane, and the force applied by the stone on the geomembrane" (Reference 1).

λ=	1	Unitless	(Assume loose arrangement)
d_s=	0.0127	m	(Assume 0.5-inch protrusion)
d_{cs}=	0.003	m	(Assume 25% of d_s for a subangular protrusion)
F_p=	326	Newtons (N)	(Reference 1, Equation 1)
F_p=	1,012	kiloPascals (kPa)	(Reference 1, Equation 2)
	21,141	pounds per square foot (psf)	conversion kPa to psf

Pressure Applied ($P_{applied}$):

- Depth of material on top of geomembrane, d = 125 feet
- Unit weight of material on top of geomembrane, γ = 95 pounds per cubic foot (pcf)

F_p = 21,141 psf

$P_{applied}$ = d * γ = 11,875 psf

Factor of Safety (FS) = F_p / $P_{applied}$

FS = $\dfrac{21{,}141}{11{,}875}$ = **1.8** **<= For 0.5-inch protrusion**

5.0 CONCLUSION

The resulting factor of safety against geomembrane puncture on the subgrade side slope is 1.8, assuming a 0.5 inch subangular protrusion.

6.0 REFERENCES

1) Giroud, J.P., et. Al., Theoretical Analysis of Geomembrane Puncture, Geosynthetics International, 1995, Vol. 2, No. 6.

7.0 ATTACHMENTS

Attachment 1-Table 1: Function Z_{ε}
Attachment 2-Table 2: NSF specifications for puncture resistance and tensile stress and strain at yield of HDPE geomembranes

Table 1. Function Z_s.

ε (%)	Z_s (-)	ε (%)	Z_s (-)	ε (%)	Z_s (-)
0	0.000	2.6	0.381	12	0.728
0.2	0.109	2.8	0.395	13	0.749
0.3	0.134	3	0.408	14	0.768
0.4	0.154	3.2	0.420	15	0.785
0.5	0.172	3.4	0.432	16	0.801
0.6	0.188	3.6	0.443	17	0.816
0.8	0.217	3.8	0.454	18	0.830
1	0.242	4	0.465	19	0.844
1.2	0.264	5	0.513	20	0.856
1.4	0.284	6	0.555	25	0.905
1.6	0.303	7	0.591	30	0.940
1.8	0.321	8	0.624	35	0.964
2	0.337	9	0.654	40	0.980
2.2	0.353	10	0.681	50	0.997
2.4	0.367	11	0.705	57	1.00

Taken from: Giroud, J.P., et. Al., Theoretical Analysis of Geomembrane Puncture, Geosynthetics International, 1995, Vol. 2, No. 6.

Table 2. NSF specifications for puncture resistance and tensile stress and strain at yield of HDPE geomembranes (NSF 1991).

Nominal thickness	t_{GM} (mm)	1.0	1.5	2.0	2.5
Puncture resistance	F_P (N)	214	321	428	535
Tensile stress at yield	σ_Y (MPa)	14.75 for any thickness			
Tensile strain at yield	ε_Y (%)	12 for any thickness			

Notes: The puncture resistance is as measured according to FTMS No. 101C Method 2065. The probe has a diameter of 6.35 mm.

Taken from: Giroud, J.P., et. Al., Theoretical Analysis of Geomembrane Puncture, Geosynthetics International, 1995, Vol. 2, No. 6.

APPENDIX G

Leachate Collection System Calculations

CALCULATIONS

Date:	6/17/2020	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE COLLECTION PIPE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Determine the minimum pipe diameter for the leachate collection system piping for Cells 5 through 9 of the JH Campbell Dry Ash Landfill.

2.0 GIVEN

Minimum slope of leachate collection pipe = 1.0% (post-settlement)

Note: The maximum leachate generation rate occurs during short-term conditions, however, conservatively assume all settlement has occurred.

Approx. Maximum Contributing Area = 2.5 acres (Cell 9, center area)

Note: Each of the cells are designed with more than one leachate collection pipe. The maximum contributing area for the largest cell (cell 9, total area of 7.5 acres) is 2.5 acres, which is the central contribution area.

3.0 METHODS

Maximum Daily Leachate Vol = 11,161 cf/acre/day; (from HELP Analysis)

Note: to determine the greatest volume possible for leachate, the open condition assumes the addition of both leachate and run-off during open conditions

1. Compare the maximum leachate generation rate to the capacity of the proposed leachate collection header pipe.

2. Use Manning's Equation to select minimum pipe size for each area, where :

$$Q_{TL} = \left(\frac{1.49}{n}\right) S^{1/2} {R_h}^{2/3} A$$

For Pipe flowing full

$$R_h = \frac{A}{P}$$

$$A = \pi r^2 = \frac{\pi D^2}{4} \text{ (flowing full) or } = \frac{\pi D^2}{8} \text{ (half full)}$$

$$P = 2\pi r = \pi D$$

$$R_h = \frac{D}{4}$$

Where,

n = Manning's Roughness number
Rh = Hydraulic Radius
A= Flow Area
P = Wetted perimeter
S = slope
Q = Daily Leachate Generation
Q_{TL}= total leachate

3. The maximum daily leachate production rate shown above represents the peak volume for an open condition assuming 5 feet of CCR. Conservatively assume that this condition will exist across the entire cell. In addition, assume that all the flow must enter the pipe: ignore the capacity of the gravel.

Date:	6/17/2020	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE COLLECTION PIPE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CALCULATION

Maximum Leachate Generation Rate

Peak daily leachate generation rate over largest contributing area = 27,902 cf/day

Converting the peak daily rate to cubic feet per second (cfs) = **0.32 cfs**

Minimum Pipe Diameter Required

Use Manning's Equation to determine the min. pipe diameter required to convey the max. leachate generated at the site.

For HDPE pipe, Manning's n = 0.012 (Represents long-term conditions)

$$Q_{TL} = \left(\frac{1.49}{n}\right) S^{1/2} R_h{}^{2/3} A$$

Cell ID	Slope of Pipe (ft/ft)	Area of Cell (acre)	Max. Daily Leachate Gen (cf/acre/day)	Total Leachate (cf/sec)
9	0.0100	2.500	11161	0.3229

Proposed Pipe Flow Capacity

Use Manning's Equation to determine the proposed pipe capacity.

Pipe OD (in)	**Schedule**	**Wall Thickness (in)**	**Pipe ID (in)**	**Half-Full Flow Capacity (cfs)**	**Full Flow Capacity (cfs)**	**Factor of Safety**
8.625	SDR 11	0.830	6.965	**0.453**	**0.907**	1.4

5.0 CONCLUSION

The capacity of a 8-inch diameter SDR 11 HDPE pipe at the minimum slope of 1.0% (post-settlement) exceeds the peak leachate generation rate predicted for a conservative estimate of the worst-case conditions. Calculations assume that all drainage and runoff on a peak daily flow. Therefore, a 8-inch diameter SDR 11 HDPE pipe will be adequate for use as the leachate collection header pipe.

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CALCULATIONS

Date:	2/3/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE COLLECTION PIPING HOLE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Determine the minimum required leachate collection pipe hole spacing for the collection pipe with the CCR Landfill.

2.0 METHODS

1) Estimate the maximum leachate flow length into each leachate collection pipe.
2) Estimate the peak daily leachate production rate.
3) Estimate the required open area for flow into the sump collection pipes.
4) Calculate the minimum required hole spacing based on a maximum entrance velocity (V) of 0.1 ft/sec (Driscol, "Groundwater and Wells")
5) Apply a factor of safety of 1.5 to account for clogging of pipes.
6) The longest length of the collection pipe is approximately 860 feet (Cell 9).
7) The peak daily leachate generation rate is 11,161 cubic feet per acre per day (ft^3/acre/day) for an entire cell. There are 3 pipes in the largest Cell (Cell 9 at 7.5 acres), so resulting peak flow is 3,720 ft^3/acre/day.

3.0 ASSUMPTIONS/ GIVEN:

The length of leachate pipe (L) =	860	ft
The peak daily leachate percolation rate is, (r) =	27,832	gal/acre/day
Peak daily leachate percolation rate (conversion) =	3,720	ft^3/acre/day
Area of infiltration (a) (Cell 9 is largest cell) =	7.5	acres
The peak daily leachate percolation rate (Q=r*a) =	27,903	ft^3/day
Average Flow Rate (Q) conversion =	3.23E-01	ft^3/sec
The collection pipe will be perforated with circular holes of diameter (D_{hole}) =	**0.375**	in
Due to potential clogging of holes, a factor of safety is applied (FS) =	1.5	

4.0 CALCULATIONS:

The area per hole = π $(D_{hole}/2)^2$ =	0.11	in^2
The peak flow rate (Q) =	27,903	ft^3/day
The peak flow rate (Q) =	3.23E-01	ft^3/sec (conversion)

Q=CAV with C (discharge coefficient for holes) =0.62 and V (velocity) =0.1

Therefore, the required open area = A_{open} = Q / (0.62)*(0.1 ft/sec) =	5.21	ft^2
Conversion =	750.07	in^2
The minimum number of holes per linear foot = A_{open} / ($Area_{hole}$ * L) =	7.9	holes per linear foot
Apply a factor of safety (FS) of 1.5 for clogging =	**11.8**	holes per linear foot

5.0 CONCLUSION:

Use 12 holes per foot

Applying a factor of safety of 1.5, the pipe hole spacing should be configured with a minimum of 7.9 holes per linear foot. To address potential scale accumualtion, Golder selected 12 holes per linear foot for the leachate collection pipes.

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	2/3/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	RISER PIPE HOLE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Determine the minimum required pipe hole spacing for the riser pipe in the sump.

2.0 METHODS

1) Estimate the required open area for flow into the riser pipes into the sump.

The flow through the pipe orifice is estimated using Bernoulli's Equation (Ref.1).

Flow through Pipe Orifice (hole):

$$\textit{Bernoulli Equation:} \quad Q_b = C \cdot A_b \cdot (2 \cdot g \cdot \Delta h)^{0.5}$$

where Q_b = inflow capacity per orifice (per hole or slot), ft3/sec;
C = discharge coefficient = 0.62;
A_b = cross-sectional area of a slot or hole on the selected perforated pipe, ft2;
g = gravitational constant (32.2 ft/sec2);
Δh = liquid head, ft.

2) Once the inflow capacity per hole in the pipe is determined, the minimum required number of holes per foot can be calculated as follows:

$$N_{required} = \frac{Q_{pump}}{Q_b \bullet \text{Length of perforated pipe in sump } (l)}$$

Where $N_{required}$ = Minimum Required Perforations (holes) per foot
l = Length of perforated pipe in sump (feet)
Q_b = Leachate Flow into pipe (gal/min)
Q_{pump} = Pump rate (gpm)

3) Evaluate the proposed design as follows:

Leachate Flow into pipe in sump:

$$Q_{pipe} = N_{design} \bullet \text{Length of perforated pipe in sump } (l) \bullet Q_b$$

Where N_{design} = Proposed Number of Perforations (holes) per foot
l = Length of perforated pipe in sump (feet)
Q_b = Leachate Flow into pipe (gal/min)

Date:	2/3/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	RISER PIPE HOLE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

2.0 METHODS cont.:

Factor of Safety: Flow into pipe *to* pump capacity.

$$FS = \frac{Q_{pipe}}{Q_{pump}}$$

3.0 ASSUMPTIONS/GIVENS:

1) The pipe perforations will have a minimum diameter of 3/8-inch (See Engineering Drawings).
2) The length of perforated pipe in the sump will be at a minimum of 40-feet (See Engineering Drawings).
3) Primary sump pumps will have a maximum capacity of 150 gallons per minute (gpm) as requested by the Owner.
4) Based on sump pump on/off levels, the minimum liquid head in the sump is 2.9-feet.

4.0 CALCULATIONS

Leachate inflow capacity per hole:

$$\textit{Bernoulli Equation:} \quad Qb = C \cdot Ab \cdot (2 \cdot g \cdot \Delta h)^{0.5}$$

discharge coefficient = 0.62;	C	0.62	
Diameter of round hole in inches =		0.375	in
cross-sectional area of a slot or hole on the selected perforated pipe, ft^2 ;	A_b	0.00077	ft^2
gravitational constant (g = 32.2 ft/sec^2); and,	g	32.2	ft/sec^2
liquid head, ft.	Δh	2.90	ft

$(2 \cdot g \cdot \Delta h)^{0.5} = v_{entrance}$

v = limit leachate entrance velocity, ft./sec

	$v_{entrance}$	**13.67**	ft/sec
inflow capacity per orifice (per hole or slot), ft^3/sec;	Q_b	0.00650	ft^3/sec
inflow capacity per orifice (per hole or slot), gal/min;	Q_b	**2.90**	**gpm**

Minimum required number of perforation holes per foot of pipe:

$$N_{required} = \frac{Q_{pump}}{Q_b \bullet \text{Length of perforated pipe in sump } (l)}$$

Pump rate (gpm)	Q_{pump}	150	gpm
Length of perforated pipe in sump (feet)	l	40	ft
Minimum Required Number of Perforations (holes) per foot	$N_{required}$	1.3	holes/ft

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CALCULATIONS

Date:	2/3/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	RISER PIPE HOLE SIZING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CALCULATIONS CONT.:

CHECKING PROPOSED DESIGN

Leachate flow into pipe in sump as designed:

$$Q_{pipe} = N_{design} \cdot \text{Length of perforated pipe in sump } (l) \cdot Q_b$$

Designed Number of Perforations (holes) per foot	p	6	
Length of perforated pipe in sump (feet)	l	40	ft
Leachate Flow into pipe (gal/min)	Q_{pipe}	**697**	**gpm**

Factor of Safety: Flow into pipe *to* pump capacity.

$$FS = \frac{Q_{pipe}}{Q_{pump}}$$

Pump rate (gpm)	Q_{pump}	150	gpm
Factor of Safety: Flow into pipe *to* pump capacity	**FS**	**4.6**	**OK**

5.0 CONCLUSION

The minimum required number of holes per foot for the riser pipe in the sump is 1.3, assuming a 3/8-inch diameter holes, maximum sump pump rate of 150 gpm, and a minimum length of perforated pipe of 40-feet. Golder selected 6 holes per linear foot for the riser pipes.

6.0 REFERENCE

1 - Geotechnical Aspects of Landfill Design and Construction, X. QIAN; R. KOERNER; D. GRAY; 2002 PRENTICE-HALL, INC.

APPENDIX H

Pipe Crushing Calculations

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CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

To evaluate the structural integrity of the proposed and existing 8-inch diameter HDPE or PVC perforated leachate collection and riser pipes within the CCR Landfill at the JH Campbell under the vertical loading imposed by the waste placement.

2.0 METHOD:

The structural integrity of the HDPE piping will be evaluated by estimating the maximum load and deflection applied at final grades. Cell 5 and 6 were selected for the analysis of the proposed and existing cells, respectively, since they contain the highest thickness of waste (worst case scenario). Limiting strain was selected 2.7% (Ref 1) and maximum allowable deflection was selected 7.5% (Ref 2, 3 and 4).

3.0 ASSUMPTIONS:

1 - Pipe Material and Loading
Properties such as wall thickness, pipe stiffness, and modulus of elasticity were based on manufacturer's literature from Plexco piping (Chevron).

2- Loading
The average waste density was assumed at 95 pounds per cubic foot (pcf), and the maximum fill heights were determined based on ENGINEERING DRAWINGS taking into account the future vertical expansion.

3- Material Surrounding Pipe

Based on the current design, the material surrounding the pipe will be coarse-grained soils. Reference 1 , Table 9.3, presents a range of values on the appropriate soil modulus for coarse-grained soils of 200 pounds per square inch (psi) to 3,000 psi : a value of 3,000 psi is chosen for a high degree of compaction. This value is reasonable given that the coarse-grained soil will be under relatively high loads.

4- Existing leachate collection system pipes are assumed to have 12, 3/8-inch holes per foot.

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CALCULATION:

Pipe Loading - Example for 6" diameter HDPE Pipe only

$$W_{p=}\frac{12}{12-\mathrm{N}*\mathrm{D}}*W$$ (See Ref. 1, pg. 306, equation 9.18.)

$$W=\left[\sum(H)*D_W*OD\right]*\frac{1\,psf}{144\,psi}$$ (See Ref. 1, pg. 306, equation 9.18.)

where:

Wp = Total pipe load adjusted for pipe perforation, (pounds per inch)
H = Thickness of overburden, (ft)
Hf = Thickness of final cover, (ft)
Hd = Thickness of drainage layer, (ft)
D_w = Unit weight of overburden, (pcf)
Df= Unit weight of final cover, (pcf)
Dd= Unit weight of drainage layer, (pcf)
N = Number of holes per foot of pipe
D = Diameter of perforation, (inch)
W = Vertical Stress on pipe, (pounds per inch), see Ref. 1 for perforated pipe
OD = Outside diameter of pipe (in)

Solving for Load on 8 " SDR 11 HDPE Pipe with Given Height of Waste Overburden

D_w =	95.0	pcf for waste	
Df=	100.0	pcf	
Dd=	100.0	pcf	
H =	125.0	ft	(includes allowance for future airspace recovery)
Hf =	3.00	ft	
Hd =	1.00	ft	
OD =	8.63	in	
ID =	6.97	in	
N =	12.0	holes per foot	
D =	0.375	in	

$$W=\left[\sum(H)*D_W*OD\right]*\frac{1\,psf}{144\,psi}$$

W = 735 lbs/in

$$W_{p=}\frac{12}{12-\mathrm{N}*\mathrm{D}}*W$$

Wp = 1,176 lbs/in

Deflection (modified Iowa)

$$\%\,Deflection=\frac{\Delta Y}{D}*100 \qquad \%\,Deflection=\frac{\Delta Y}{2*r}*100$$ (See Ref. 1, page 308, equation 9.19.)

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 Calculation cont.:

$$\Delta X = \frac{D_l(K) * W_p * r^3}{(Ef * I) + (0.061(Es * r^3))}$$ (See Ref. 1, page 305, equation 9.16.)

$$\Delta Y \approx \Delta X$$ for <10% deflection (See Reference 1, page 308.)

where :

% Deflection = Amount of pipe deflection expected for load applied to top of pipe. Allowable deflection determined by comparison of pipe strain.
ΔY = Deflection of pipe in vertical direction
ΔX = Deflection of pipe in horizontal direction, as per Ref. 1, eqn. 9.16
D_1 = Deflection lag factor, 1.0 for long term as per Ref. 1, Table 9.2, pg 307
K = Bedding Constant, 0.1 as per Ref. 1, Table 9.1, page 306
W_p = Total pipe load adjusted for pipe perforation, (psi)
Ef = Pipe modulus of elasticity, (psi)
Es = Soil modulus for backfill around pipe, (psi)
OD = Outside diameter of pipe (in)
ID = Inside diameter of pipe (in)
Tp = Pipe wall thickness (in), Tp = (OD-ID)/2
r = Mean pipe radius (in), r=(OD-Tp)/2
I = Moment of inertia (in^3), I = Tp^3/12

Solving for Deflection and Factor of Safety for Strain and buckling w/given Ht. of Waste Overburden

D_1 =	1	
K =	0.1	
Es =	3,000	psi
Ef =	25,600	psi
Tp = (OD-ID)/2 =	0.83	in
r = (OD-Tp)/2 =	3.90	in
I = Tp^3/12 =	0.05	in^3

$$\Delta X = \frac{D_l(K) * W_p * r^3}{(Ef * I) + (0.061(Es * r^3))}$$

ΔX =	0.58	in
ΔY = ΔX =	0.58	in

$$\% \, Deflection = \frac{\Delta Y}{2 * r} * 100$$

% Deflection = 7.4 OK

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 Calculation cont.:

Constrained Wall Buckling (Ref. 2)

$$P = \frac{W_p}{OD}$$

$$P_{cr} = \frac{2.32 * Ep * 0.87}{SDR^3}$$

$$P_b = 0.8\sqrt{P_{cr} * Es}$$

$$FS_{wb} = \frac{P_b}{P}$$

where:

P = Overburden pressure, corrected for perforations (psi)
Wp = Total pipe load adjusted for pipe perforation, (pounds per inch)
OD = Outside diameter of pipe, (in)
P_{cr} = Critical Buckling soil pressure at the top of the pipe, (psi)
Es = Soil modulus for backfill around pipe, (psi)
Ep = Pipe modulus of elasticity, (psi)
SDR = Standard Dimension Ratio for selected pipe
FS_{cr} = Factor of Safety for critical buckling

Solving for Deflection and Factor of Safety for Strain and buckling w/given Ht. of Waste Overburden

Wp = 1,176 lbs/in
OD = 8.625 in

$$P = \frac{W_p}{OD}$$

P = 136.4 lbs/in^2

Es = 3,000 psi
Ep = 25,600 psi
SDR = 11

$$P_{cr} = \frac{2.32 * Ep * 0.87}{SDR^3}$$

P_{cr} = 38.82 psi

$$P_b = 0.8\sqrt{P_{cr} * Es}$$

Pb = 273 psi

$$FS_{wb} = \frac{P_b}{P}$$

FS_{wb} = 2.0 OK

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 Calculation cont.:

Percent Pipe Strain (Ref. 3)

$$e = 6.0 * \left(\frac{\Delta Y}{2 * r}\right)\left(\frac{0.53 * Tp}{2 * r}\right) * 100\%$$

where:

e = Maximum allowable pipe strain, 4.2 % as per Ref .3
ΔY = Deflection of pipe in vertical direction
Tp = Pipe wall thickness (in), Tp = (OD-ID)/2
r = Mean pipe radius (in), r=(OD-Tp)/2
OD = Pipe outside diameter, (in)
ID = Pipe inside diameter, (in)

Solving for Deflection and Factor of Safety for Strain and buckling w/given Ht. of Waste Overburden

Tp = (OD-ID)/2 = 0.83 in
r = (OD-Tp)/2 = 3.90 in
ΔY = 0.58 in

$$e = 6.0 * \left(\frac{\Delta Y}{2 * r}\right)\left(\frac{0.53 * Tp}{2 * r}\right) * 100\%$$

e = 2.51 % **OK**

Fs_{strain} = 2.7%/e = 1.1 OK

5.0 CONCLUSION:

The pipes are designed to withstand the expected loads.

	8-inch HDPE SDR 11 LCS Pipe		
	Estimated	Max. Allowed	Acceptable?
Pipe Deflection (%)	7.4	7.5	**OK**
Wall Buckling Safety Factor	2.0	>1.5	**OK**
Pipe Strain (%)	1.1	2.7	**OK**

TABLE 2 - Summary of Results

See attached Table 2 for the 18-inch SDR 17 and 8 inch SCH 80 PVC pipe calculations. Results are acceptable.

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

6.0 REFERENCES:

1 - Geotechnical Aspects of Landfill Design and Construction, X. QIAN; R. KOERNER; D. GRAY; 2002 PRENTICE-HALL, INC.

2 - Engineering Manual Book 2. System Design, Chevron Chemical Company, 2003, 1050 Busse Highway, Suite 200, Bensenville, IL 60106, (630)-350-3700, pg 111&112.

3 - Plastic Pipe Design Manual - Lamson Vylon Pipe, Cleveland, Ohio, pg7.

4 - ASTM F - 894 High Density Spirolite Polyethylene Pipe Product Data, 2006, Industrial Pipe Fittings LLC, Bulletin 910, pg 12.

5 - DRISCOPIPE SYSTEM DESIGN, Phillips Driscopipe, Inc., 1990, P.O Box 83-83866, 2929 North Central Expressway, Suite 100; Richardson, Texas 75083, (800)572-0662.

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CALCULATIONS

Date:	May-21	**Made by:**	BAB
Project No.:	19132873	**Checked by:**	DJS
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	TDJ
Project Short Title:	(CPA)		

TABLE 2		**UNITS**			
Pipe Material			**PVC**	**HDPE**	**HDPE**
Pipe Size			8	18	8
Schedule			80		
SDR=Standard Dimension Ratio	SDR			17	11
Prism Load on Buried Pipe					
In-Place Density of Overburden	Dw	pcf	95	95	95
Maximum Fill depth over pipe per design (assuming future airspace recovery)	H	ft	125	125	125
Outside Diameter of Pipe	OD	in	8.625	18.000	8.625
Inside Diameter of pipe	ID	in	7.189	17.000	6.965
Pipe Wall Thickness	Tp	in	0.718	0.500	0.830
Tp=(OD-ID)/2					
Vertical Stress on pipe	W	lbs/in	711.26	1484.38	711.26
W=(Dw*H*OD)*(1/144)					
Dia. of perforations	D	in	0.375	0.375	0.375
No: of Perforation per foot	N	/ft	12	6	12
Modified Vertical stress	Wp	lbs/in	1138	1827	1138
Wp = (W*12)/(12-(D*N))					
Horizontal Deflection					
Modified IOWA Method					
Deflection Lag factor	D1		1	1	1
Mean Pipe radius	r	in	3.95	8.75	3.90
r=(OD-Tp)/2					
Bedding Thickness	Tb	in.	3	3	3
Bedding Constant	K		0.1	0.1	0.1
Modulus Soil Reaction	Es	psi	3000	3000	3000
Pipe Flexural Modulus	Ef	psi	360000	25600	25600
Moment of Inertia	I	in^3	0.031	0.010	0.048
$I = (Tp^3/12)$					
Horizontal Deflection	X	in	0.314	0.996	0.559
$X = (D1*K*Wp*r^3)/((Ef*I)+(0.061*Es*r^3))$					
Vertical Deflection	Y	in	0.314	0.996	0.559
If <10% DEFLECTION then X = Y					
Percentage Deflection		%	4.0	5.7	7.2
(Y/2*r)*100				**Acceptable**	**Acceptable**
Factor of Safety for pipe deflection	FS		**7.6**		
FS=30%/deflection for PVC			**Acceptable FS**		
Ring Bending Strain					
e = 6.0*(Y/2r)(0.53*Tp/2r)*100%	e		NR	0.52	2.43
Provided F.S.				**8.1**	**1.1**
Limiting strain = 2.7%					
Pipe Buckling					
Overburden Pressure, corrected for perforations	P	lbs/in	NR	101.50	131.94
P=Wp/OD					
Modulus Soil Reaction	Es	psi		3000	3000

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CALCULATIONS

Date:	May-21	**Made by:**	BAB
Project No.:	19132873	**Checked by:**	DJS
Subject:	Permit Revision Landfill Pipe Crushing	**Reviewed by:**	TDJ
Project Short Title:	(CPA)		

TABLE 2			**UNITS**			
Pipe Material				**PVC**	**HDPE**	**HDPE**
Pipe Size				8	18	8
Pipe Modulus of Elasticity		Ep	psi		25600	25600
Critical Buckling Pressure		Pcr	lbs/in		10.52	38.82
Pcr=2.32*Ep*.87/SDR^3						
Modified Buckling Pressure, includes soil interaction		Pb	lbs/in		142.1	273.0
Pb=0.8*(Pcr*Es)^0.5						
Factor of Safety for pipe buckling		FS			**1.4**	**2.1**
FS=Pb/P						

APPENDIX I

Geotextile Filtration Calculation

GOLDER MEMBER OF WSP

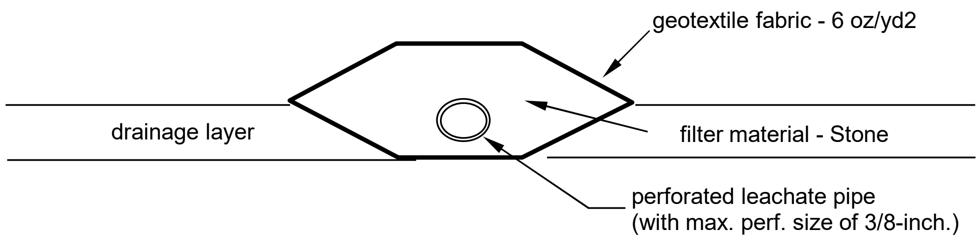
CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	FILTRATION FABRIC CLOGGING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Evaluate the material criteria used for preventing unacceptable quantities of clogging with respect to the leachate collection system (LCS) pipe hole size. Determine the gradation of filter material to surround the LCS pipes and specify the requirements for a geotextile to function as separation between the filter material and the drainage materials.

2.0 GEOMETRY



3.0 ASSUMPTIONS/GIVENS

1. The hole diameter in the lateral drains of the LCS is 3/8-inch. The diameter of the holes was chosen based on the strength and deflection requirements of the leachate pipe, and the inflow quantities of the leachate (see Leachate Pipe Crushing and Deflection Calculation and Leachate Collection Pipe Hole Spacing Calculation).

2. The filter material to be used is a washed stone. The filter material shall be a graded, cohesionless soil filter which does not have more than 5%, by weight, that passes the 3/8-inch sieve and which does not permit the passage of soil particles that are more than 3 inches in any dimension (Ref 2). Diameter at which 85% of the filter material is smaller (D85) is assumed to be between 3/4 inch and 1 inch.

3. The drainage material shall have a hydraulic conductivity equal to or greater than 1×10^{-3} cm/sec, be free of any organic material and also have less than 5%, by weight, passing the No. 200 sieve.

4.0 METHOD

Step 1 - Specify the gradation restraints for the filter material (Ref. 1)

$$\frac{D_{85}}{D_{max}} \geq 2 \qquad\qquad \frac{D_{85}}{0.375\text{ inch}} \geq 2$$

$$D_{max} = 0.375\text{ inch}$$

$$D_{85} \geq 2^* D_{max} \qquad\qquad D_{85} \geq 2^*\ 0.0.375$$

where :

D_{85} = diameter at which 85% of the filter material is smaller.

D_{max} = maximum opening of the pipe drain

$$D_{85} \geq 0.75\text{ in.} \quad \text{or} \quad 19.05\text{ mm}$$

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	FILTRATION FABRIC CLOGGING	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 METHOD CONT.

Step 2 - The requirements for the relationship between the geotextile and the drainage materials that it will filter is specified (Ref. 2) as the following:

$$\frac{O_{95}}{D_{85}} \leq 2.0 \qquad\qquad O_{95} \leq 2 * D_{85}$$

where :

D_{85} = diameter at which 85% of the drainage material is smaller.

O_{95} = Apparent Opening Size of geotextile (mm)

Evaluating for a 6 oz/yd^2 geotextile fabric

O_{95} = 0.212 mm (Ref 3)

D_{85} $\geq$ 0.424 mm (minimum grain size for sand drainage material)

Step 3 - Determine the required permeability of the geotextile filter around the leachate trench aggregate.

The required permeability is calculated by assuming all flow to go through a 1-ft wide geotextile at the top of the trench. This will be the most critical scenario.

The following equation applies per unit foot of trench:

$$k * i * 1' * 1' = q_{max} * L*1'$$

where: k = required permeability of geotextile

i = hydraulic gradient

q_{max} = maximum leachate impingement rate from HELP model

L = maximum length of accepting areas from both sides of the trench drain

5.0 CALCULATIONS

Step 1: Gradation Restraints:

A conservative value of 1 inches (25.4 mm) is assumed as D85 for this calculation.

D_{85} - design $\geq$ 19.05 mm $\qquad$ D_{85} - Actual $\geq$ 25.4 mm

$$\frac{D_{85}}{D_{max}} \geq \frac{25.4}{9.525} = 2.7 \qquad \textbf{OK}$$

5.0 CALCULATIONS CONT.

Step 2: Filter Fabric (Geotextile) vs. the Drainage Material

Typical gradation for similar drainage sand material based on unpublished data from Golder Associates Lansing Laboratory, was used to estimate the design D_{85}. The design D_{85} was conservatively assumed as 2.0 mm for this calculation.

$$\frac{O_{95}}{D_{85}} = \frac{0.212}{2.0} = 0.11 \leq 2 \quad \textbf{OK}$$

Step 3: Required Permeability of the Geotextile Around the Leachate Trench Aggregate

$$k * i * 1' * 1' = q_{max} * L*1'$$

where: k = required permeability of geotextile

i = hydraulic gradient = 1

q_{max} = maximum leachate impingement rate, i.e. peak daily, from HELP model
= 11,161 (cf/acre/day)
= 9.04E-05 (cm/sec)

L = maximum leachate flow path length of accepting areas from both sides of the trench drain
= 50 ft
= 1,524 cm

The specifications for as-manufactured geotextile parameters are:

Water Flow Rate= 4480 L/min/m2

The permeability of the geocomposite is reduced using a reduction factor (RF):

RF=RFcr X RFcc X RFbc X RFscb = 16.20

where:

(Ref. 4)	RFcr =	1.5	Reduction Factor for Creep
	RFin =	1.0	Reduction Factor for Intrusion
	RFcc =	3.0	Reduction Factor for Chemical Clogging
	RFbc =	1.2	Reduction Factor for Biological Clogging
	RFscb =	3.0	Reduction Factor for Soil Clogging

$k_{manufacturer}$ = 0.46 cm/sec

$k_{required}$ = **0.14 cm/sec** < $k_{manufacturer}$ = 0.46 cm/sec **OK**

Therefore, the manufacturer's standard specifications is sufficient.

6.0 CONCLUSION

The selected materials to prevent clogging in the leachate collection system pipes, 3/4 inch washed stone (around the pipe) and 6 oz/sy non woven geotextile, met the specification of gradation restraints and Part 115 Rule 423.(4)(b).

7.0 REFERENCE

1. Design of small dams, U.S. Dept. of the Int., Bureau of Recl., US Government Printing Office, Washington, 1973.
2. Rule 423.(4)(b), Michigan Department of Environmental Quality, PA 451 Part 115 Rules
3. GSE Nonwoven Geotextiles Product Specifications, 2014.
4. Qian, Xuede; Donald Gray, and Robert M. Koerner, “Estimation of Maximum Liquid Head over Landfill Barriers”, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, May 2004.

APPENDIX J

Leachate Mounding Calculation

Leachate Head-On-Liner Calculation

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE MOUNDING - GEOCOMPOSITE ON THE FLOOR, SAND ON THE SIDESLOPES	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Evaluate the maximum leachate mounding for the geocomposite option and the toe drain strip anticipated within the leachate collection system for the Open and Intermediate Condition using peak daily leachate production results under a 5-feet of waste depth (Open) and 50-feet waste depth (Intermediate) scenario.

2.0 ASSUMPTIONS

1) The leachate collection piping will serve as a conduit to transfer liquid from the drainage layer to the sump and have a flow capacity large enough to maintain the head on the primary liner less than 1-foot in depth as per the EGLE regulations.

2) The leachate collection system consists of 24 inches of $1x10^{-3}$ centimeters per second (cm/sec) sand on the side slopes and a single sided geocomposite on the floor, as per the drawings.

3) The depth of the leachate head at any point will be designed to be less than the thickness of the drainage media per the MDEQ regulations.

4) Assuming a factor of safety of minimum 2, the depth of the leachate head on the leachate collection system at any point on the liner is designed to be less than or equal to 6 inches.

4) The percolation rate will be derived from the largest peak daily infiltration rate calculated by the HELP Model for the open and intermediate stages of the landfill.

6) Use a typical manufacturer's material that exhibits the lowest permeability and thinnest thickness to meet the Transmissivity requirements. The Transmissivity is reported based on a low loading condition for the open case (500 pounds per square foot (psf)) and a higher loading for the intermediate case (7,000 psf).

5) Per the subgrade design - See Sheet 5, the maximum flow length is 50-feet sloped at 2-percent toward the leachate collection piping.

3.0 METHODS

1) Two mounding methods will be used to calculate the head on the liner, Giroud 2000, and McEnroe's 93 (Ref. 1) using the peak daily volume estimated by the HELP Model.

2) The open condition considers a waste depth of 5-feet, i.e. the first lift of waste, 500 pounds per square foot (psf) normal load and a peak daily volume of:

11,161 cubic feet per acre per day (cf/acre/day)
83,495 gallons per acre per day (gpad)

3) The intermediate condition considers a waste depth of 70-feet, 7,000 psf normal load, i.e. the operational waste depth, and a peak daily volume of:

11,161 cubic feet per acre per day (cf/acre/day)
83,495 gallons per acre per day (gpad)

Leachate Head-On-Liner Calculation

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE MOUNDING - GEOCOMPOSITE ON THE FLOOR, SAND ON THE SIDESLOPES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill Expansion Construction Permit Application (CPA)

4.0 CALCULATIONS

1) **INTERMEDIATE CASE**
The Transmissivity of the geocomposite is reduced using the procedures presented in the Geosynthetic Research Institute GC8- "Determination of the Allowable Flow Rate in a Drainage Geocomposite" (Ref. 1).

	Geocomposite:			
	Measured Transmissivity (T-meas) =	1.00E-03	m^2/sec	(Ref. 2)
	Hydraulic Conductivity =	15.75	cm/sec	
	RF=RFcr X RFcc X RFbc =	1.37		
	where:			
In an INTERMEDIATE case, older waste, reduction factors are considered.	RFcr =	1.2	Reduction Factor for Creep	
	RFin =	1.0	Reduction Factor for Intrusion (already accounted for in normal loading)	
	RFcc =	1.2	Reduction Factor for Chemical Clogging	
	RFbc =	1.0	Reduction Factor for Biological Clogging	
	Allowed Transmissivity (T-allowed) =	7.31E-04	m^2/sec	T-allowed = T-meas/RF
	hydraulic conductivity K =	32593.50	ft/day	Allowed Transmissivity/thickness
	conversion =	11.50	cm/sec	
	Thickness of geonet =	250	mils	

2) **OPEN CASE**
The Transmissivity of the geocomposite is as manufacturered.

	Geocomposite:			
	Measured Transmissivity (T-meas) =	1.00E-03	m^2/sec	(Ref. 2)
	Hydraulic Conductivity =	15.75	cm/sec	
	RF=RFcr X RFcc X RFbc =	1.00		
	where:			
In an OPEN case, newly placed waste, the reduction factors are not yet considered.	RFcr =	1.0	Reduction Factor for Creep	
	RFin =	1.0	Reduction Factor for Intrusion	
	RFcc =	1.0	Reduction Factor for Chemical Clogging	
	RFbc =	1.0	Reduction Factor for Biological Clogging	
	Allowed Transmissivity (T-allowed) =	1.00E-03	m^2/sec	T-allowed = T-meas/RF
	hydraulic conductivity K =	44617.24	ft/day	Allowed Transmissivity/thickness
	conversion =	15.75	cm/sec	
	Thickness of geonet =	250	mils	

Leachate Head-On-Liner Calculation

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE MOUNDING - GEOCOMPOSITE ON THE FLOOR, SAND ON THE SIDESLOPES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill Expansion Construction Permit Application (CPA)

CALCULATIONS Continuation:

See following worksheets:

1. Bi-axial 250 mil geocomposite layer on the floor with the intermediate HELP model case.
2. Bi-axial 250 mil geocomposite layer on the floor with the open HELP model case.

4.0 CONCLUSION

Using these materials the anticipated head on the composite liner system is less than 1 foot and less than the thickness of the drainage layer geocomposite as well. Therefore, the drainage layer will function properly.

5.0 REFERENCES

1) GRI Standard GC8 - Determination of the Allowable Flow Rate of a Drainage Geocomposite, Geosynthetic Research Institute, April 17, 2001.

2) GSE 250-mil Geocomposite Product Specification from GSE, 2013.

3) Qian, Xuede; Donald Gray, and Robert M. Koerner, “Estimation of Maximum Liquid Head over Landfill Barriers”, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, May 2004.

Leachate Head-On-Liner Calculation

FACILITY:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)	5/24/2021
UNIT:	Intermediate Floor	Sheet 2

PRIMARY LEACHATE COLLECTION SYSTEM

	Design Variables for input				
	Calculated Values				
		Units		Units	Notation
Slope to Pipe	0.0200	ft/ft	2.00%		***S1***
Slope of Pipe	0.0150	ft/ft	1.50%		***S2***
Combined Slope	0.0250	ft/ft	2.50%		***S***
Slope Angle	0.025	radians	1.43	degrees	**a**
Max. Perp. Length to Pipe (1)	50	feet	600	inches	
Adjusted Flow Length	50	feet	600	inches	***L***
Geocomposite Thickness	250	mils	0.25	inches	
Geocomposite Permeability	15.75	cm/sec			
Reduction/Safety Factor	1.37			RFcr, cc, bc	***INTERMEDIATE***
Geocomposite Permeability	11.50	cm/s	391,076	in/day	***K geotextile***
Effective Permeability	1.15E+01	cm/s	391,076	in/day	***K avg.***
Percolation Rate (2)	83,495	gpad	3.0751	ipad	***r***

Predicted Leachate Head				
Method	**Modeled Design**			
Giroud 2000	**0.24**	inches	$\leq$ 0.25 inches	OK
McEnroe's 93	**0.18**	inches	$\leq$ 0.25 inches	OK

R =	0.0126	
A =	0.9745	
B =	N/A	
R < 0.25	0.012	Y max
	0.181	y max
R = 0.25	N/A	Y max
	N/A	y max
R > 0.25	N/A	Y max
	N/A	y max

Notes:
(1) Leachate will be collected at the toe of the slope (see Engineering Drawings)

(2) Only the geocomposite drainage layer is being considered in this calculation.

Leachate Head-On-Liner Calculation

FACILITY:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)	5/24/2021
UNIT:	Open Floor	Sheet 3

PRIMARY LEACHATE COLLECTION SYSTEM

	Design Variables for input				
	Calculated Values				
		Units		Units	Notation
Slope to Pipe	0.0200	ft/ft	2.00%		***S1***
Slope of Pipe	0.0150	ft/ft	1.50%		***S2***
Combined Slope	0.0250	ft/ft	2.50%		***S***
Slope Angle	0.025	radians	1.43	degrees	**a**
Max. Perp. Length to Pipe [1]	50	feet	600	inches	
Adjusted Flow Length	50	feet	600	inches	***L***
Geocomposite Thickness	250	mils	0.25	inches	
Geocomposite Permeability	15.75	cm/sec			
Reduction/Safety Factor	1.00			RFcr, cc, bc	***OPEN***
Geocomposite Permeability	15.75	cm/s	535,344	in/day	***K geotextile***
Effective Permeability	1.57E+01	cm/s	535,344	in/day	***K avg.***
Percolation Rate [2]	83,495	gpad	3.0751	ipad	***r***

Predicted Leachate Head				
Method	**Modeled Design**			
Giroud 2000	**0.17**	inches	≤ 0.25 inches	OK
McEnroe's 93	**0.13**	inches	≤ 0.25 inches	OK

R =	0.0092	
A =	0.9814	
B =	N/A	
R < 0.25	0.009	Y max
	0.133	y max
R = 0.25	N/A	Y max
	N/A	y max
R > 0.25	N/A	Y max
	N/A	y max

Notes:
(1) Leachate will be collected at the toe of the slope (see Engineering Drawings)
(2) Only the geocomposite drainage layer is being considered in this calculation.

APPENDIX K

HELP Model Calculations

CALCULATIONS

Date:	24-May-21	**Made by:**	ACB
Project No.:	19132873	**Checked by:**	TDJ
Subject:	HELP MODEL - Ash Landfill	**Reviewed by:**	GJD

Project Short Title: JH Campbell Dry Ash Landfill Expansion Construction Permit Application

1.0 OBJECTIVE

Estimate the average and peak leachate generation rates for the open, operational, and closure stages of the JH Campbell dry ash landfill using the new waste height of 125-feet for an expansion.

2.0 METHOD

Use the HELP Model (Ref. 1) with layers simulating the proposed liner, waste, and cover materials, along with climatic data and evapotranspiration parameters consistent with anticipated site conditions.

Model (OP) open condition, (IT) intermediate cover condition, and (FC) final cover condition.

3.0 GIVEN

General:

Climate data was synthetically generated through the Visual HELP Model using default coefficients for Grand Rapids, MI and historic temperature and rainfall data for Grand Rapids, MI. Cross slope of the landfill floor is assumed 2% along the leachate flow path. The final cover slope is assumed to be 5% at the plateau area.
Due to some uncertianty regarding CCR characteristics, all scenarios have been modelled using two separate hydraulic conductivities ($1.0x10^{-5}$ and $1.0x10^{-6}$).

Initial Condition
Case 1: Base Liner System with 5 feet CCR and hydraulic conductivity of $1.0x10^{-5}$ (1A) or $1.0x10^{-6}$ (1B)

5 feet of coal combustion residue (CCR)
12-inch soil protective layer
Geocomposite with 220-mil geonet core
60-mil HDPE geomembrane
240-mil Geosynthetic Clay Liner (GCL)
Geocomposite with 200-mil geonet core
60-mil HDPE geomembrane
Subgrade Soil

Intermediate Condition
Case 2: Base Liner System with 50 feet CCR and hydraulic conductivity of $1.0x10^{-5}$ (2A) or $1.0x10^{-6}$ (2B)

50 feet of coal combustion residue (CCR)
12-inch soil protective layer
Geocomposite with 220-mil geonet core
60-mil HDPE geomembrane
240-mil Geosynthetic Clay Liner (GCL)
Geocomposite with 200-mil geonet core
60-mil HDPE geomembrane
Subgrade Soil

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	24-May-21	**Made by:**	ACB
Project No.:	19132873	**Checked by:**	TDJ
Subject:	HELP MODEL - Ash Landfill	**Reviewed by:**	GJD

Project Short Title: JH Campbell Dry Ash Landfill Expansion Construction Permit Application

Final Conditions

Case 3: Final, with Cap and 89 feet CCR and hydraulic conductivity of $1.0x10^{-5}$ (3A) or $1.0x10^{-6}$ (3B)

6-inch topsoil
24-inch protective soil layer
40-mil HDPE Geomembrane
6-inch thick grading layer
125 feet of coal combustion residue (CCR)
12-inch soil protective layer
Geocomposite with 220-mil geonet core
60-mil HDPE geomembrane
240-mil Geosynthetic Clay Liner (GCL)
Geocomposite with 200-mil geonet core
60-mil HDPE geomembrane
Subgrade Soil

4.0 ASSUMPTIONS

1) Bottom liner geomembrane modeled as having 2 pinholes/acre, 2 installation defects/acre, and good placement quality.

2) Initial soil and waste moisture contents calculated by model assuming a steady-state condition.

3) **Open Condition - Methodology/Assumptions**
   6-inches of daily cover soil
   5 feet of waste
   Bare ground
   Leaf area index = 0
   Evaporative zone depth = 8-inches
   1% of area allowed to have runoff
   10-yr simulation period

4) **Intermediate Cover Condition - Methodology/Assumptions**
   6-inches of daily cover soil
   50 ft of waste
   Fair grass
   Leaf area index = 1
   Evaporative zone depth = 8-inches
   75% of area allowed to have runoff
   10-yr simulation period

5) **Final Cover Condition - Methodology/Assumptions**
   125 feet of waste
   Good grass
   Leaf area index = 4
   Evaporative zone depth = 20-inches
   100% of area allowed to have runoff
   Surface Slope = 5%
   30-yr simulation period

Date:	24-May-21	**Made by:**	ACB
Project No.:	19132873	**Checked by:**	TDJ
Subject:	HELP MODEL - Ash Landfill	**Reviewed by:**	GJD

Project Short Title: JH Campbell Dry Ash Landfill Expansion Construction Permit Application

5.0 RESULTS

See Table 1 - HELP MODEL SUMMARY TABLE, and attached HELP output files.

A total of 3 scenarios are analyzed, and the input and output values are included on Table 1.

6.0 CONCLUSION

Review of the HELP results indicates that the maximum peak daily leachate generation rate occurred for open conditions and is estimated as 11,161 gallons/acre/day. This peak value is used to size the leachate collection system piping, pumps, and sump.

7.0 REFERENCES

1.) *HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL VERSION 3.07 (1 NOVEMBER 1997), DEVELOPED BY ENVIRONMENTAL LABORATORY, USAE WATERWAYS EXPERIMENT STATION, FOR USEPA RISK REDUCTION ENGINEERING LABORATORY*

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JH CAMPBELL DRY ASH LANDFILL PERMIT UPGRADE
CONSTRUCTION PERMIT APPLICATION
Table 1 - HELP MODEL SUMMARY TABLE

PN: 19132873
Made by: ACB
Checked: TDJ
Reviewed: GJD

Scenarios	Surface Water Notes	CCR Hydraulic Conductivity	Material	Thickness (inches)	Hydraulic Conductivity (k) k (cm/sec)	Drainage Length ft	Slope (%)	LEACHATE GENERATION: Average Annual Total Leachate Generation ft^3/acre/yr	Average Daily Total Leachate Generation ft^3/acre/day	Average Daily Total Leachate Generation gal/acre/day	Peak Daily Leachate Generation ft^3/acre/day	Peak Daily Leachate Generation gal/acre/day	Notes
OPEN CONDITION 10 YEARS	Bare Soil, 1% Area Runoff	Case 1A - 1.0×10^{-5} cm/sec.	5 feet of coal combustion residue (CCR)	60	1.0E-05	n/a	n/a	68,010	186.33	1,394	10,737	80,327	Assumes both leachate and run-off
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner (GCL)	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						
		Case 1B - 1.0×10^{-6} cm/sec.	5 feet of coal combustion residue	60	1.0E-06	n/a	n/a	89,360	244.82	1,832	11,161	83,495	Assumes both leachate and run-off
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						
INTERMEDIATE CONDITION 10 YEARS	Bare Soil, 1% Area Runoff	Case 2A - 1.0×10^{-5} cm/sec.	50 feet of coal combustion residue	50	1.0E-05	n/a	n/a	62,900	172.33	1,289.20	10,666	79,791	Assumes both leachate and run-off
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						
		Case 2B - 1.0×10^{-6} cm/sec.	50 feet of coal combustion residue	50	1.0E-06	n/a	n/a	89,342	244.77	1,831	11,161	83,494	Assumes both leachate and run-off
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner (GCL)	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						
FINAL COVER CONDITION 30 YEARS	Good Stand of Grass, 100% Area Runoff	Case 3A - 1.0×10^{-5} cm/sec.	6-inch topsoil	6	1.2E-04	n/a	n/a	39.56	0.108	0.81	0.67	5.02	
			24-inch protective soil layer	24	1.0E-03	180	25.00%						
			40-mil HDPE Geomembrane	0.04	2.0E-13	n/a	n/a						
			6-inch thick grading layer	6	1.0E-03	n/a	n/a						
			125 feet of coal combustion residue (CCR)	1500	1.0E-05	n/a	n/a						
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner (GCL)	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						
FINAL COVER CONDITION 30 YEARS	Good Stand of Grass, 100% Area Runoff	Case 3B - 1.0×10^{-6} cm/sec.	6-inch topsoil	6	1.2E-04	n/a	n/a	4.62	0.013	0.09	0.10	0.76	
			24-inch protective soil layer	24	1.0E-03	180	25.00%						
			40-mil HDPE Geomembrane	0.04	2.0E-13	n/a	n/a						
			6-inch thick grading layer	6	1.0E-03	n/a	n/a						
			125 feet of coal combustion residue (CCR)	1500	1.0E-06	n/a	n/a						
			12-inch soil protective layer	12	1.0E-03	n/a	n/a						
			Geocomposite with 220-mil geonet core	0.22	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			240-mil Geosynthetic Clay Liner (GCL)	0.24	1.0E-09	n/a	n/a						
			Geocomposite with 200-mil geonet core	0.2	33	100	2.00%						
			60-mil HDPE geomembrane	0.06	2.0E-13	n/a	n/a						
			Subgrade Soil	12	1.0E-03	n/a	n/a						

Notes:
ft = feet
in = inches
ft^3 = cubic feet
yr = year
gal = gallons
vol. = volume
% = percent
n/a = not applicable

Consumers J.H. Campbell Landfill Vertical Expansiong Construction Permit Application
HELP3 Model Analyses - Input Information

Case 1A - Open, 5 feet of CCR with hydraulic conductivity of 10^{-5} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	5 feet of CCR	Vertical percolation	0 [1]	60	0.541	0.187	0.047	0.249	1.0E-05					
2	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
3	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
4	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
5	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
6	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
7	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
8	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

[1] For layer 1, material texture No. 30 (fly ash) was selected but the model changed to zero because the hydraulic conductivity (Ksat) was changed from 5.0 x 10^{-5} to 1.0 x 10^{-5} cm/sec.
The same applies to layer 5, changing the Ksat changed the material texture number to 0.

Case 1B - Open, 5 feet of CCR with hydraulic conductivity of 10^{-6} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	5 feet of CCR	Vertical percolation	0 [1]	60	0.541	0.187	0.047	0.249	1.0E-06					
2	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
3	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
4	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
5	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
6	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
7	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
8	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

Case 2A - Intermediate, 50 feet of CCR with hydraulic conductivity of 10^{-5} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	50 feet of CCR	Vertical percolation	0 [1]	600	0.541	0.187	0.047	0.249	1.0E-05					
2	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
3	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
4	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
5	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
6	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
7	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
8	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

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HELP3 Model Analyses - Input Information

Case 2B - Intermediate, 50 feet of CCR with hydraulic conductivity of 10^{-6} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	50 feet of CCR	Vertical percolation	0 [1]	600	0.541	0.187	0.047	0.249	1.0E-06					
2	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
3	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
4	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
5	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
6	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
7	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
8	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

Case 3A - Final, 89 feet of CCR with hydraulic conductivity of 10^{-5} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	6 inch topsoil	Vertical percolation	10	6	0.398	0.244	0.136	0.3519	1.2E-04					
2	24-in thick protective layer	Lateral drainage	5	24	0.457	0.131	0.058	0.2583	1.0E-03	180	25			
3	40-mil HDPE geomembrane	Geomembrane	35	0.04	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
4	6-in thick grading layer	Vertical percolation	5	6	0.457	0.131	0.058	0.2583	1.0E-03					
5	125 feet of CCR	Vertical percolation	0 [1]	1500	0.541	0.187	0.047	0.249	1.0E-05					
6	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
7	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
8	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
9	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
10	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
11	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
12	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

Case 3B - Final, 89 feet of CCR with hydraulic conductivity of 10^{-6} cm/sec

Layer No.	Layer Description	HELP Layer Type	Material Texture No.	Thickness	Porosity	Field Capacity	Wilting Point	Initial Wtr Content	Ksat	Drainage Layer Length	Drainage Layer Slope	Pinhole Density	Defects	Placement Quality
				inches	vol/vol	vol/vol	vol/vol	vol/vol	cm/sec	feet	percent	#/acre	#/acre	
1	6 inch topsoil	Vertical percolation	10	6	0.398	0.244	0.136	0.3519	1.2E-04					
2	24-in thick protective layer	Lateral drainage	5	24	0.457	0.131	0.058	0.2583	1.0E-03	180	25			
3	40-mil HDPE geomembrane	Geomembrane	35	0.04	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
4	6-in thick grading layer	Vertical percolation	5	6	0.457	0.131	0.058	0.2583	1.0E-03					
5	125 feet of CCR	Vertical percolation	0 [1]	1500	0.541	0.187	0.047	0.249	1.0E-06					
6	Protective layer	Vertical percolation	5	12	0.457	0.131	0.058	0.1312	1.0E-03					
7	Geocomposite w/ 220 mil geonet core	Lateral drainage	34	0.22	0.85	0.01	0.005	0.01	33	100	2			
8	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
9	240 mil GCL	Barrier	0 [1]	0.24	0.75	0.747	0.4	0.75	1.0E-09					
10	Geocomposite w/ 200 mil geonet core	Lateral drainage	34	0.2	0.85	0.01	0.005	0.01	33	100	2			
11	60-mil HDPE geomembrane	Geomembrane	35	0.06	0.000	0.000	0.000	0.000	2.0E-13			1	1	Good
12	Subgrade (sandy onsite soils)	Vertical percolation	5	12	0.457	0.131	0.058	0.1286	1.0E-03					

Highlighted layers are final cover layers

```
****************************************************************************
****************************************************************************
**                                                                        **
**                                                                        **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE             **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)              **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                 **
**                    USAE WATERWAYS EXPERIMENT STATION                   **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                        **
**                                                                        **
****************************************************************************
****************************************************************************


PRECIPITATION DATA FILE:    C:\data\jhc1\DATA4.D4
TEMPERATURE DATA FILE:      C:\data\jhc1\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\data\jhc1\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\data\jhc1\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\data\jhc1\DATA10A.D10
OUTPUT DATA FILE:           C:\data\jhc1\JHC1A.OUT


TIME:  11:36     DATE:   6/10/2020


****************************************************************************

     TITLE:  Campbell Case1

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   0
          THICKNESS                  =     60.00   INCHES
```

```
POROSITY                      =      0.5410 VOL/VOL
FIELD CAPACITY                =      0.1870 VOL/VOL
WILTING POINT                 =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.2467 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-05 CM/SEC



                        LAYER  2
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   5
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.4570 VOL/VOL
FIELD CAPACITY                =      0.1310 VOL/VOL
WILTING POINT                 =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.1313 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000005000E-02 CM/SEC



                        LAYER  3
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER  34
THICKNESS                     =      0.22   INCHES
POROSITY                      =      0.8500 VOL/VOL
FIELD CAPACITY                =      0.0100 VOL/VOL
WILTING POINT                 =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   33.0000000000     CM/SEC
SLOPE                         =      2.00   PERCENT
DRAINAGE LENGTH               =    100.0    FEET



                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                     =      0.06   INCHES
POROSITY                      =      0.0000 VOL/VOL
FIELD CAPACITY                =      0.0000 VOL/VOL
WILTING POINT                 =      0.0000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC


                        LAYER  6
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  7
                        --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD
```

```
                         LAYER  8
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   5
   THICKNESS                   =     12.00   INCHES
   POROSITY                    =      0.4570 VOL/VOL
   FIELD CAPACITY              =      0.1310 VOL/VOL
   WILTING POINT               =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.1292 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF 33.% AND
          A SLOPE LENGTH OF  250. FEET.

SCS RUNOFF CURVE NUMBER             =     97.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      4.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      1.919  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.164  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.188  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     18.113  INCHES
TOTAL INITIAL WATER                 =     18.113  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

```
            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------
```

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
EVAPORATIVE ZONE DEPTH	=	4.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.81	1.71	2.87	4.04	3.26	3.12
	2.78	3.48	2.77	3.08	2.53	2.59
STD. DEVIATIONS	0.49	0.70	1.42	1.42	1.05	1.14
	1.59	2.09	1.96	1.74	1.22	0.56

RUNOFF

TOTALS	1.227	1.309	2.679	2.882	1.384	1.228
	1.120	1.659	1.142	1.325	0.808	0.539
STD. DEVIATIONS	0.975	1.099	1.909	1.101	0.806	0.738
	1.046	1.521	1.264	1.148	0.677	0.603

EVAPOTRANSPIRATION

TOTALS	0.381	0.393	0.448	1.894	1.959	1.803
	1.622	1.820	1.509	1.341	1.113	0.464
STD. DEVIATIONS	0.109	0.077	0.188	0.818	0.591	0.627
	0.598	0.753	0.629	0.448	0.228	0.106

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.1486	0.1178	0.0947	0.0845	0.1325	0.1508
	0.1145	0.0945	0.0964	0.1290	0.1290	0.1423
STD. DEVIATIONS	0.0938	0.0813	0.0688	0.0643	0.0948	0.0881
	0.0660	0.0734	0.0786	0.0957	0.0876	0.1013

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0015	0.0017	0.0016	0.0015	0.0014	0.0016

	0.0017	0.0016	0.0015	0.0016	0.0014	0.0013
STD. DEVIATIONS	0.0008	0.0008	0.0008	0.0008	0.0006	0.0007
	0.0007	0.0007	0.0005	0.0005	0.0009	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0004	0.0003	0.0002	0.0002	0.0003	0.0004
	0.0003	0.0002	0.0002	0.0003	0.0003	0.0003
STD. DEVIATIONS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.03 (4.349)	123543.4	100.00
RUNOFF	17.301 (3.6017)	62802.62	50.834
EVAPOTRANSPIRATION	14.746 (1.3072)	53528.54	43.328
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.43467 (0.78859)	5207.857	4.21541
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP	0.000 (0.000)		

OF LAYER 4

LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000 (	0.00000)	0.001	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (	0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 7	0.000 (	0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.01834 (	0.00563)	66.575	0.05389
CHANGE IN WATER STORAGE	0.534 (	1.5517)	1937.84	1.569

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	3.16	11470.801
RUNOFF	2.938	10665.0801
DRAINAGE COLLECTED FROM LAYER 3	0.01996	72.43967
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 4	0.001	
MAXIMUM HEAD ON TOP OF LAYER 4	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 7	0.000	
MAXIMUM HEAD ON TOP OF LAYER 7	0.001	

```
    LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                0.0 FEET

    PERCOLATION/LEAKAGE THROUGH LAYER  8       0.000129         0.46708

    SNOW WATER                                 4.13         15000.8857


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.5286

    MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0470

     ***  Maximum heads are computed using McEnroe's equations.  ***

          Reference:  Maximum Saturated Depth over Landfill Liner
                      by Bruce M. McEnroe, University of Kansas
                      ASCE Journal of Environmental Engineering
                      Vol. 119, No. 2, March 1993, pp. 262-270.

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******************************************************************************

                FINAL WATER STORAGE AT END OF YEAR   10
      ----------------------------------------------------------------------
                 LAYER        (INCHES)       (VOL/VOL)
                 -----        --------       ---------
                   1           17.9365         0.2989

                   2            2.4182         0.2015

                   3            0.0035         0.0159

                   4            0.0000         0.0000

                   5            0.1800         0.7500

                   6            0.0020         0.0100

                   7            0.0000         0.0000

                   8            1.3671         0.1139

                SNOW WATER      1.544
```

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\data\jhc1\DATA4.D4
TEMPERATURE DATA FILE:      C:\data\jhc1\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\data\jhc1\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\data\jhc1\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\data\jhc1\DATA10B.D10
OUTPUT DATA FILE:           C:\data\jhc1\JHC1B.OUT


TIME:  11:55     DATE:   6/10/2020


******************************************************************************

     TITLE:  Campbell Case1B

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                  =     60.00   INCHES
```

```
POROSITY                    =      0.5410 VOL/VOL
FIELD CAPACITY              =      0.1870 VOL/VOL
WILTING POINT               =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1973 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999997000E-06 CM/SEC


                        LAYER  2
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   5
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4570 VOL/VOL
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.22   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC


                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  7
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  8
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   5
   THICKNESS                   =     12.00   INCHES
   POROSITY                    =      0.4570 VOL/VOL
   FIELD CAPACITY              =      0.1310 VOL/VOL
   WILTING POINT               =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.1293 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


            GENERAL DESIGN AND EVAPORATIVE ZONE DATA
            ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF 33.% AND
          A SLOPE LENGTH OF  250. FEET.

SCS RUNOFF CURVE NUMBER             =     97.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      4.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      0.853  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.164  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.188  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     15.144  INCHES
TOTAL INITIAL WATER                 =     15.144  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR


             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------
```

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
EVAPORATIVE ZONE DEPTH	=	4.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.81	1.71	2.87	4.04	3.26	3.12
	2.78	3.48	2.77	3.08	2.53	2.59
STD. DEVIATIONS	0.49	0.70	1.42	1.42	1.05	1.14
	1.59	2.09	1.96	1.74	1.22	0.56

RUNOFF

TOTALS	1.474	1.407	2.777	3.348	2.318	2.014
	1.855	2.535	1.987	2.328	1.618	0.947
STD. DEVIATIONS	0.975	1.196	1.950	1.188	0.930	0.856
	1.225	1.768	1.621	1.480	0.948	0.957

EVAPOTRANSPIRATION

TOTALS	0.384	0.397	0.447	1.313	0.910	1.040
	0.882	0.867	0.712	0.640	0.662	0.425
STD. DEVIATIONS	0.103	0.077	0.162	0.567	0.338	0.458
	0.411	0.454	0.390	0.262	0.185	0.095

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0005	0.0005	0.0005	0.0004	0.0006	0.0006
	0.0006	0.0007	0.0007	0.0006	0.0007	0.0008
STD. DEVIATIONS	0.0006	0.0005	0.0005	0.0004	0.0003	0.0002
	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0008	0.0007	0.0007	0.0010	0.0016	0.0016

```
                          0.0018   0.0018   0.0018   0.0017   0.0017   0.0014

   STD. DEVIATIONS        0.0008   0.0008   0.0008   0.0007   0.0004   0.0005
                          0.0007   0.0006   0.0006   0.0007   0.0007   0.0004


-------------------------------------------------------------------------------
               AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
   AVERAGES               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
   AVERAGES               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   10
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET      PERCENT
                                -------------------   -------------   ---------
 PRECIPITATION                   34.03     (   4.349)     123543.4     100.00

 RUNOFF                          24.610    (  4.0222)      89334.68     72.310

 EVAPOTRANSPIRATION               8.681    (  0.7636)      31511.64     25.507

 LATERAL DRAINAGE COLLECTED       0.00698 (  0.00399)         25.355    0.02052
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH      0.00000 (  0.00000)          0.001     0.00000
   LAYER  5

 AVERAGE HEAD ON TOP              0.000 (    0.000)
```

OF LAYER 4			
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.00000 (0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000 (0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 7	0.000 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.01654 (0.00243)	60.049	0.04861
CHANGE IN WATER STORAGE	0.719 (1.1044)	2611.70	2.114

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	3.16	11470.801
RUNOFF	3.075	11160.7686
DRAINAGE COLLECTED FROM LAYER 3	0.00006	0.21364
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 4	0.000	
MAXIMUM HEAD ON TOP OF LAYER 4	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.00000	0.00002
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 7	0.000	
MAXIMUM HEAD ON TOP OF LAYER 7	0.001	

```
      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)                0.0 FEET

      PERCOLATION/LEAKAGE THROUGH LAYER  8       0.000130         0.47027

      SNOW WATER                                 4.13         15000.8857


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.2399

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0470


       ***  Maximum heads are computed using McEnroe's equations.  ***

            Reference:  Maximum Saturated Depth over Landfill Liner
                        by Bruce M. McEnroe, University of Kansas
                        ASCE Journal of Environmental Engineering
                        Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************




******************************************************************************

                   FINAL WATER STORAGE AT END OF YEAR   10
    ----------------------------------------------------------------------
                    LAYER        (INCHES)       (VOL/VOL)
                    -----        --------       ---------
                      1           17.6528         0.2942

                      2            1.5720         0.1310

                      3            0.0022         0.0100

                      4            0.0000         0.0000

                      5            0.1800         0.7500

                      6            0.0020         0.0100

                      7            0.0000         0.0000

                      8            1.3860         0.1155

                   SNOW WATER      1.544
```

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**               FOR USEPA RISK REDUCTION ENGINEERING LABORATORY            **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\data\jhc2\DATA4.D4
TEMPERATURE DATA FILE:      C:\data\jhc2\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\data\jhc2\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\data\jhc2\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\data\jhc2\DATA10A.D10
OUTPUT DATA FILE:           C:\data\jhc2\JHC2A.OUT


TIME:  12: 2     DATE:   6/10/2020


******************************************************************************

     TITLE:  Campbell Case2A

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                  =    600.00   INCHES
```

```
POROSITY                     =      0.5410 VOL/VOL
FIELD CAPACITY               =      0.1870 VOL/VOL
WILTING POINT                =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1930 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                        LAYER  2
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   5
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.4570 VOL/VOL
FIELD CAPACITY               =      0.1310 VOL/VOL
WILTING POINT                =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1313 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                    =      0.22   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    100.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC


                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  7
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
```

```
                        LAYER  8
                        --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   5
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4570 VOL/VOL
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1292 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF 33.% AND
          A SLOPE LENGTH OF  250. FEET.

SCS RUNOFF CURVE NUMBER             =     97.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      4.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      1.919  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.164  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.188  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    119.095  INCHES
TOTAL INITIAL WATER                 =    119.095  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

```
            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------
```

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
EVAPORATIVE ZONE DEPTH	=	4.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.81	1.71	2.87	4.04	3.26	3.12
	2.78	3.48	2.77	3.08	2.53	2.59
STD. DEVIATIONS	0.49	0.70	1.42	1.42	1.05	1.14
	1.59	2.09	1.96	1.74	1.22	0.56

RUNOFF

TOTALS	1.227	1.309	2.679	2.882	1.384	1.228
	1.120	1.659	1.142	1.325	0.808	0.539
STD. DEVIATIONS	0.975	1.099	1.909	1.101	0.806	0.738
	1.046	1.521	1.264	1.148	0.677	0.603

EVAPOTRANSPIRATION

TOTALS	0.381	0.393	0.448	1.894	1.959	1.803
	1.622	1.820	1.509	1.341	1.113	0.464
STD. DEVIATIONS	0.109	0.077	0.188	0.818	0.591	0.627
	0.598	0.753	0.629	0.448	0.228	0.106

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0029	0.0016	0.0022	0.0014	0.0018	0.0027
	0.0027	0.0022	0.0023	0.0029	0.0020	0.0021
STD. DEVIATIONS	0.0023	0.0018	0.0026	0.0015	0.0013	0.0019
	0.0019	0.0014	0.0010	0.0012	0.0017	0.0013

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0015	0.0008	0.0007	0.0007	0.0012	0.0014

	0.0015	0.0013	0.0014	0.0015	0.0010	0.0011
STD. DEVIATIONS	0.0013	0.0008	0.0008	0.0006	0.0008	0.0006
	0.0005	0.0004	0.0004	0.0006	0.0004	0.0006

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.03 (4.349)	123543.4	100.00
RUNOFF	17.301 (3.6017)	62802.62	50.834
EVAPOTRANSPIRATION	14.746 (1.3072)	53528.54	43.328
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.02690 (0.00882)	97.649	0.07904
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP	0.000 (0.000)		

```
  OF LAYER  4

LATERAL DRAINAGE COLLECTED      0.00000 (  0.00000)         0.000    0.00000
  FROM LAYER  6

PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.000     0.00000
  LAYER  7

AVERAGE HEAD ON TOP             0.000 (    0.000)
  OF LAYER  7

PERCOLATION/LEAKAGE THROUGH     0.01429 (  0.00321)        51.874     0.04199
  LAYER  8

CHANGE IN WATER STORAGE         1.946   (  1.0089)       7062.75      5.717

*******************************************************************************


*******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
     PRECIPITATION                               3.16         11470.801

     RUNOFF                                      2.938        10665.0801

     DRAINAGE COLLECTED FROM LAYER  3            0.00022          0.80469

     PERCOLATION/LEAKAGE THROUGH LAYER  5        0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  4             0.000

     MAXIMUM HEAD ON TOP OF LAYER  4             0.003

     LOCATION OF MAXIMUM HEAD IN LAYER  3
           (DISTANCE FROM DRAIN)                 0.0 FEET

     DRAINAGE COLLECTED FROM LAYER  6            0.00000          0.00002

     PERCOLATION/LEAKAGE THROUGH LAYER  7        0.000000         0.00000

     AVERAGE HEAD ON TOP OF LAYER  7             0.000

     MAXIMUM HEAD ON TOP OF LAYER  7             0.001
```

```
LOCATION OF MAXIMUM HEAD IN LAYER  6
      (DISTANCE FROM DRAIN)                0.0 FEET

PERCOLATION/LEAKAGE THROUGH LAYER  8       0.000129        0.46799

SNOW WATER                                 4.13        15000.8857


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.5286

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0470


 ***  Maximum heads are computed using McEnroe's equations.  ***

      Reference:  Maximum Saturated Depth over Landfill Liner
                  by Bruce M. McEnroe, University of Kansas
                  ASCE Journal of Environmental Engineering
                  Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************
```

```
******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   10
    ----------------------------------------------------------------------
               LAYER        (INCHES)       (VOL/VOL)
               -----        --------       ---------
                 1          133.7981         0.2230

                 2            1.6174         0.1348

                 3            0.0022         0.0100

                 4            0.0000         0.0000

                 5            0.1800         0.7500

                 6            0.0020         0.0100

                 7            0.0000         0.0000

                 8            1.4079         0.1173

              SNOW WATER      1.544
```

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\data\jhc2\DATA4.D4
TEMPERATURE DATA FILE:      C:\data\jhc2\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\data\jhc2\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\data\jhc2\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\data\jhc2\DATA10B.D10
OUTPUT DATA FILE:           C:\data\jhc2\JHC2B.OUT


TIME:  12:51     DATE:   6/10/2020


******************************************************************************

     TITLE:  Campbell Case2B

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    600.00   INCHES
```

```
POROSITY                    =      0.5410 VOL/VOL
FIELD CAPACITY              =      0.1870 VOL/VOL
WILTING POINT               =      0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1880 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999997000E-06 CM/SEC


                        LAYER  2
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   5
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4570 VOL/VOL
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.22   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  4
                        --------

                TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  5
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC



                        LAYER  6
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET



                        LAYER  7
                        --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
```

```
   INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
   FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
   FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
   FML PLACEMENT QUALITY       =  3 - GOOD
```

```
                         LAYER  8
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   5
   THICKNESS                   =     12.00   INCHES
   POROSITY                    =      0.4570 VOL/VOL
   FIELD CAPACITY              =      0.1310 VOL/VOL
   WILTING POINT               =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT  =      0.1292 VOL/VOL
   EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
           GENERAL DESIGN AND EVAPORATIVE ZONE DATA
           ----------------------------------------

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
          GROUND CONDITIONS, A SURFACE SLOPE OF 33.% AND
          A SLOPE LENGTH OF  250. FEET.

SCS RUNOFF CURVE NUMBER             =     97.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      4.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      0.853  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      2.164  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      0.188  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =    116.123  INCHES
TOTAL INITIAL WATER                 =    116.123  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

```
            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------
```

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
EVAPORATIVE ZONE DEPTH	=	4.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.81	1.71	2.87	4.04	3.26	3.12
	2.78	3.48	2.77	3.08	2.53	2.59
STD. DEVIATIONS	0.49	0.70	1.42	1.42	1.05	1.14
	1.59	2.09	1.96	1.74	1.22	0.56

RUNOFF

TOTALS	1.474	1.407	2.777	3.348	2.318	2.014
	1.855	2.535	1.987	2.328	1.618	0.947
STD. DEVIATIONS	0.975	1.196	1.950	1.188	0.930	0.856
	1.225	1.768	1.621	1.480	0.948	0.957

EVAPOTRANSPIRATION

TOTALS	0.384	0.397	0.447	1.313	0.910	1.040
	0.882	0.867	0.712	0.640	0.662	0.425
STD. DEVIATIONS	0.103	0.077	0.162	0.567	0.338	0.458
	0.411	0.454	0.390	0.262	0.185	0.095

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0003	0.0002
	0.0003	0.0003	0.0002	0.0003	0.0003	0.0002
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0009	0.0014	0.0013

```
                       0.0017   0.0014   0.0013   0.0014   0.0015   0.0007

   STD. DEVIATIONS     0.0000   0.0000   0.0001   0.0006   0.0005   0.0004
                       0.0008   0.0005   0.0005   0.0007   0.0006   0.0003


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   10
-------------------------------------------------------------------------------
                                    INCHES           CU. FEET       PERCENT
                              -------------------  -------------  ---------
 PRECIPITATION                 34.03    (   4.349)     123543.4     100.00

 RUNOFF                        24.610   (  4.0222)      89334.68     72.310

 EVAPOTRANSPIRATION             8.681   (  0.7636)      31511.64     25.507

 LATERAL DRAINAGE COLLECTED     0.00206 (  0.00040)         7.472    0.00605
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)         0.000     0.00000
   LAYER  5

 AVERAGE HEAD ON TOP            0.000 (    0.000)
```

```
  OF LAYER  4

LATERAL DRAINAGE COLLECTED      0.00000 (  0.00000)        0.000    0.00000
  FROM LAYER  6

PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.000     0.00000
  LAYER  7

AVERAGE HEAD ON TOP             0.000 (    0.000)
  OF LAYER  7

PERCOLATION/LEAKAGE THROUGH     0.01159 (  0.00377)       42.074     0.03406
  LAYER  8

CHANGE IN WATER STORAGE         0.729   (  1.1054)      2647.56      2.143

*******************************************************************************


*******************************************************************************

             PEAK DAILY VALUES FOR YEARS    1 THROUGH   10
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
     PRECIPITATION                                3.16         11470.801

     RUNOFF                                       3.075        11160.7686

     DRAINAGE COLLECTED FROM LAYER  3             0.00003          0.09723

     PERCOLATION/LEAKAGE THROUGH LAYER  5         0.000000         0.00002

     AVERAGE HEAD ON TOP OF LAYER  4              0.000

     MAXIMUM HEAD ON TOP OF LAYER  4              0.000

     LOCATION OF MAXIMUM HEAD IN LAYER  3
           (DISTANCE FROM DRAIN)                  0.0 FEET

     DRAINAGE COLLECTED FROM LAYER  6             0.00000          0.00002

     PERCOLATION/LEAKAGE THROUGH LAYER  7         0.000000         0.00000

     AVERAGE HEAD ON TOP OF LAYER  7              0.000

     MAXIMUM HEAD ON TOP OF LAYER  7              0.001
```

```
     LOCATION OF MAXIMUM HEAD IN LAYER  6
           (DISTANCE FROM DRAIN)                0.0 FEET

     PERCOLATION/LEAKAGE THROUGH LAYER  8       0.000128         0.46482

     SNOW WATER                                 4.13         15000.8857


     MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.2399

     MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.0470


      ***  Maximum heads are computed using McEnroe's equations.  ***

           Reference:  Maximum Saturated Depth over Landfill Liner
                       by Bruce M. McEnroe, University of Kansas
                       ASCE Journal of Environmental Engineering
                       Vol. 119, No. 2, March 1993, pp. 262-270.

*******************************************************************************
```

```
*******************************************************************************

                  FINAL WATER STORAGE AT END OF YEAR   10
    ----------------------------------------------------------------------
```

LAYER	(INCHES)	(VOL/VOL)
1	118.6821	0.1978
2	1.5720	0.1310
3	0.0022	0.0100
4	0.0000	0.0000
5	0.1800	0.7500
6	0.0020	0.0100
7	0.0000	0.0000
8	1.4340	0.1195
SNOW WATER	1.544	

****
****

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\data\jhc3\DATA4.D4
TEMPERATURE DATA FILE:       C:\data\jhc3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\data\jhc3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\data\jhc3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\data\jhc3\DATA10A.D10
OUTPUT DATA FILE:            C:\data\jhc3\JHC3A.OUT


TIME:  13: 2     DATE:   6/10/2020


******************************************************************************

     TITLE:  Campbell Case3A

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
           THICKNESS                 =     6.00   INCHES
```

```
  POROSITY                     =      0.3980 VOL/VOL
  FIELD CAPACITY               =      0.2440 VOL/VOL
  WILTING POINT                =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3519 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                         LAYER  2
                         --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   5
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.4570 VOL/VOL
  FIELD CAPACITY               =      0.1310 VOL/VOL
  WILTING POINT                =      0.0580 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.2583 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
  SLOPE                        =     25.00   PERCENT
  DRAINAGE LENGTH              =    180.0    FEET



                         LAYER  3
                         --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
  THICKNESS                    =      0.04   INCHES
  POROSITY                     =      0.0000 VOL/VOL
  FIELD CAPACITY               =      0.0000 VOL/VOL
  WILTING POINT                =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY          =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
  FML PLACEMENT QUALITY        =  3 - GOOD



                         LAYER  4
                         --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
              MATERIAL TEXTURE NUMBER   5
THICKNESS                   =     6.00   INCHES
POROSITY                    =     0.4570 VOL/VOL
FIELD CAPACITY              =     0.1310 VOL/VOL
WILTING POINT               =     0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1584 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =  1500.00   INCHES
POROSITY                    =     0.5410 VOL/VOL
FIELD CAPACITY              =     0.1870 VOL/VOL
WILTING POINT               =     0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1870 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC


                        LAYER  6
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   5
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.4570 VOL/VOL
FIELD CAPACITY              =     0.1310 VOL/VOL
WILTING POINT               =     0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


                        LAYER  7
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =     0.22   INCHES
POROSITY                    =     0.8500 VOL/VOL
FIELD CAPACITY              =     0.0100 VOL/VOL
WILTING POINT               =     0.0050 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC


                        LAYER 10
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET
```

LAYER 11

```
            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD
```

LAYER 12

```
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   5
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.4570 VOL/VOL
FIELD CAPACITY              =      0.1310 VOL/VOL
WILTING POINT               =      0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1292 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF 25.% AND
         A SLOPE LENGTH OF  180. FEET.
```

SCS RUNOFF CURVE NUMBER	=	94.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.572	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.302	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.932	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	293.066	INCHES
TOTAL INITIAL WATER	=	293.066	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	283	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.87	1.45	2.46	3.90	2.80	3.63
	2.81	3.03	3.10	2.94	2.64	2.52
STD. DEVIATIONS	0.60	0.58	1.11	1.50	0.99	1.74
	1.43	1.65	1.81	1.43	1.27	0.76
RUNOFF						
TOTALS	0.770	1.155	2.691	2.223	0.437	0.619
	0.413	0.527	0.511	0.485	0.255	0.278
STD. DEVIATIONS	0.832	1.087	1.501	1.513	0.415	0.626
	0.477	0.628	0.548	0.502	0.272	0.363

```
EVAPOTRANSPIRATION
------------------
  TOTALS                 0.435    0.393    0.384    1.777    2.271    2.735
                         2.535    2.320    2.022    1.340    0.923    0.492

  STD. DEVIATIONS        0.093    0.079    0.164    0.891    0.677    0.938
                         0.903    1.111    0.901    0.372    0.190    0.136

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
  TOTALS                 0.6415   0.3481   0.2252   0.2961   0.5393   0.4282
                         0.3404   0.2398   0.1932   0.3354   0.5608   0.8004

  STD. DEVIATIONS        0.3609   0.1858   0.1072   0.1560   0.1511   0.1400
                         0.1307   0.0795   0.1050   0.3203   0.4124   0.4505

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------
  TOTALS                 0.0308   0.0187   0.0136   0.0164   0.0273   0.0226
                         0.0190   0.0145   0.0120   0.0178   0.0271   0.0369

  STD. DEVIATIONS        0.0143   0.0080   0.0051   0.0068   0.0060   0.0056
                         0.0055   0.0036   0.0047   0.0131   0.0161   0.0171

LATERAL DRAINAGE COLLECTED FROM LAYER  7
----------------------------------------
  TOTALS                 0.0003   0.0002   0.0002   0.0002   0.0009   0.0014
                         0.0020   0.0018   0.0015   0.0011   0.0007   0.0005

  STD. DEVIATIONS        0.0009   0.0004   0.0005   0.0009   0.0017   0.0020
                         0.0025   0.0022   0.0022   0.0019   0.0015   0.0012

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 10
----------------------------------------
  TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11
```

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 12

TOTALS	0.0004	0.0004	0.0004	0.0001	0.0004	0.0005
	0.0007	0.0007	0.0006	0.0005	0.0003	0.0004
STD. DEVIATIONS	0.0009	0.0008	0.0007	0.0004	0.0009	0.0008
	0.0009	0.0008	0.0009	0.0010	0.0008	0.0007

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	2.7923	1.6601	0.9801	1.3319	2.3473	1.9260
	1.4817	1.0438	0.8689	1.4598	2.5227	3.4842
STD. DEVIATIONS	1.5711	0.8807	0.4665	0.7019	0.6576	0.6295
	0.5689	0.3459	0.4722	1.3943	1.8548	1.9609

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 11

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

***

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.15	(4.771)	120333.3	100.00
RUNOFF	10.364	(3.0394)	37621.92	31.265
EVAPOTRANSPIRATION	17.626	(2.3094)	63981.00	53.170
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.94833	(1.21188)	17962.422	14.92722
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.25677	(0.04973)	932.074	0.77458
AVERAGE HEAD ON TOP OF LAYER 3	1.825	(0.448)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.01090	(0.01110)	39.560	0.03288
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.00550	(0.00642)	19.980	0.01660
CHANGE IN WATER STORAGE	0.195	(1.4649)	708.40	0.589

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.16	11470.801
RUNOFF	2.906	10548.7246
DRAINAGE COLLECTED FROM LAYER 2	0.06105	221.61604
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002463	8.94138
AVERAGE HEAD ON TOP OF LAYER 3	8.238	
MAXIMUM HEAD ON TOP OF LAYER 3	15.179	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	3.8 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00018	0.67084
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 10	0.00000	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000	
MAXIMUM HEAD ON TOP OF LAYER 11	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 10 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000128	0.46527
SNOW WATER	5.58	20264.4355

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3864
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1165

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.4270	0.2378
2	5.4060	0.2253
3	0.0000	0.0000
4	0.9713	0.1619
5	287.8495	0.1919
6	1.5776	0.1315
7	0.0022	0.0102
8	0.0000	0.0000
9	0.1800	0.7500
10	0.0020	0.0100
11	0.0000	0.0000
12	1.3849	0.1154
SNOW WATER	0.120	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\data\jhc3\DATA4.D4
TEMPERATURE DATA FILE:      C:\data\jhc3\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\data\jhc3\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\data\jhc3\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\data\jhc3\DATA10B.D10
OUTPUT DATA FILE:           C:\data\jhc3\JHC3B.OUT


TIME:  13:28     DATE:   6/10/2020


******************************************************************************

     TITLE:  Campbell Case3B

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  10
          THICKNESS                  =      6.00   INCHES
```

```
  POROSITY                    =      0.3980 VOL/VOL
  FIELD CAPACITY              =      0.2440 VOL/VOL
  WILTING POINT               =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.3519 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.119999997000E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
         FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                        LAYER  2
                        --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER   5
  THICKNESS                   =     24.00   INCHES
  POROSITY                    =      0.4570 VOL/VOL
  FIELD CAPACITY              =      0.1310 VOL/VOL
  WILTING POINT               =      0.0580 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.2583 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
  SLOPE                       =     25.00   PERCENT
  DRAINAGE LENGTH             =    180.0    FEET



                        LAYER  3
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.04   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  4
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
```

MATERIAL TEXTURE NUMBER 5

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1310 VOL/VOL
WILTING POINT	=	0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1402 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	1500.00 INCHES
POROSITY	=	0.5410 VOL/VOL
FIELD CAPACITY	=	0.1870 VOL/VOL
WILTING POINT	=	0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1870 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999997000E-06 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 5

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1310 VOL/VOL
WILTING POINT	=	0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1310 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 34

THICKNESS	=	0.22 INCHES
POROSITY	=	0.8500 VOL/VOL
FIELD CAPACITY	=	0.0100 VOL/VOL
WILTING POINT	=	0.0050 VOL/VOL

```
INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
SLOPE                       =      2.00   PERCENT
DRAINAGE LENGTH             =    100.0    FEET


                        LAYER  8
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =      0.06   INCHES
POROSITY                    =      0.0000 VOL/VOL
FIELD CAPACITY              =      0.0000 VOL/VOL
WILTING POINT               =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  9
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.24   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999972000E-09 CM/SEC


                        LAYER 10
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  34
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
```

```
  INITIAL SOIL WATER CONTENT  =      0.0100 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =   33.0000000000     CM/SEC
  SLOPE                       =      2.00   PERCENT
  DRAINAGE LENGTH             =    100.0    FEET


                              LAYER 11
                              --------

                  TYPE 4 - FLEXIBLE MEMBRANE LINER
                    MATERIAL TEXTURE NUMBER  35
  THICKNESS                   =      0.06   INCHES
  POROSITY                    =      0.0000 VOL/VOL
  FIELD CAPACITY              =      0.0000 VOL/VOL
  WILTING POINT               =      0.0000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
  FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
  FML INSTALLATION DEFECTS    =      1.00   HOLES/ACRE
  FML PLACEMENT QUALITY       =  3 - GOOD


                              LAYER 12
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   5
  THICKNESS                   =     12.00   INCHES
  POROSITY                    =      0.4570 VOL/VOL
  FIELD CAPACITY              =      0.1310 VOL/VOL
  WILTING POINT               =      0.0580 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.1295 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC


              GENERAL DESIGN AND EVAPORATIVE ZONE DATA
              ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #10 WITH BARE
         GROUND CONDITIONS, A SURFACE SLOPE OF 25.% AND
         A SLOPE LENGTH OF  180. FEET.
```

SCS RUNOFF CURVE NUMBER	=	94.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.572	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	3.302	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.932	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	294.644	INCHES
TOTAL INITIAL WATER	=	294.644	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GRAND RAPIDS MICHIGAN

STATION LATITUDE	=	42.53	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00	
START OF GROWING SEASON (JULIAN DATE)	=	123	
END OF GROWING SEASON (JULIAN DATE)	=	283	
EVAPORATIVE ZONE DEPTH	=	8.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.91	1.53	2.48	3.56	3.03	3.86
3.02	3.45	3.14	2.89	2.93	2.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.00	23.70	33.10	46.30	57.50	67.10
71.40	69.60	62.10	50.90	38.50	27.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GRAND RAPIDS MICHIGAN
AND STATION LATITUDE = 42.53 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.87	1.45	2.46	3.90	2.80	3.63
	2.81	3.03	3.10	2.94	2.64	2.52
STD. DEVIATIONS	0.60	0.58	1.11	1.50	0.99	1.74
	1.43	1.65	1.81	1.43	1.27	0.76
RUNOFF						
TOTALS	0.770	1.155	2.691	2.223	0.437	0.619
	0.413	0.527	0.511	0.485	0.255	0.278
STD. DEVIATIONS	0.832	1.087	1.501	1.513	0.415	0.626
	0.477	0.628	0.548	0.502	0.272	0.363

```
EVAPOTRANSPIRATION
------------------
  TOTALS                 0.435    0.393    0.384    1.777    2.271    2.735
                         2.535    2.320    2.022    1.340    0.923    0.492

  STD. DEVIATIONS        0.093    0.079    0.164    0.891    0.677    0.938
                         0.903    1.111    0.901    0.372    0.190    0.136

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
  TOTALS                 0.6415   0.3481   0.2252   0.2961   0.5393   0.4282
                         0.3404   0.2398   0.1932   0.3354   0.5608   0.8004

  STD. DEVIATIONS        0.3609   0.1858   0.1072   0.1560   0.1511   0.1400
                         0.1307   0.0795   0.1050   0.3203   0.4124   0.4505

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------
  TOTALS                 0.0308   0.0187   0.0136   0.0164   0.0273   0.0226
                         0.0190   0.0145   0.0120   0.0178   0.0271   0.0369

  STD. DEVIATIONS        0.0143   0.0080   0.0051   0.0068   0.0060   0.0056
                         0.0055   0.0036   0.0047   0.0131   0.0161   0.0171

LATERAL DRAINAGE COLLECTED FROM LAYER  7
----------------------------------------
  TOTALS                 0.0001   0.0001   0.0001   0.0002   0.0003   0.0002
                         0.0001   0.0001   0.0001   0.0000   0.0001   0.0001

  STD. DEVIATIONS        0.0002   0.0002   0.0002   0.0003   0.0004   0.0003
                         0.0003   0.0002   0.0002   0.0002   0.0002   0.0002

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 10
----------------------------------------
  TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                         0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11
```

```
  ------------------------------------
    TOTALS                 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  PERCOLATION/LEAKAGE THROUGH LAYER 12
  ------------------------------------
    TOTALS                 0.0004   0.0004   0.0005   0.0006   0.0007   0.0006
                           0.0005   0.0004   0.0003   0.0002   0.0002   0.0004

    STD. DEVIATIONS        0.0008   0.0009   0.0010   0.0009   0.0010   0.0009
                           0.0010   0.0010   0.0008   0.0006   0.0006   0.0008


-------------------------------------------------------------------------------
             AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES               2.7923   1.6601   0.9801   1.3319   2.3473   1.9260
                           1.4817   1.0438   0.8689   1.4598   2.5227   3.4842

    STD. DEVIATIONS        1.5711   0.8807   0.4665   0.7019   0.6576   0.6295
                           0.5689   0.3459   0.4722   1.3943   1.8548   1.9609

  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  DAILY AVERAGE HEAD ON TOP OF LAYER 11
  -------------------------------------
    AVERAGES               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

    STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                           0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************
```

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	33.15	(4.771)	120333.3	100.00
RUNOFF	10.364	(3.0394)	37621.92	31.265
EVAPOTRANSPIRATION	17.626	(2.3094)	63981.00	53.170
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.94833	(1.21188)	17962.422	14.92722
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.25677	(0.04973)	932.074	0.77458
AVERAGE HEAD ON TOP OF LAYER 3	1.825	(0.448)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00127	(0.00201)	4.615	0.00383
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.00532	(0.00837)	19.307	0.01604
CHANGE IN WATER STORAGE	0.205	(1.4605)	744.02	0.618

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.16	11470.801
RUNOFF	2.906	10548.7246
DRAINAGE COLLECTED FROM LAYER 2	0.06105	221.61604
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.002463	8.94138
AVERAGE HEAD ON TOP OF LAYER 3	8.238	
MAXIMUM HEAD ON TOP OF LAYER 3	15.179	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	3.8 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00003	0.10187
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 10	0.00000	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 11	0.000	
MAXIMUM HEAD ON TOP OF LAYER 11	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 10 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000132	0.48057
SNOW WATER	5.58	20264.4355

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3864

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1165

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.4270	0.2378
2	5.4060	0.2253
3	0.0000	0.0000
4	2.8802	0.1600
5	287.8083	0.1919
6	1.5720	0.1310
7	0.0022	0.0100
8	0.0000	0.0000
9	0.1800	0.7500
10	0.0020	0.0100
11	0.0000	0.0000
12	1.3948	0.1162
SNOW WATER	0.120	

****
****

APPENDIX L

Sump and Pump Calculations

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE SUMP EFFECTIVE VOLUME	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

1.) Calculate the effective working volume for the typical primary leachate collection sump for Cells 5 through 9.
2.) Determine the minimum time to fill the sump.

2.0 ASSUMPTIONS/GIVENS

1.) Minimum Dimensions of the Sump in Cell 9:

Bottom Width = 40 ft
Bottom Length = 50 ft

Top Width = 58 ft
Top Length = 68 ft

Depth = 3 ft

Side slope = 3H to 1V

2.) Sump gravel porosity:

n_s = 0.35 = porosity of the sump gravel (Ref 1.)

3.) The maximum, i.e. peak daily, leachate generation rate as computed by the HELP Model (Ref. 2):

q_{max} = 11,161 gal/acre/day

4.) There is one sump per cell.

5.) The largest cell is Cell 9 plus adjacent slope area.

max. cell size = 11.5 acre

3.0 METHODS

1.) The maximum anticipated leachate generation rate was estimated using the HELP model.

2.) The effective storage volume of the sump is estimated as the volume of frustum of pyramid using the following equation:

Frustum of Pyramid

$$V = \frac{h^* (A_1 + A_2 + (A_1{}^*A_2)^{1/2})}{3}$$

where A_1 = area at base of sump
A_2 = area at top of sump
h = depth of sump

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	LEACHATE SUMP EFFECTIVE VOLUME	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

4.0 CALCULATIONS

1.) Sump Volume

See attached Sump Calculator, from EGLE sump calculation.
From sump calculator:

Total Effective Volume =	22,914 gallons	(assuming pump on at a depth of 2.99 ft and pump off at a depth of 1.0 ft)
Working Volume =	**16,840 gallons**	(assuming a gravel porosity of 0.35.)

2.) Time to Fill the Sump

maximum flow rate into sump = q_{max} * max. cell area

q_{max} =	11,161 gal/acre/day
max. cell size =	11.5 acre
maximum flow rate into sump =	128,352 gal/day
conversion =	89 gpm

The time required to fill the sump considering the sump working volume and under maximum leachate flow rate is:

= 189 minutes
= **3.1 hrs**

5.0 CONCLUSIONS

Each sump will have a total capacity (working volume) of approximately 16,840 gallons. Under the maximum, i.e. peak daily leachate generation rate, the empty sump will be filled to the crest in approximately 3.1 hours. The sumps are designed to be used in conjunction with a pump operating system to maintain less than 1-ft of head on the liner.

6.0 REFERENCES

1. Porosity of Gravel taken from Holtz, R. and Kovacs, W.,(1980) An Introduction to Geotechnical Engineering, p104.

2. Leachate flow rates taken from the calculations for leachate generation rates, HELP Model.

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	EXPECTED LEACHATE SUMP - PUMPING CYCLES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill Expansion Construction Permit Application (CPA)

1.0 OBJECTIVE

Evaluate the expected pumping times and cycles from the leachate collection sump under various flows and considering different pumps within Cells 5 through 9 in the JHC Landfill.

2.0 METHOD

1. Use the HELP model to estimate the maximum anticipated leachate generation rates.

2. Estimate the effective useful storage volume of leachate taking in account pump on and pump off elevations.

The effective storage volume of the sump is estimated as the volume of frustum of pyramid using the following equation:

Frustum of Pyramid

$$V = \frac{h^* [A_1 + A_2 + (A_1 * A_2)^{1/2}]}{3}$$

where A_1 = area at base of sump
A_2 = area at top of sump
h = depth of sump

3. Using the HELP output for 2 conditions of peak daily flow and peak intermediate flow; determine the pumping time and cycles for a 150 gpm pump. Calculate the total leachate volume generated for a half day period during the cells largest leachate generation stage.

3.0 ASSUMPTIONS/GIVENS

1.) Sump gravel porosity:
n_s = 0.35 = porosity of the sump gravel (Ref 1.)

2.) There is one sump per cell and the largest cell is Cell 9, at 7.5 acres plus 4 acres of adjacent sideslope.

3.) Assuming pump on at a depth of 3.99 ft and pump off at a depth of 1.0 ft.

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	EXPECTED LEACHATE SUMP - PUMPING CYCLES	**Reviewed by:**	GJD

Project Short Title: J.H. Campbell Landfill Expansion Construction Permit Application (CPA)

4.0 CALCULATIONS

Sample Calculation: *Leachate Sump Volume @ Cell 9, largest cell area*

1.) See attached Sump Calculator, from MDEQ.

2.) From the attached calculation, the effective useful volume of the sump 19,556 gallons:

a) A 150 GPM pump will have the following operating values during peak daily flows:

acres contributing to sump		11.50		
design infiltration rate - gpad	r	11,161	gpad	Peak daily flow (Open Condition)
gpd		128,352	gpd	
Effective Useful Sump Volume *(from "Sump Calculator")*		**19,556**	gal	
Pump rate (gpm)	Qp	150.00	gpm	
Pump operating time (min)	t	130.37	min	
Pump operating time (hours)	t	2.17	hr	

Therefore the pump will cycle continuously (discounting flow into sump while the pump is running).

5.0 CONCLUSIONS

Considering the different flow volumes expected during the life of the landfill and the output and cycle characteristics of the pump evaluated, maintaining leachate level compliance is achievable.

6.0 REFERENCES

1. Porosity of Gravel taken from Holtz, R. and Kovacs, W.,(1980) An Introduction to Geotechnical Engineering, p104.

2. Leachate flow rates taken from the calculations for leachate generation rates, HELP Model.

PRIMARY SUMP VOLUME

GOLDER

Facility:	JW Campbell CCR		
Inspection Date:	na		
Cell:	9 plus adjacent slope area		
Acreage:	11.5	acres	
Avg. Waste Depth:	125	feet	
Cover:	na		

Pump Run Times:	Cycles		Time/cycle	
Design:	3.178808	per day	453	min
Actual:		per day		min
Pump Capacity:	min	150	gpm	
	(Min)	(Max)		

NOTE: If pump is single speed, record in "Max" ("NA" in Min.) If variable speed, use 'min' for low rate; 'max' for top rate.

Expected pump run time

16840gal. ÷ 150 gpm = 112 min

Runoff / *Coefficient:* 1 (0.1=10%)

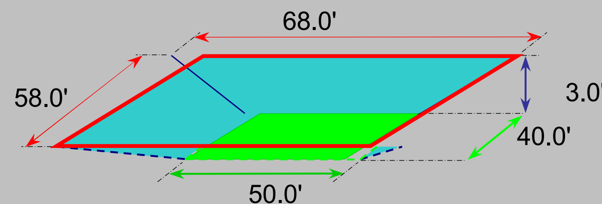
SUMP:

	elevation (feet)	depth (inches)
Top:	3.00	36.0
Pump On:	2.99	35.9
Pump Off:	1.00	12.0
Bottom:	0.00	0.0

Design total volume:	22,914	gallons
Desigh working volume:	16,840	gallons
Sump elev. @ insp.:	na	feet

	Whole Sump		'Effective' Sump	
top lgth.	68.0	feet	67.9	feet
top wdth.	58.0	feet	57.9	feet
bottom lgth.	50.0	feet	56.0	feet
bottom wdth.	40.0	feet	46.0	feet
Depth	3.00	feet	23.9	inches
Porosity (*n*)	0.350	(≈ 30-40%)	0.350	(≈ 30-40%)
Total volume	8,753	feet	6,432	feet
Total volume	65,469	gallons	48,113	gallons
Usefull vol.	22,914	gallons	**16,840**	gallons

Intrinsically safe electrical? yes



GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	PRIMARY LEACHATE PUMP SIZE	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

1.0 OBJECTIVE

Size the leachate sump pumps for each Cell in terms of total dynamic head and flow rate to be able to remove leachate from the sump while maintaining one foot or less head on the liner system.

2.0 ASSUMPTIONS/GIVENS

1.) The pump performances determined by this calculation are based on predicted maximum annual flow rate of open condition from the HELP model. Flow rates may be monitored during landfill operation and closure to determine actual pump performance and selection.

11,161 gallons/acre/day (Open Condition)

2.) Leachate will be pumped from expansion Cells 5, 6, 7, 8 and 9 to a gravity line located along the landfill southern edge (Cells 5 and 6) and western edge (Cells 7,8 and 9).

3.) Permit Engineering Drawings 600-1 and 600-2 depict the leachate gravity line locations, routes and tie-in locations.

4.) Design dimension of the leachate sump system :

Item	Constructed Cell 5	Cell 6	Cell 7	Cell 8	Cell 9
Bottom of Sump EL. (ft)	604.3	605.4	609.6	609.1	608.4
Crest of Sump EL. (ft)	607.3	608.4	612.6	612.1	611.4
Sump Pump "on" EL. (ft)	607.29	608.39	612.59	612.09	611.39
Sump Pump "off" EL. (ft)	605.3	606.4	610.6	610.1	609.4
Riser Side slope Crest EL. (ft)	632.0	636.0	620.0	620.0	620.0
Riser Side slope Length (ft)	28	31	10	11	12
Length to Gravity Line Tie-in Location (ft)	30	30	30	30	30

Note: 1 -The design dimension are approximate values.

2- The sumps are 4 feet deep. Pump "on" is assumed to be just below the rim and pump "off" at 1-ft above the bottom.

3.0 CALCULATIONS

Individual Sump Pump Inflow Rates

The HELP modeling results, see section F.1.d.7, will be used to determine the maximum leachate flow rate to the cells sump area. Peak annual drainage (worst case scenario) estimates for each cell are as follows:

11,161 gallons/acre/day (Open Condition)

INDIVIDUAL SUMP INFLOW RATES

Sump	Area of Influence (acres) [1]		Average Leachate Flow Rate (gal/day) [2]	Average Leachate Flow Rate (gal/min.)
	Cell	Adjacent Slope		
Cell 5	7.0	4.5	128,352	89.1
Cell 6	7.2	4.5	130,584	90.7
Cell 7	6.2	4.5	119,423	82.9
Cell 8	6.3	4.5	120,539	83.7
Cell 9	7.5	4.0	128,352	89.1

Note Cell 5 is constructed -

Note: 1 -The area of influence consists of the cell area plus the side slope area of the adjacent cells that could contribute to water inflow (see fill progression on the Engineering Drawings).

2- The peak leachate flow rate in gallons per day is equal the max. peak leachate flow (from HELP Model) times the area of influence (in acres).

Date:	May-21	**Made by:**	NFM
Project No.:	19132873	**Checked by:**	TDJ
Subject:	PRIMARY LEACHATE PUMP SIZE	**Reviewed by:**	GJD
Project Short Title:	J.H. Campbell Landfill Expansion Construction Permit Application (CPA)		

3.0 CALCULATIONS CONT.

2.) The pump compatibility is reflected by plotting the Total Dynamic Head (TDH) against the manufacturers performance curves. The TDH calculation accounts for static (elevation) head, losses due to friction (as a function of flow rate) and minor losses resulting from fittings.

$TDH = H_s + H_f + H_m$

Where

H_s = Static Head, feet

H_f = Friction Head Loss, feet

$$H_f = L/100 * 0.2083 * \frac{100^{1.85} * Q^{1.85}}{C^{1.85} * D^{4.87}}$$

H_m = Minor Head Loss, feet

$$H_m = \frac{V^2 \Sigma\kappa_i}{2g} = \frac{16(448.3\ ^{gpm/cfs})^2 Q^2 \Sigma k_i}{p^2 D^2}$$

L = Length, feet

Q = Flow rate, gpm

C = Hazen Williams Roughness

D = Inside Diameter, inch

The following pages calculate the total dynamic head for the leachate pump considering each cell design.

4.0 RESULTS

See pages 3 through 7.

Pump Sizing Summary Table

Pump Location	Pump Discharge Pipe Size (inches)	Design Capacity w/ Design Factors Added (GPM)	TDH (ft)	Required Horsepower (hp) [3]	EPG Pump Type[1] (or Equal) Matches previous Cell 5's Pump Type
Existing Cell 5 Pump	3 inch pumps to manhole	111	56	4.5	EPG WSD Surepump 31-1, 2.0 hp
Sump Pump Cell 6	3 inch pumps to manhole	113	36	2.9	EPG WSD Surepump 31-2, 5.0 hp
Sump Pump Cell 7	3 inch pumps to manhole	104	28	2.1	EPG WSD Surepump 31-1, 2.0 hp
Sump Pump Cell 8	3 inch pumps to manhole	105	29	2.2	EPG WSD Surepump 31-1, 2.0 hp
Sump Pump Cell 9	3 inch pumps to manhole	111	32	2.6	EPG WSD Surepump 31-1, 2.0 hp

Notes:
1.) See Attachments.
2.) See attached for Cell 4's typical O&M Manual for the Primary Pump, or equal.
3.) Owner directed use of a similar pump as previous Cell 4.
4.) Note that high level alarm controls shall be installed between each pump station and sump to allow for the cell sump pump to turn off if a high level alarm has been reached in the pump stations.
5.) The Owner/Operator may choose to use a smaller pump once a cell has reached intermediate condition or has been closed.

Client:	**JH Campbell**	
Project:	**Vertical Expansion Constuction Permit**	
Job No.:	**19132873**	
Tag No.:	**Cell 5**	
Service & Source:	**Leachate**	
No. of pumps in series:	1	
Comments:		
Operating Data:		units
Fluid:	leachate	
Pumping Temp	115	deg F
% Solids (by weight):	1	%
S.G. Liquid:	1	
S.G. Dry Solids:	2	
S.G. Pulp:	1.01	
Particle Size (50% pass):	n/a	microns
Viscosity :	n/a	cp
pH:	5	
Flow	89.1	gpm
Design Factor	1.25	
Design Capacity:	111	gpm
Installation:		
Operation:		hrs/day
Pump on Elevation (max):	607.29	ft
Pump Off Elevation (min):	605.30	ft
Pump Elevation:	605.30	ft
Discharge Elevation:	632.00	ft
Res. Press. Req'd. :		psi
Absolute Pressure:		ft (abs)
Vapor Pressure:		ft
Operating Data (Misc.):		
Pump Type:	EPG	
Model:	WSD Surepump 31-1, 2.0 hp	
Sump Depth:	3.0	ft
Pump Length:		ft
Available Air Pressure:		psig
Cable Length:	100-ft min.	ft
Remarks:		
Results:		
NPSHA:	1	ft (abs)
Frict.+Vel.+Misc. Head	29	ft
Static Head (Max):	27	ft
Static Head (Min):	25	ft
TDH (Max):	56	ft
TDH (Min):	54	ft
Estimated. Efficiency.:	35.00	%
Estimated BHP:	4.51	hp

Pump Head		Date:	1/20/2021
Calculation Sheet		By:	TDJ
Friction:	Suct.:	Disch:	units
Pipe Size:	2.00	2.00	in
Pipe I.D. :	2.00	2.00	in
Material:	HDPE	HDPE	
"C" Factor:	140	140	
Velocity:	11.4	11.4	fps
Velocity Head:	2.0	2.0	ft
Unit Head Loss:	0.235	0.235	ft/ft
Friction Head:	0.2	23.9	ft
Entrance/Exit Head:	1.0	2.0	ft
Residual Press. Head:		0.0	ft
Miscellaneous Head			ft
Miscellaneous Head			ft
Equivalent Lengths (Ftgs. & Valves):			
Suction:	L/D	Qty.	Length(ft.):
90 Ell	16		
45 Ell	10		
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3		
B.F. Valve:	40		
Check Valve:	50		
Vertical Pipe:			
Horizontal Pipe:		1	1
Other:			
Other:			
Total Equiv. Length:			1
Discharge:	L/D	Qty.	Length(ft.):
90 Elbow	16	2	5
45 Elbow	10	2	3
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3	1	1
Butterfly Valve:	40		
Check Valve:	50	1	8
Vertical Pipe:			27
Horizontal Pipe:		58	58
Other:			
Other:			
Total Equiv. Length:			102

Client:	**JH Campbell**	
Project:	**Vertical Expansion Construction Permit**	
Job No.:	**19132873**	
Tag No.:	**Cell 6**	
Service & Source:	**Leachate**	
No. of pumps in series:	1	
Comments:		
Operating Data:		units
Fluid:	leachate	
Pumping Temp	115	deg F
% Solids (by weight):	1	%
S.G. Liquid:	1	
S.G. Dry Solids:	2	
S.G. Pulp:	1.01	
Particle Size (50% pass):	n/a	microns
Viscosity :	n/a	cp
pH:	5	
Flow	90.7	gpm
Design Factor	1.25	
Design Capacity:	113	gpm
Installation:		
Operation:		hrs/day
Pump On Elevation (max):	608.39	ft
Pump Off Elevation (min):	606.40	ft
Pump Elevation:	606.40	ft
Discharge Elevation:	636.00	ft
Res. Press. Req'd. :		psi
Absolute Pressure:		ft (abs)
Vapor Pressure:		ft
Operating Data (Misc.):		
Pump Type:	EPG or Equal	
Model:	WSD Surepump 31-2, 5.	0
Sump Depth:	3.0	ft
Pump Length:		ft
Available Air Pressure:		psig
Cable Length:	100-ft min.	ft
Remarks:		
Results:		
NPSHA:	1	ft (abs)
Frict.+Vel.+Misc. Head	32	ft
Static Head (Max):	30	ft
Static Head (Min):	28	ft
TDH (Max):	61	ft
TDH (Min):	59	ft
Estimated. Efficiency.:	35.00	%
Estimated BHP:	5.02	hp

Pump Head		Date:	1/20/2021
Calculation Sheet		By:	TDJ
Friction:	Suct.:	Disch:	units
Pipe Size:	2.00	2.00	in
Pipe I.D. :	2.00	2.00	in
Material:	HDPE	HDPE	
"C" Factor:	140	140	
Velocity:	11.6	11.6	fps
Velocity Head:	2.1	2.1	ft
Unit Head Loss:	0.242	0.242	ft/ft
Friction Head:	0.2	26.1	ft
Entrance/Exit Head:	1.0	2.1	ft
Residual Press. Head:		0.0	ft
Miscellaneous Head			ft
Miscellaneous Head			ft
Equivalent Lengths (Ftgs. & Valves):			
Suction:	L/D	Qty.	Length(ft.):
90 Ell	16		
45 Ell	10		
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3		
B.F. Valve:	40		
Check Valve:	50		
Vertical Pipe:			
Horizontal Pipe:		1	1
Other:			
Other:			
Total Equiv. Length:			1
Discharge:	L/D	Qty.	Length(ft.):
90 Elbow	16	2	5
45 Elbow	10	2	3
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3	1	1
Butterfly Valve:	40		
Check Valve:	50	1	8
Vertical Pipe:			30
Horizontal Pipe:		61	61
Other:			
Other:			
Total Equiv. Length:			108

Client:	**JH Campbell**	
Project:	**Vertical Expansion Construction Permit**	
Job No.:	**19132873**	
Tag No.:	**Cell 7**	
Service & Source:	**Leachate**	
No. of pumps in series:	1	
Comments:		
Operating Data:		units
Fluid:	leachate	
Pumping Temp	115	deg F
% Solids (by weight):	1	%
S.G. Liquid:	1	
S.G. Dry Solids:	2	
S.G. Pulp:	1.01	
Particle Size (50% pass):	n/a	microns
Viscosity :	n/a	cp
pH:	5	
Flow	82.9	gpm
Design Factor	1.25	
Design Capacity:	104	gpm
Installation:		
Operation:		hrs/day
Pump on Elevation (max):	612.59	ft
Pump Off Elevation (min):	610.60	ft
Pump Elevation:	610.60	ft
Discharge Elevation:	620.00	ft
Res. Press. Req'd. :		psi
Absolute Pressure:		ft (abs)
Vapor Pressure:		ft
Operating Data (Misc.):		
Pump Type:	EPG	
Model:	WSD Surepump 31-1, 2.	0
Sump Depth:	3.0	ft
Pump Length:		ft
Available Air Pressure:		psig
Cable Length:	100-ft min.	ft
Remarks:		
Results:		
NPSHA:	1	ft (abs)
Frict.+Vel.+Misc. Head	18	ft
Static Head (Max):	9	ft
Static Head (Min):	7	ft
TDH (Max):	28	ft
TDH (Min):	26	ft
Estimated. Efficiency.:	35.00	%
Estimated BHP:	2.09	hp

Pump Head		Date:	1/20/2021
Calculation Sheet		By:	TDJ
Friction:	Suct.:	Disch:	units
Pipe Size:	2.00	2.00	in
Pipe I.D. :	2.00	2.00	in
Material:	HDPE	HDPE	
"C" Factor:	140	140	
Velocity:	10.6	10.6	fps
Velocity Head:	1.7	1.7	ft
Unit Head Loss:	0.205	0.205	ft/ft
Friction Head:	0.2	13.8	ft
Entrance/Exit Head:	0.9	1.7	ft
Residual Press. Head:		0.0	ft
Miscellaneous Head			ft
Miscellaneous Head			ft
Equivalent Lengths (Ftgs. & Valves):			
Suction:	L/D	Qty.	Length(ft.):
90 Ell	16		
45 Ell	10		
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3		
B.F. Valve:	40		
Check Valve:	50		
Vertical Pipe:			
Horizontal Pipe:		1	1
Other:			
Other:			
Total Equiv. Length:			1
Discharge:	L/D	Qty.	Length(ft.):
90 Elbow	16	2	5
45 Elbow	10	2	3
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3	1	1
Butterfly Valve:	40		
Check Valve:	50	1	8
Vertical Pipe:			9
Horizontal Pipe:		40	40
Other:			
Other:			
Total Equiv. Length:			67

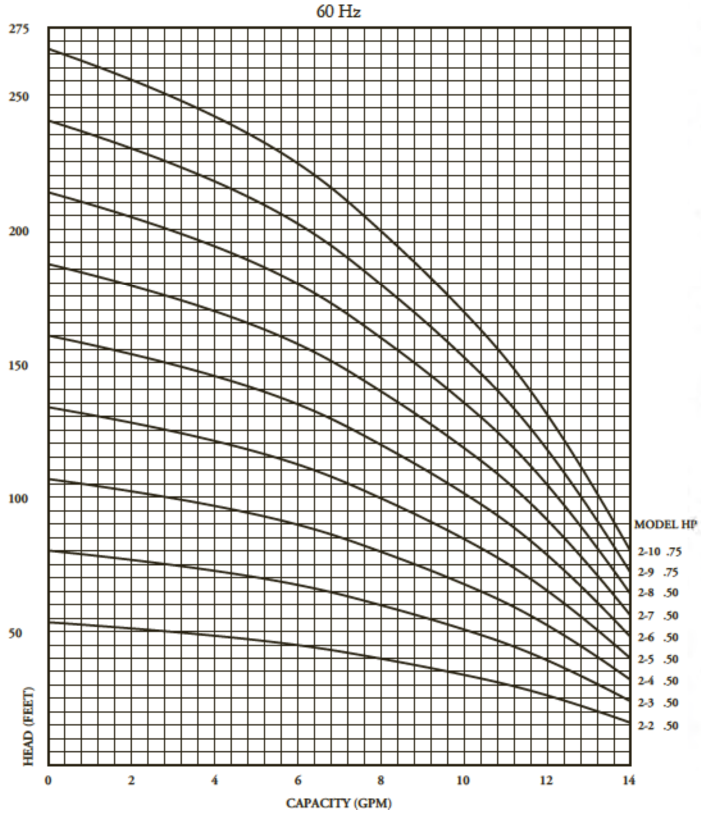
Client:	**JH Campbell**	
Project:	**Vertical Expansion Construction Permit**	
Job No.:	**19132873**	
Tag No.:	**Cell 8**	
Service & Source:	**Leachate**	
No. of pumps in series:	1	
Comments:		
Operating Data:		units
Fluid:	leachate	
Pumping Temp	115	deg F
% Solids (by weight):	1	%
S.G. Liquid:	1	
S.G. Dry Solids:	2	
S.G. Pulp:	1.01	
Particle Size (50% pass):	n/a	microns
Viscosity :	n/a	cp
pH:	5	
Flow	83.7	gpm
Design Factor	1.25	
Design Capacity:	105	gpm
Installation:		
Operation:		hrs/day
Pump on Elevation (max):	612.09	ft
Pump Off Elevation (min):	610.10	ft
Pump Elevation:	610.10	ft
Discharge Elevation:	620.00	ft
Res. Press. Req'd. :		psi
Absolute Pressure:		ft (abs)
Vapor Pressure:		ft
Operating Data (Misc.):		
Pump Type:	EPG	
Model:	WSD Surepump 31-1, 2.0 hp	
Sump Depth:	3.0	ft
Pump Length:		ft
Available Air Pressure:		psig
Cable Length:	100-ft min.	ft
Remarks:		
Results:		
NPSHA:	1	ft (abs)
Frict.+Vel.+Misc. Head	19	ft
Static Head (Max):	10	ft
Static Head (Min):	8	ft
TDH (Max):	29	ft
TDH (Min):	27	ft
Estimated. Efficiency.:	35.00	%
Estimated BHP:	2.19	hp

Pump Head		Date:	1/20/2021
Calculation Sheet		By:	TDJ
Friction:	Suct.:	Disch:	units
Pipe Size:	2.00	2.00	in
Pipe I.D. :	2.00	2.00	in
Material:	HDPE	HDPE	
"C" Factor:	140	140	
Velocity:	10.7	10.7	fps
Velocity Head:	1.8	1.8	ft
Unit Head Loss:	0.209	0.209	ft/ft
Friction Head:	0.2	14.3	ft
Entrance/Exit Head:	0.9	1.8	ft
Residual Press. Head:		0.0	ft
Miscellaneous Head			ft
Miscellaneous Head			ft
Equivalent Lengths (Ftgs. & Valves):			
Suction:	L/D	Qty.	Length(ft.):
90 Ell	16		
45 Ell	10		
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3		
B.F. Valve:	40		
Check Valve:	50		
Vertical Pipe:		1	1
Horizontal Pipe:			
Other:			
Other:			
Total Equiv. Length:			1
Discharge:	L/D	Qty.	Length(ft.):
90 Elbow	16	2	5
45 Elbow	10	2	3
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3	1	1
Butterfly Valve:	40		
Check Valve:	50	1	8
Vertical Pipe:			10
Horizontal Pipe:		41	41
Other:			
Other:			
Total Equiv. Length:			68

Client:	**JH Campbell**	
Project:	**Vertical Expansion Construction Permit**	
Job No.:	**19132873**	
Tag No.:	**Cell 9**	
Service & Source:	**Leachate**	
No. of pumps in series:	1	
Comments:		
Operating Data:		units
Fluid:	leachate	
Pumping Temp	115	deg F
% Solids (by weight):	1	%
S.G. Liquid:	1	
S.G. Dry Solids:	2	
S.G. Pulp:	1.01	
Particle Size (50% pass):	n/a	microns
Viscosity :	n/a	cp
pH:	5	
Flow	89.1	gpm
Design Factor	1.25	
Design Capacity:	111	gpm
Installation:		
Operation:		hrs/day
Pump on Elevation (max):	611.39	ft
Pump Off Elevation (min):	609.40	ft
Pump Elevation:	609.40	ft
Discharge Elevation:	620.00	ft
Res. Press. Req'd. :		psi
Absolute Pressure:		ft (abs)
Vapor Pressure:		ft
Operating Data (Misc.):		
Pump Type:	EPG	
Model:	WSD Surepump 31-1, 2.0 hp	
Sump Depth:	3.0	ft
Pump Length:		ft
Available Air Pressure:		psig
Cable Length:	100-ft min.	ft
Remarks:		
Results:		
NPSHA:	1	ft (abs)
Frict.+Vel.+Misc. Head	22	ft
Static Head (Max):	11	ft
Static Head (Min):	9	ft
TDH (Max):	32	ft
TDH (Min):	30	ft
Estimated. Efficiency.:	35.00	%
Estimated BHP:	2.60	hp

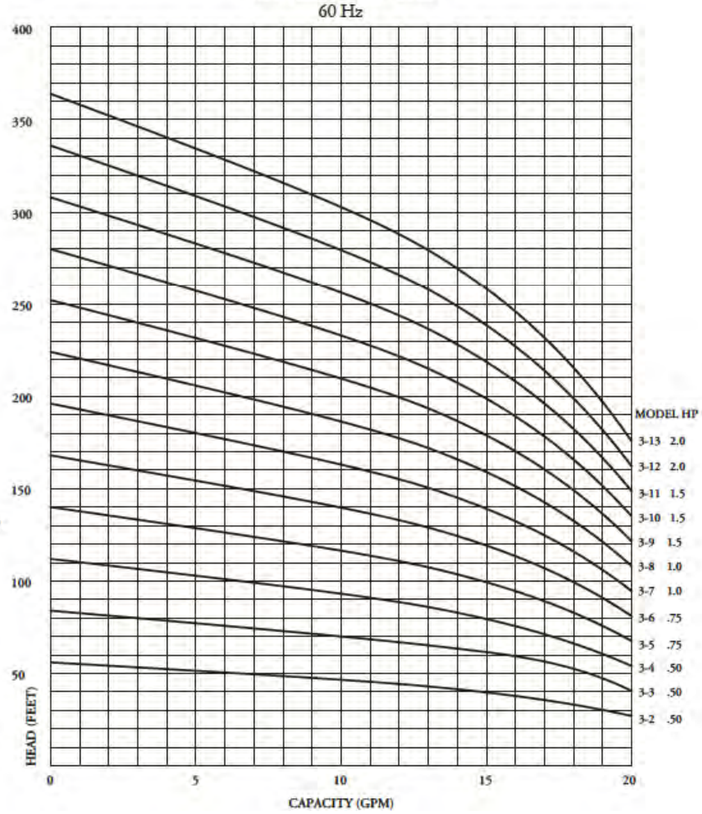
Pump Head		Date:	1/20/2021
Calculation Sheet		By:	TDJ
Friction:	Suct.:	Disch:	units
Pipe Size:	2.00	2.00	in
Pipe I.D. :	2.00	2.00	in
Material:	HDPE	HDPE	
"C" Factor:	140	140	
Velocity:	11.4	11.4	fps
Velocity Head:	2.0	2.0	ft
Unit Head Loss:	0.235	0.235	ft/ft
Friction Head:	0.2	16.4	ft
Entrance/Exit Head:	1.0	2.0	ft
Residual Press. Head:		0.0	ft
Miscellaneous Head			ft
Miscellaneous Head			ft
Equivalent Lengths (Ftgs. & Valves):			
Suction:	L/D	Qty.	Length(ft.):
90 Ell	16		
45 Ell	10		
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3		
B.F. Valve:	40		
Check Valve:	50		
Vertical Pipe:		1	1
Horizontal Pipe:			
Other:			
Other:			
Total Equiv. Length:			1
Discharge:	L/D	Qty.	Length(ft.):
90 Elbow	16	2	5
45 Elbow	10	2	3
Run of Tee:	20		
Branch of Tee:	60		
Gate Valve:	8		
Globe Valve:	340		
Plug Valve:	18		
Ball Valve:	3	1	1
Butterfly Valve:	40		
Check Valve:	50	1	8
Vertical Pipe:			11
Horizontal Pipe:		42	42
Other:			
Other:			
Total Equiv. Length:			70

SERIES 2 SurePump™
Flow Range 4-14 GPM
60 Hz



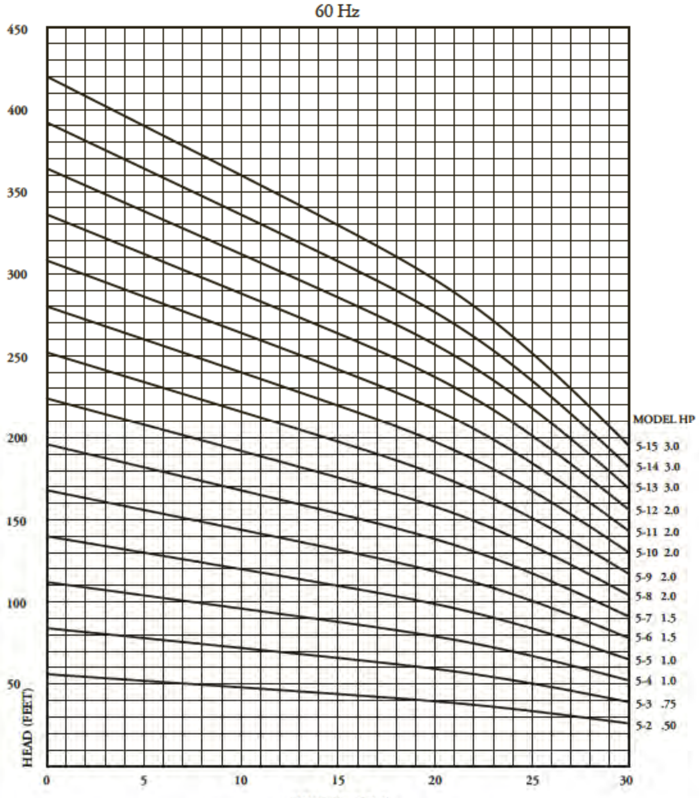
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 3 SurePump™
Flow Range 10-20 GPM
60 Hz



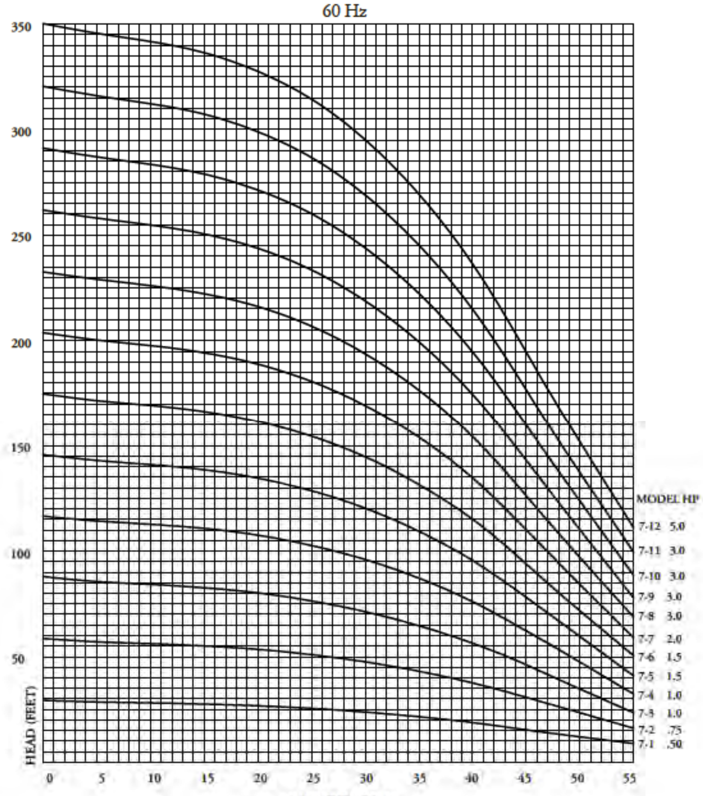
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 5 SurePump™
Flow Range 15-30 GPM
60 Hz



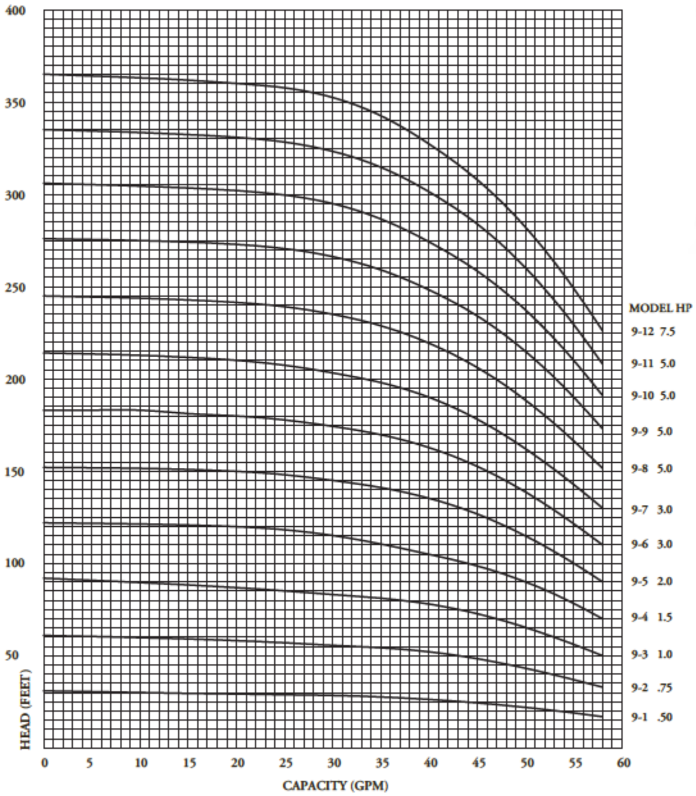
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 7 SurePump™
Flow Range 20-50 GPM
60 Hz



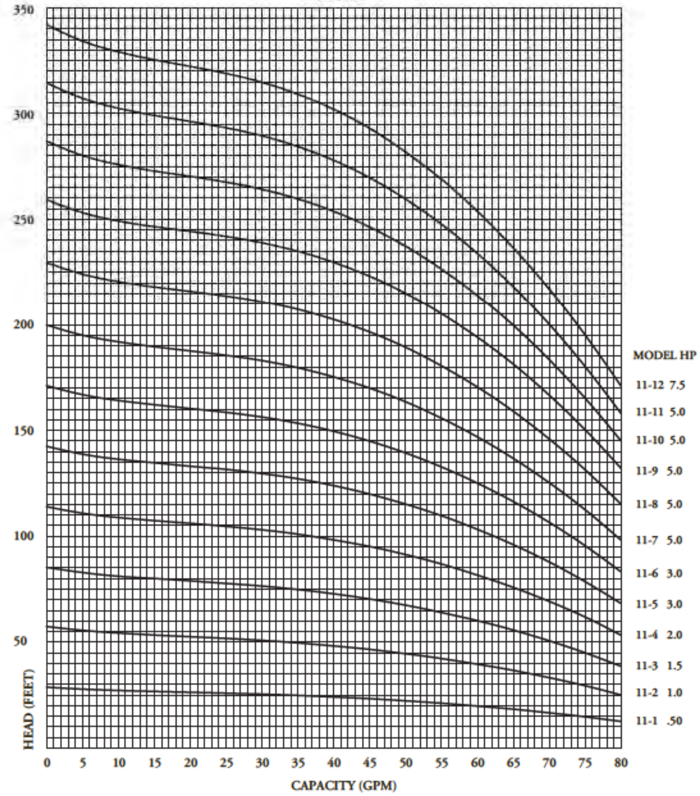
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 9 SurePump ™
Flow Range 20-50 GPM
60 Hz



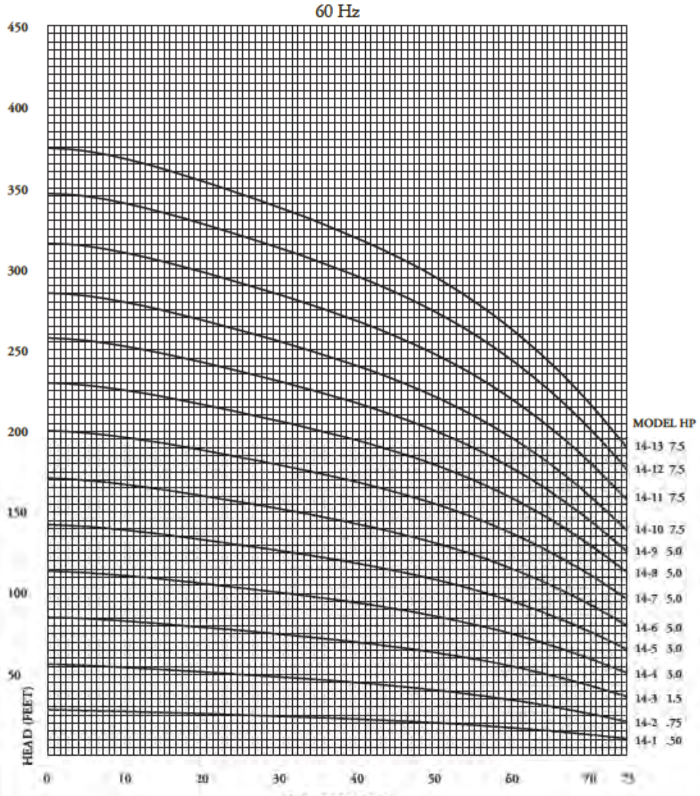
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 11 SurePump™
Flow Range 35-80 GPM
60 Hz



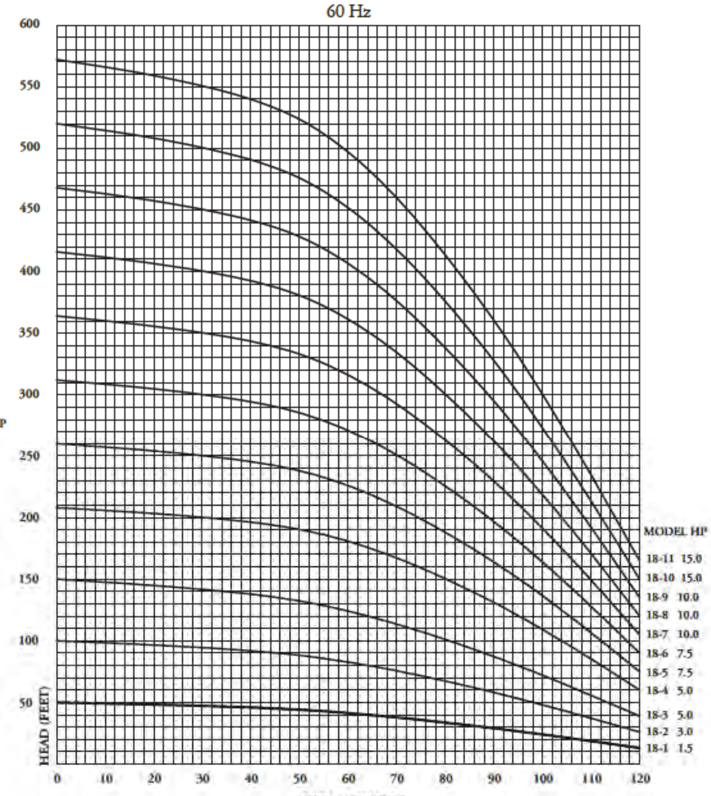
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 14 SurePump™
Flow Range 45-95 GPM
60 Hz



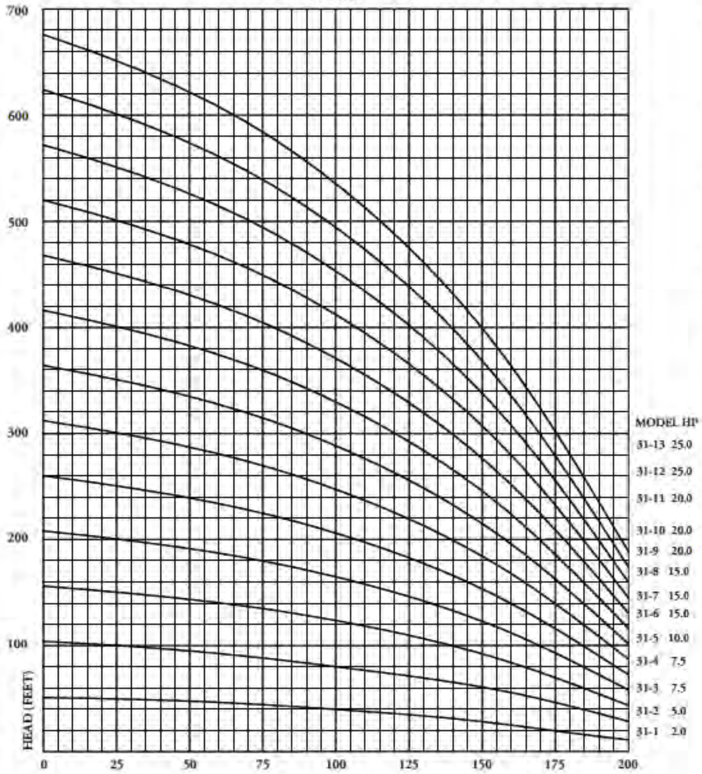
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 18 SurePump™
Flow Range 20-120 GPM
60 Hz



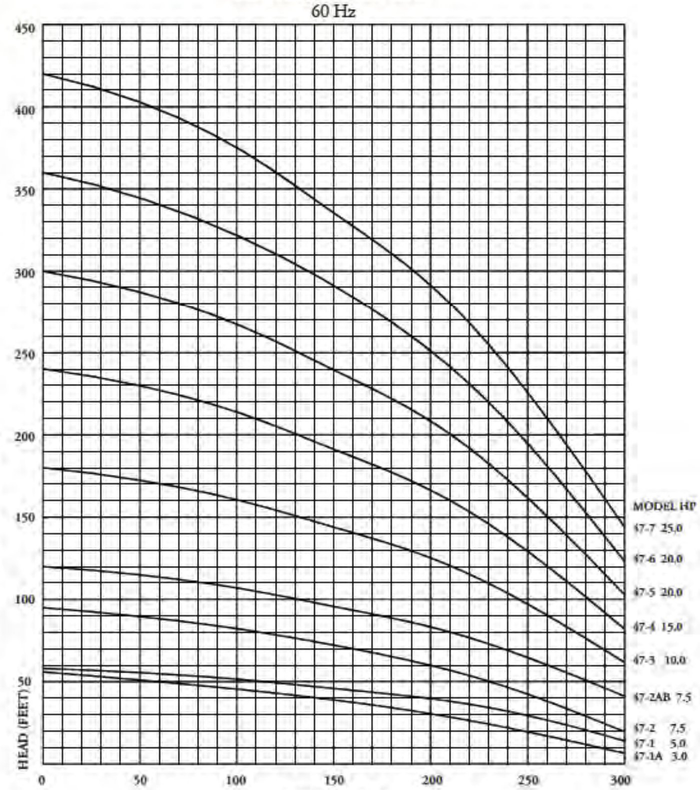
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 31 SurePump™
Flow Range 50-200 GPM
60 Hz



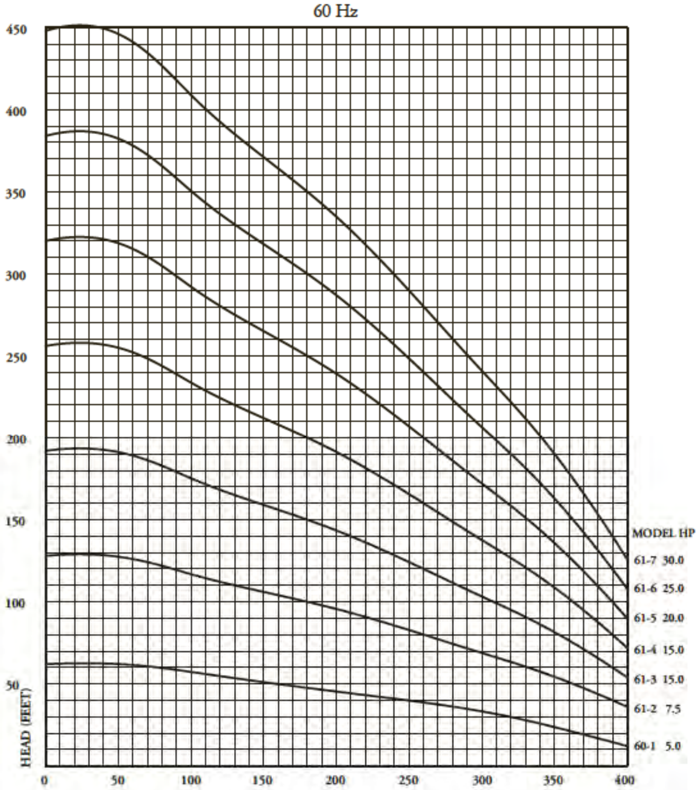
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 47 SurePump™
Flow Range 75-300 GPM
60 Hz



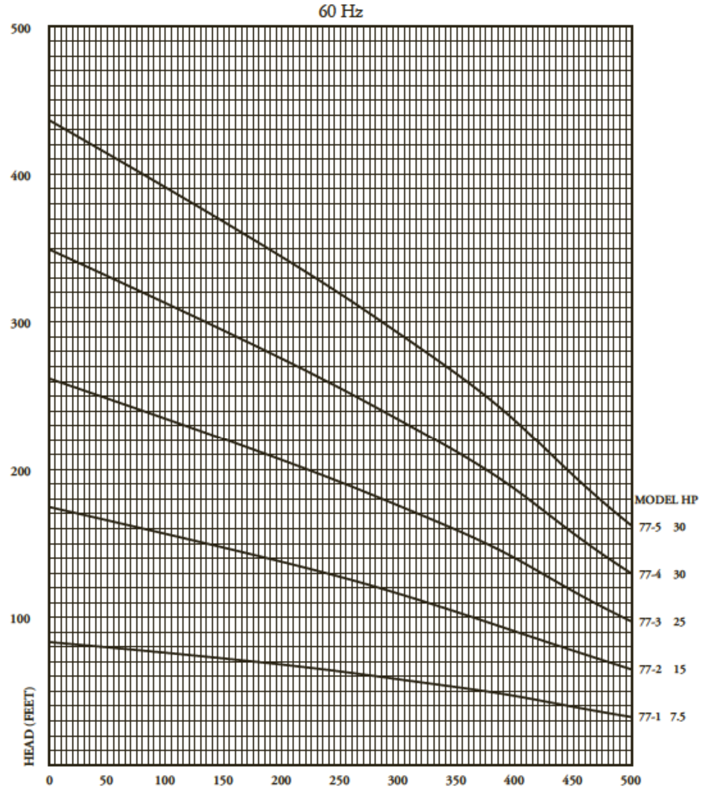
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 61 SurePump™
Flow Range 50-400 GPM
60 Hz



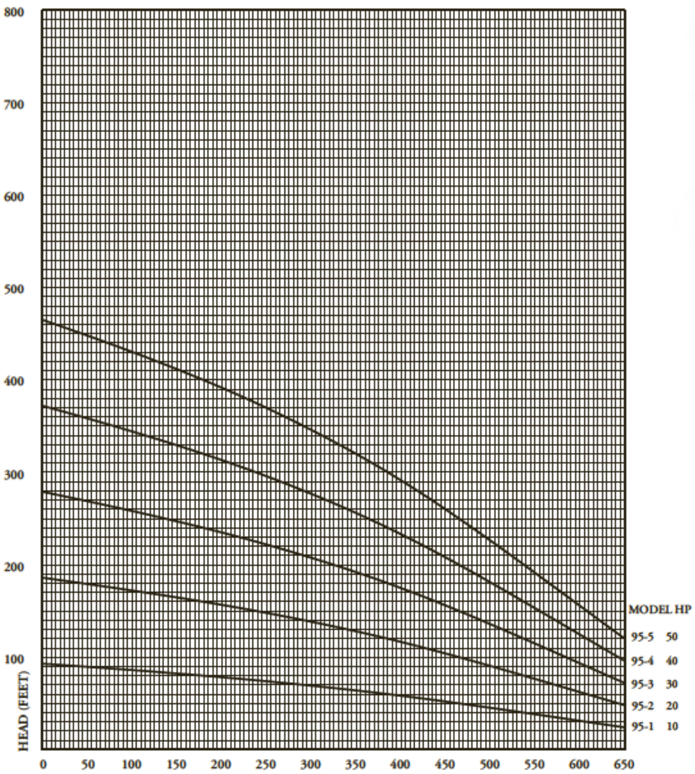
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 77 SurePump™
Flow Range 75-500 GPM
60 Hz



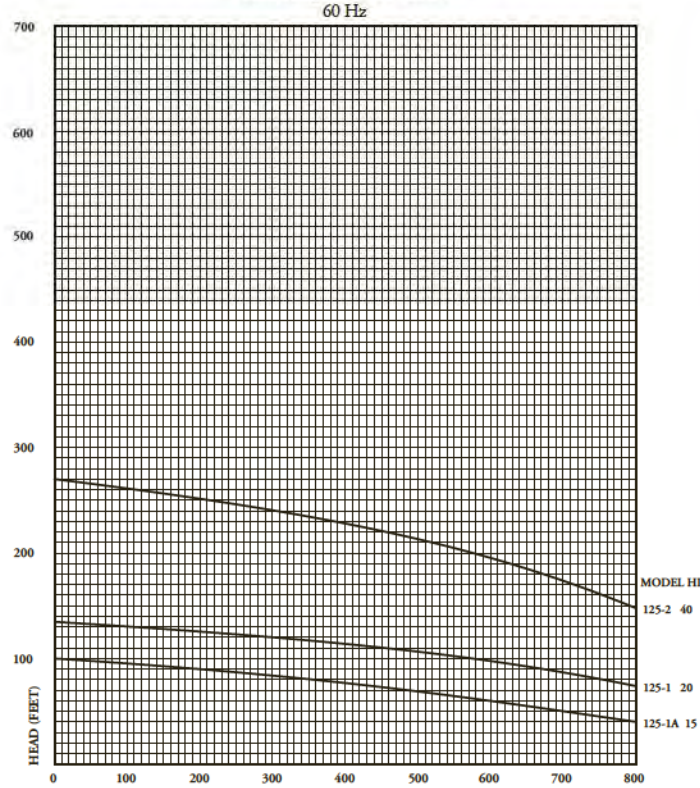
DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 95 SurePump™
Flow Range 95-680 GPM
60 Hz



DATA SUBJECT TO CHANGE WITHOUT NOTICE

SERIES 125 SurePump™
Flow Range 125-850 GPM
60 Hz



DATA SUBJECT TO CHANGE WITHOUT NOTICE

APPENDIX M

Stormwater Management System Calculations

<table>
<tr><td rowspan="3">GOLDER
MEMBER OF WSP</td><td>SUBJECT</td><td colspan="4">Storm Water Management
2020 Expansion</td></tr>
<tr><td>Job No.
Ref.</td><td>19132873
J.H. Campbell Landfill Vertical Expansion</td><td>Made By
Checked
Reviewed</td><td>HAD
DJS
TDJ</td><td>Date
Sheet</td><td>1/19/2021
1 of 1</td></tr>
</table>

OBJECTIVE: The stormwater management calculations and design for the J.H. Campbell (JHC) Landfill vertical expansion were performed in accordance with the Part 115 Rules and Ottawa County 2005 Standards and Specs for Drain Commissioner's Approval. The stormwater management controls are designed to manage the 25-year 24-hour storm event. The stormwater from the landfill is discharged to perimeter ditches where the water then infiltrates into the surrounding sandy soils. Stormwater design drawings are provided as Attachment 1 and in the Engineering Drawings, series 700.

DATA SUMMARY: Data used for the stormwater calculations and design are summarized on the attached tables. The tables provide names and acreage of watershed areas, longest flow path information (slope, length, flow type), and point of discharge locations.

METHODS: HydroCAD ® Stormwater Modeling System Version 10.00 and AutoCAD Civil 3D Hydraflow Extension was used to perform calculations for the JHC Landfill stormwater management design. SCS TR-20 Type II 24-hr method was used for these calculations with the following conditions and assumptions:

1.) Stormwater run-off occurring within developed areas of the facility will be managed to control erosion, sedimentation and stormwater discharges. Stormwater and erosion run-off will be controlled by utilizing the following controls:

1) Grass lined surface water control berm channels;
2) Articulated concrete block downchutes;
3) Perimeter facility drainage channels, culverts and sediment traps;
4) Silt fencing; and
5) Establishment of vegetative buffers between construction and stormwater channels.

2.) Precipitation Data (from NOAA Precipitation Data Frequency Server)

Storm	2-yr 24-hr	25-yr 24-hr	100-yr 24-hr
Precipitation (inches)	2.6	4.97	6.94

3.) Major Soil Types on Site (USDA - Web Soil Survey), see Attachment 2:

Soil Series Name	Hydrologic Group
Covert-Pipestone Sands	A/D
Plainfield Sands	A

4.) Curve numbers (CN) were selected for watershed areas to represent the following surface conditions:

Surface Condition	CN
Landfill Cover	79
Gravel Road	96
Perimeter Drainage	49

CALCULATIONS:

1.) Surface Water Control Berms, Downslope Chutes, Perimeter Ditches, and Culverts.

Storm water conveyances shall be designed for the 25-year-24-hour storm per the Part 115 Rules and Ottawa County Standards & Specifications for the Drain Commissioner's Approval, see Attachment 3. Calculations were also ran for the 100-year 24-hour storm for conservative measures, see Attachment 4. The stormwater berms (NW-2 and E-4) showed flows slightly exceeding the capacity for the 100-year 24-hour storm (Attachment 4), but were able to maintain the 25-year 24-hour flow per the Part 115 Rules. Design flows for culverts are taken as the flow in the ditch upstream of the culvert. Culverts have been designed with consideration to inlet and barrel (diameter, slope, roughness) control. Ditches for this site are trapezoidal and triangular in cross section and are sized using Manning's equation. Similarly trapezoidal downchute calculations were performed in HydroCAD. Additional calculations were performed to determine the size of articulated block required for the downchutes and the factor, see Attachment 5.

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$V = Q/A$$

Q = flow, cfs
n = Manning's roughness coefficient
A = Cross-sectional flow area, sq. ft.
R = Hydraulic radius, ft. (= Area/Wetted perimeter)
S = Slope of hydraulic grade line, ft./ft.
V = Velocity (feet per second, fps)

Downstream ditches will handle cumulative flows from upstream as well as their contributing watershed flows. Ditches will be lined based on their velocities. The ditch lining materials will have the following properties.

Lining	Manning's n	V (fps)
Grass	0.025	3.4
Riprap	n/a	8
Matting	0.025	8
Articulated Block	0.05	-

See the attached Tables and Attachments 3 and 4 for the HydroCAD calculations and results.

2.) Infiltration

Given that the site perimeter ditches are located within the Plainfield Sand Group A soils, there are high infiltration rates into the sand an dthus a low runoff potential from the perimeter ditches. The Plainfield sands are well drained and therfore no basins have been designed or are needed for this site.

CONCLUSIONS:

The JHC Landfill stormwater management controls are designed according to the Ottawa County Standards & Specifications for the Drain Commissioner's Approval and the Part 115 Rules. The landfill perimeter ditches are able to maintain the stormwater volume from the 25-year 24-hour storm and 100-yr 24-hr storm.

REFERENCES:

1.) Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55 (TR-55), 1986.
2.) NOAA Precipitation Data Frequency Server. Atlas 14, Volume 8, Version 2. Location name: Rothbury, MI USA. (8/18/2020).
3.) USDA - Natural Resources Conservation Service. Web Soil Survey - National Cooperative Soil Survey (8/18/2020).
4.) Ottawa County Standards & Specifications for Drain Commissioner's Approval. September 9, 2005 Amended Revision.
5.) Michigan Department of Environment, Great Lakes and Energy, Materials Management Division. Waste Management. Part 115 Rules. Part 1. General Provisions.
6.) Natural Resources and Environmental Protection Act (Excerpt). Act 451 of 1994. Part 115. Solid Waste Management.

ATTACHMENTS

Attachment 1 - Stormwater Design Drawings
Attachment 2 - Hydrologic Soil Map
Attachment 3 - HydroCAD 25-yr 24-hr Results
Attachment 4 - HydroCAD 100-yr 24-hr Results
Attachment 5 - Cell 7 and 9 Articulated Block Downchute Calculations

Tables

CEC JHC LANDFILL
SUMMARY SCHEDULE

Watershed	Area (acres)	Longest Flow Paths									Discharge Locations	
		Sheet Flow		Shallow Concentrated Flow				Channel Flow			DC	Drainage Ditch
		Slope (%)	Length (ft) (Max 300 ft)	Slope (%)	Length (ft)	Slope (%)	Length (ft)	Name	Slope (%)	Length (ft)		
NW-1	3.8	2	108	-	-	-	-	TB-1	0.6	1600	Cell 1 DC	NW
NW-2	15.7	25	300	2	158	25	192	TB-2	0.6	1370		
NE-1	3.3	2	108	-	-	-	-	TB-3	0.5	1210	Cell 2 DC	NE
NE-2	13.9	25	300	2	158	25	192	TB-4	0.5	1100		
NE-3	1	25	100	-	-	-	-	TB-5	1.8	355		
E-1	0.9	25	100	-	-	-	-	TB-7	1.8	435	Cell 3 DC	SE
E-2	5.4	2	270	25	118	-	-	TB-6	1.8	715		
E-3	2.3	25	116	-	-	-	-	TB-8	1.0	1050		
E-4	21.7	2	300	2	170	25	153	TB-9 and TB-12	1.0	2040		
SE-1	2.6	25	92	-	-	-	-	TB-11	1.0	1120	SE Catch Basin	S
SW-1	3.3	25	92	-	-	-	-	TB-13	1.0	1604	Cell 9 DC	SW
SW-2	14.7	2	300	2	170	25	153	TB-14	1.0	1408		
SW-3	0.7	25	108	-	-	-	-	TB-15	1.4	273		
SW-4	1.8	2	216	25	208			TB-16	1.4	276		
W-1	0.8	25	108	-	-	-	-	TB-17	1.4	365	Cell 7 DC	W
W-2	5.0	2	300	2	160	25	225	TB-18	1.4	118		
W-3	1.3	25	106	-	-	-	-	TB-19	1.4	558		
W-4	3.7	25	214	-	-	-	-	TB-20	1.4	352		
Toe-1	0.3	25	20	-	-	-	-	-	-	-	N/A	NW
	0.3	1	20									
	1.6	25	60									
Toe-2	0.5	25	40	-	-	-	-	-	-	-		NE
	0.3	1	20									
	2.0	25	60									
Toe-3	0.3	25	40	-	-	-	-	-	-	-		SE
	0.2	1	20									
	0.8	25	60									
Toe-4	0.4	25	40	-	-	-	-	-	-	-		SW
	0.3	1	20									
	1.3	25	60									
Toe-5	0.5	25	20	-	-	-	-	-	-	-		W
	0.1	1	20									
	0.2	25	60									

CEC JHC LANDFILL
SUMMARY SCHEDULE

Channels							
Name	**Slope (%)**	**Length (ft)**	**Shape**	**Sideslopes (H:1V)**	**Depth (ft)**	**Base Width (ft)**	**Manning's number**
TB-1	0.6	1600	Triangle	3 / 4	2	-	0.025
TB-2	0.6	1370	Tapezoid	2 / 2	2	2	0.025
TB-3	0.5	1210	Triangle	3 / 4	2	-	0.025
TB-4	0.5	1100	Tapezoid	2 / 2	2	2	0.025
TB-5	1.8	355	Triangle	3 / 4	2	-	0.025
TB-6	1.8	715	Tapezoid	2 / 2	2	2	0.025
TB-7	1.8	435	Triangle	3 / 4	2	-	0.025
TB-8	1.0	1050	Triangle	3 / 4	2	-	0.025
TB-9	1.0	1165	Tapezoid	2 / 2	2	2	0.025
TB-10	1.0	80	Triangle	3 / 4	2	-	0.025
TB-11	1.0	1120	Triangle	3 / 4	2	-	0.025
TB-12	1.0	875	Tapezoid	2 / 2	2	2	0.025
TB-13	1.0	1604	Triangle	3 / 4	2	-	0.025
TB-14	1.0	1408	Tapezoid	2 / 2	2	2	0.025
TB-15	1.4	273	Triangle	3 / 4	2	-	0.025
TB-16	1.4	276	Tapezoid	2 / 2	2	2	0.025
TB-17	1.4	365	Triangle	3 / 4	2	-	0.025
TB-18	1.4	365	Tapezoid	2 / 2	2	2	0.025
TB-19	1.4	558	Triangle	3 / 4	2	-	0.025
TB-20	1.4	545	Tapezoid	2 / 2	2	2	0.025
NW Ditch	0.35	390	Tapezoid	38 / 6	2	25	0.03
NE Ditch	0.46	876	Tapezoid	4 / 3	10	19	0.03
SE Ditch	1	364	Tapezoid	4 / 4	5	12	0.03
S Ditch	0.14	217	Tapezoid	4 / 3	8	15	0.03
SW Ditch	0.35	262	Tapezoid	4 / 4	3	14	0.03
W Ditch	0.7	143	Tapezoid	33 / 8	1	36	0.03
DC Cell 1	25	105	Tapezoid	3 / 3	2.4	6	0.05
DC Cell 2	25	140	Tapezoid	3 / 3	2.4	6	0.05
DC Cell 3	25	105	Tapezoid	3 / 3	2.4	6	0.05
DC Cell 7	25	76	Tapezoid	3 / 3	2.4	6	0.05
DC Cell 9	25	76	Tapezoid	3 / 3	2.4	6	0.05

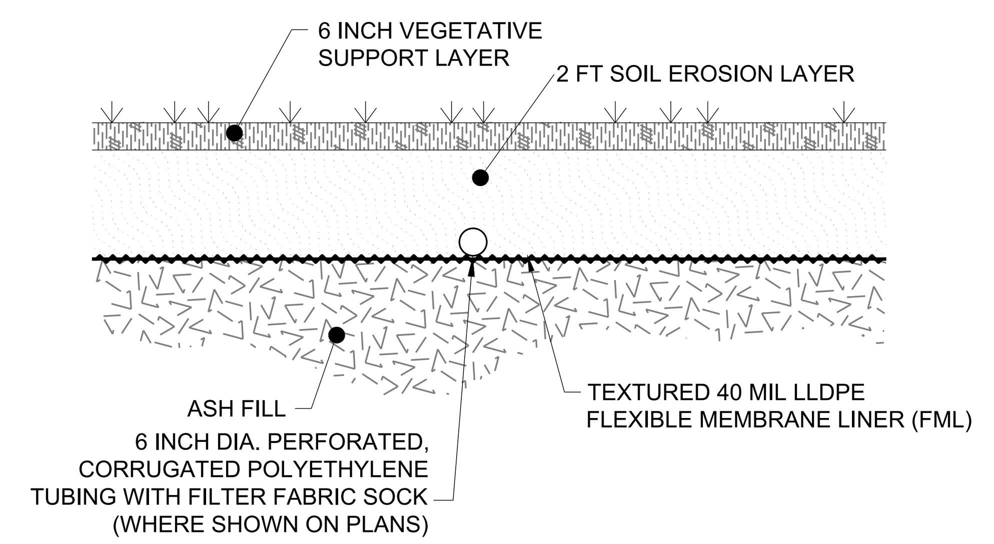
Proposed Culverts								
Name	**25-yr 24-hr Design Flow (cfs)**	**Upstream Invert El. (ft)**	**Slope (%)**	**Length (ft)**	**No. Barrels**	**Diameter (in)**	**Upstream Depth (in)**	**Max. Velocity (fps)**
SW-1 Culvert	15.0	631.2	1	120	2	24	18.1	6.9
SW-2 Culvert	35.0	651.2	1	120	2	24	11.7	5.0
DC Cell 7 Outlet	32.9	615.0	1	60	1	42	31.1	6.0
DC Cell 9 Outlet	42.2	615.0	1	60	1	42	36.0	4.7

NOTES:

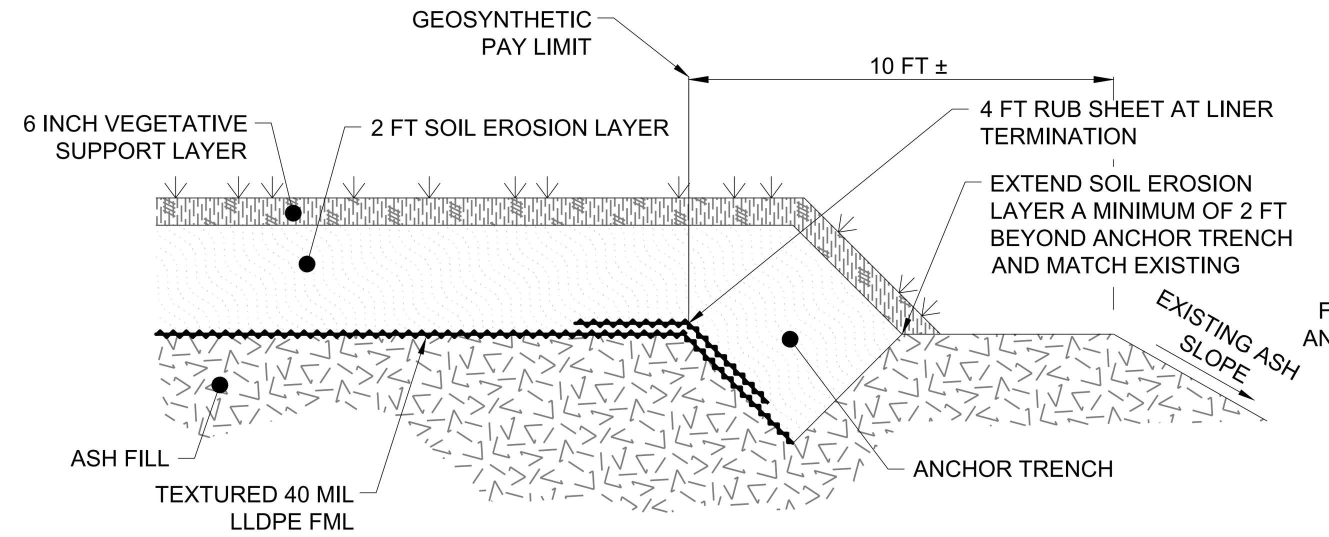
1. REFER TO THE ENGINEERING PLANS, SHEET 700-1, FOR STORM WATER FEATURE LOCATIONS.
2. ALL AREAS MEASURED USING AUTOCAD.
3. SIZES AND FLOWS MEASURED USING MANNING'S EQUATION, HYDRAFLOW, AND HYDROCAD.
4. CONTRIBUTING WATERSHEDS ARE APPROXIMATE.
5. CULVERTS SHALL BE POLYETHYLENE PIPE, OR EQUAL.

Attachment 1

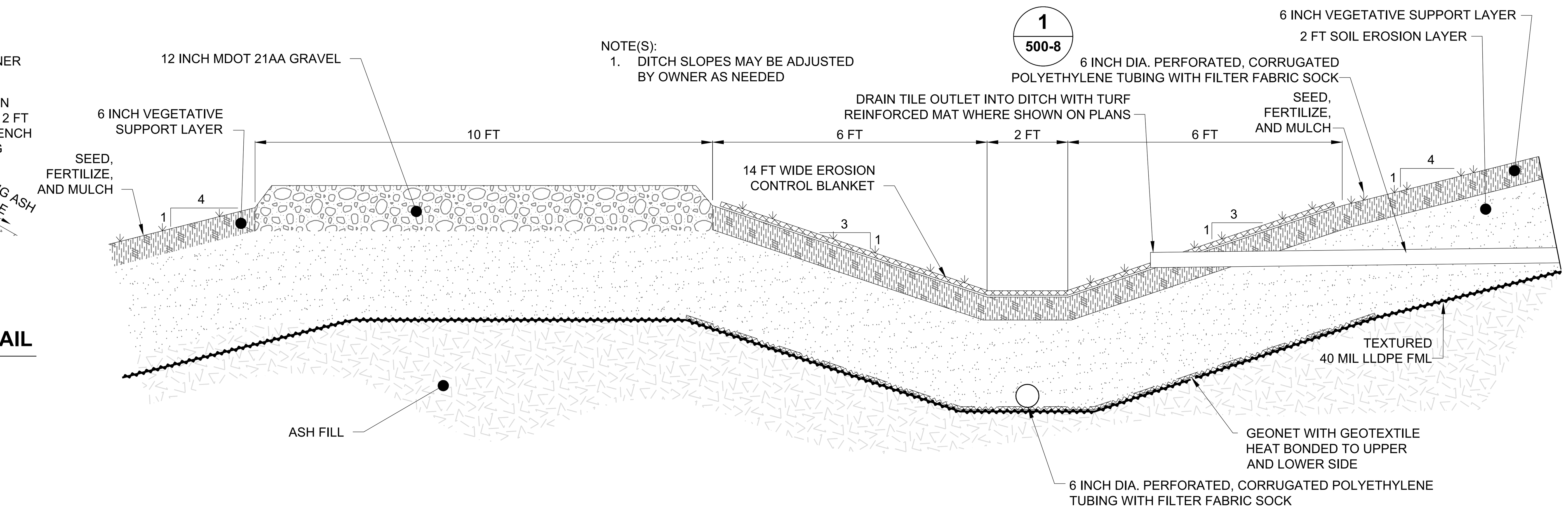
Stormwater Design Drawings



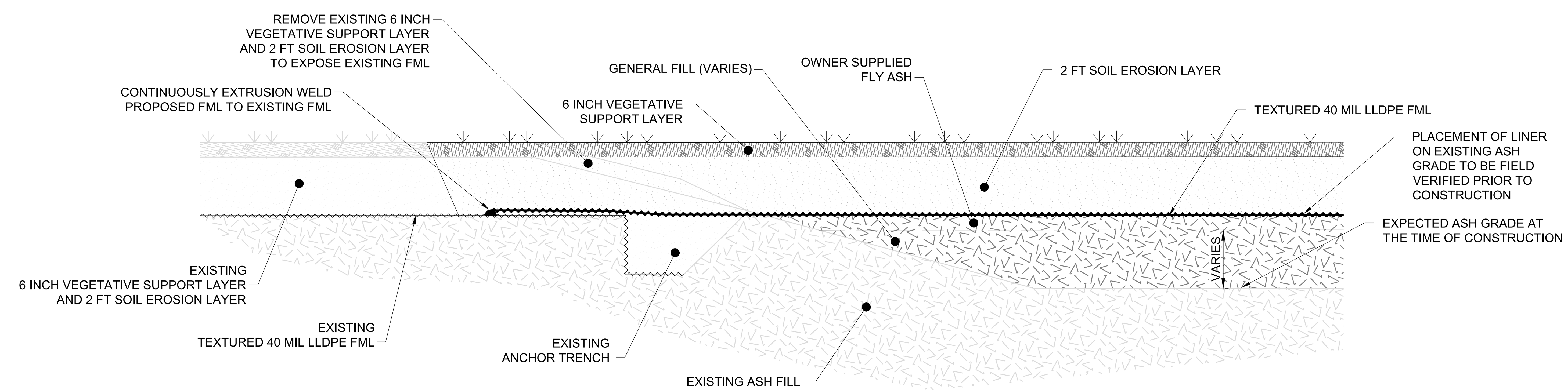
NOT TO SCALE 1 500-8 **TYPICAL FINAL COVER DETAIL**



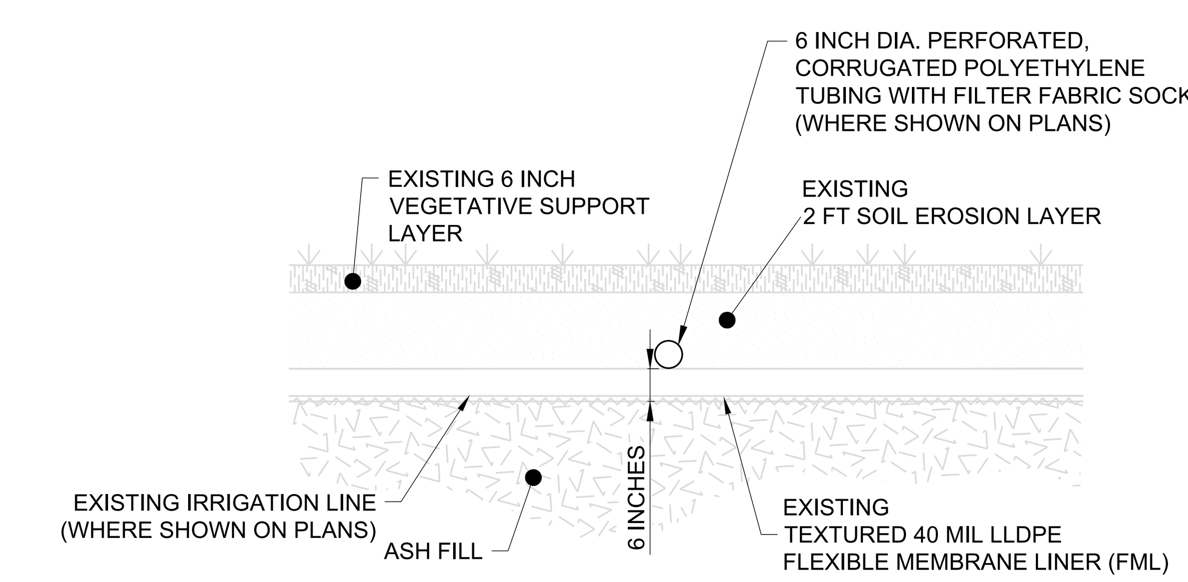
NOT TO SCALE 2 500-8 **TYPICAL FINAL COVER ANCHOR TRENCH DETAIL**



NOT TO SCALE 3 500-8 **TYPICAL DRAINAGE BENCH DETAIL**



NOT TO SCALE 4 500-8 **TYPICAL TIE-IN TO EXISTING FINAL COVER SYSTEM**



NOT TO SCALE 5 500-8 **TYPICAL DRAIN TILE IN EXISTING FINAL COVER DETAIL**

NOT TO SCALE 6 500-8 **TYPICAL TIE-IN TO EXISTING CELL ANCHOR TRENCH**

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
0	2021-05-10	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA

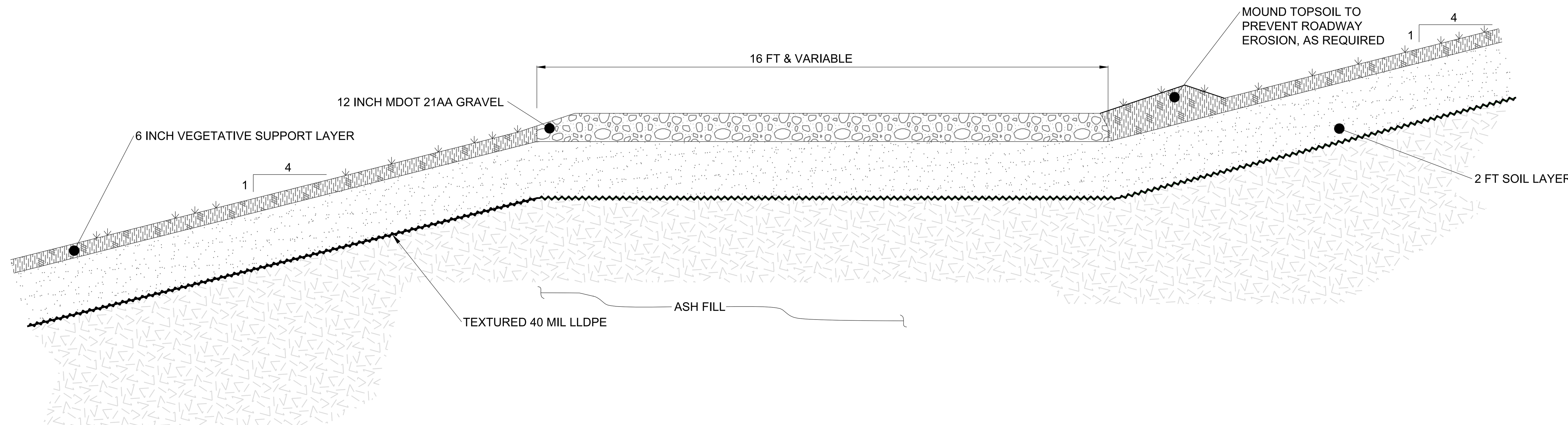
REFERENCE DRAWINGS | REV | DATE | DESCRIPTION | DR | BY | CHK | APP | CO

SIGNATURE
NAME
TIFFANY D. JOHNSON
MICHIGAN P.E. No.
6201049160

Consumers Energy
J.H. CAMPBELL PLANT
WEST OLIVE, MI

FINAL COVER DETAILS - SHEET 1

SCALE: NONE
JOB: PT-02661
DRAWING NO. ---
SHEET 500-8
REV. 0



NOT TO SCALE 1 500-9 **TYPICAL ACCESS ROAD DETAIL**

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
									0	2021-05-10	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA

SIGNATURE
NAME
TIFFANY D. JOHNSON
MICHIGAN P.E. No.
6201049160

Consumers Energy
J.H. CAMPBELL PLANT
WEST OLIVE, MI

FINAL COVER DETAILS - SHEET 2

SCALE: NONE
JOB: PT-02661
DRAWING NO. ---
SHEET 500-9
REV. 0

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
0	2021-05-10	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA

SIGNATURE

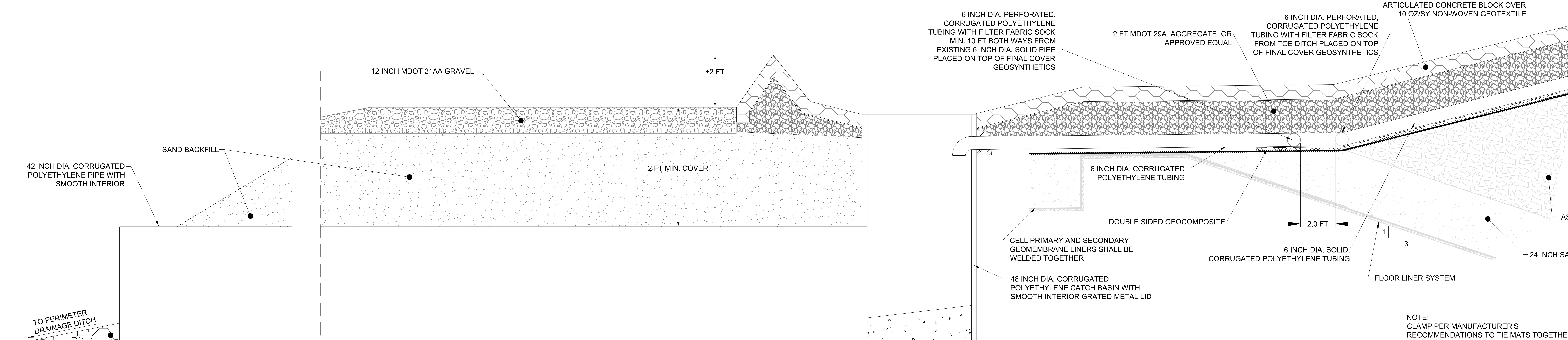
NAME
TIFFANY D. JOHNSON
MICHIGAN P.E. No.
6201049160

Consumers Energy

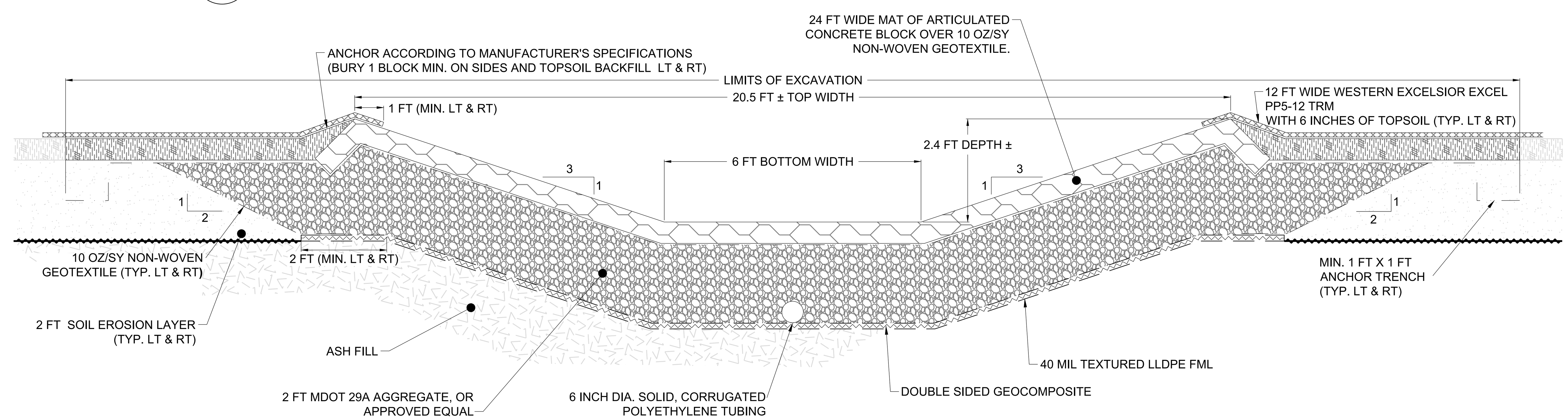
J.H. CAMPBELL PLANT
WEST OLIVE, MI

STORMWATER MANAGEMENT PLAN

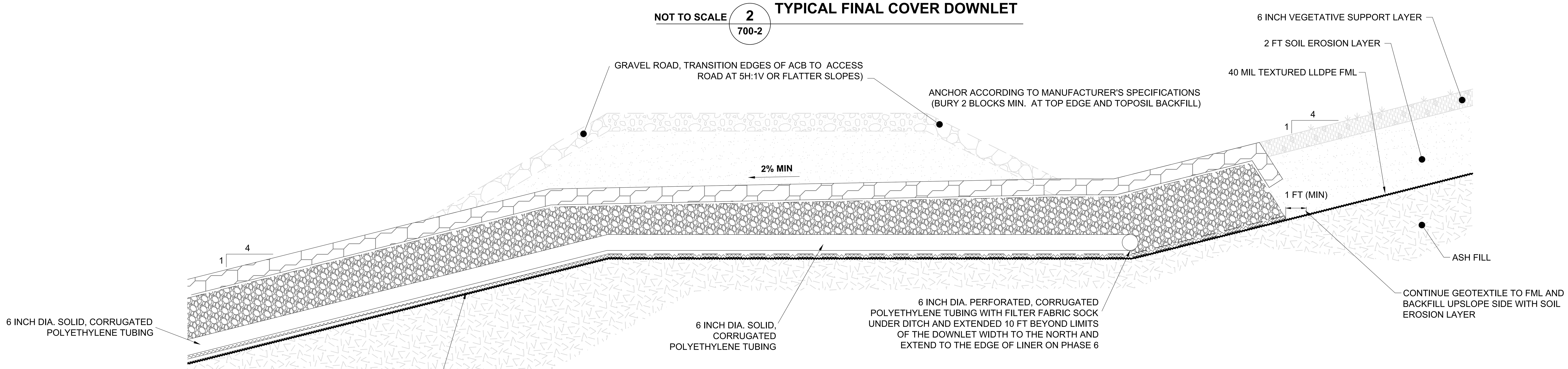
SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO. ---
SHEET 700-1
REV. 0



NOT TO SCALE 1 700-2 **TYPICAL FINAL COVER DRAINAGE OUTLET**



NOT TO SCALE 2 700-2 **TYPICAL FINAL COVER DOWNLET**



NOT TO SCALE 3 700-2 **TYPICAL INTERSECTION OF DOWNLET AND DRAINAGE BENCH**

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
0	2021-05-10	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA

SIGNATURE

NAME: TIFFANY D. JOHNSON

MICHIGAN P.E. No. 6201049160

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

STORMWATER MANAGEMENT DETAILS - SHEET 1

SCALE: NONE
JOB: PT-02661
DRAWING NO. ---
SHEET 700-2
REV. 0

NOT TO SCALE 1 700-3 **TYPICAL DRAINAGE BENCH CULVERT CROSSING**

																	SIGNATURE	
																	NAME	
																	TIFFANY D. JOHNSON	
									0	2021-05-10	SUBMITTED TO EGLE	SF	DS	GD	TJ	GA	MICHIGAN P.E. No.	
REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO	6201049160	

Consumers Energy

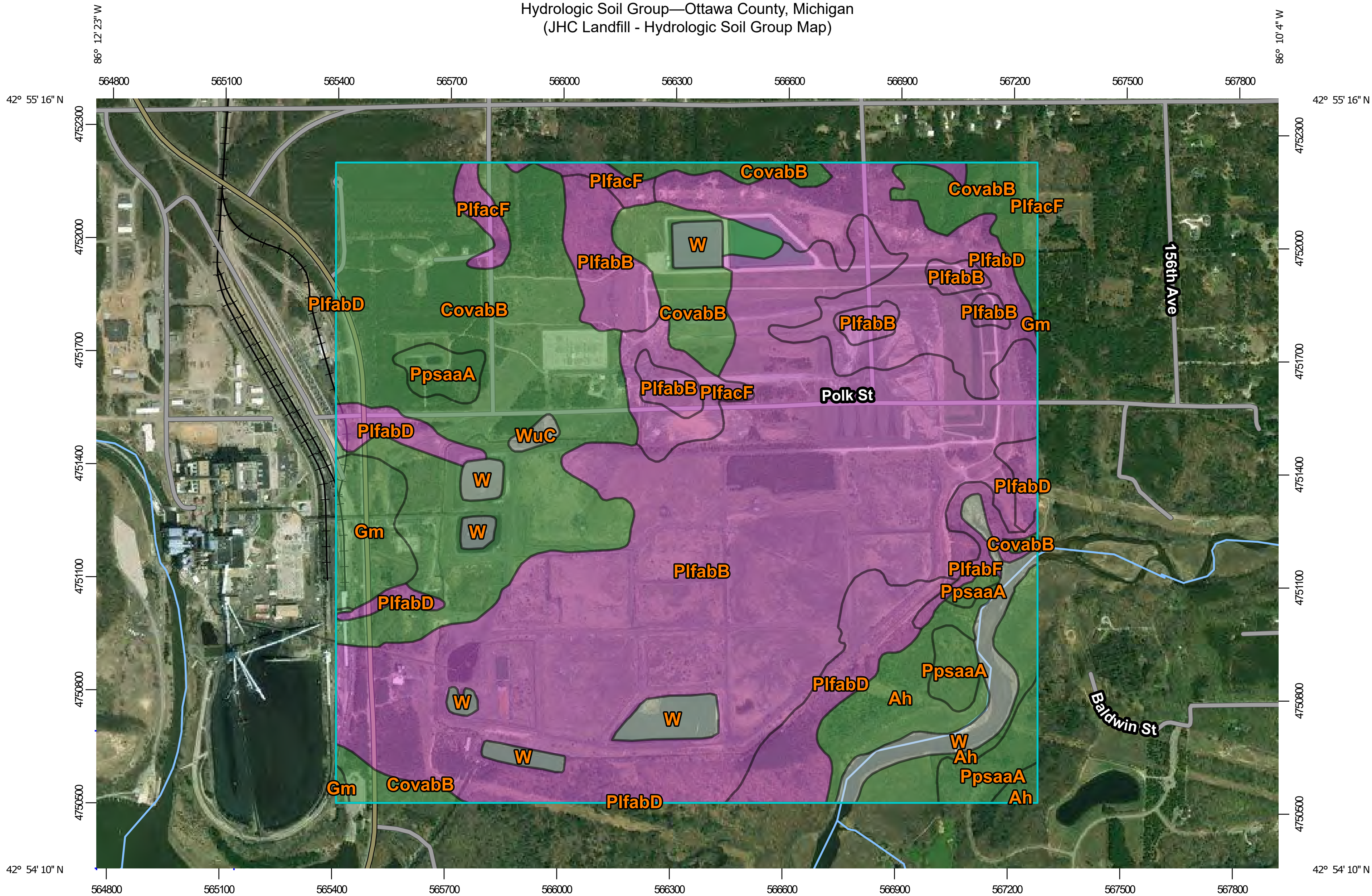
J.H. CAMPBELL PLANT
WEST OLIVE, MI

STORMWATER MANAGEMENT DETAILS - SHEET 2

SCALE: NONE
JOB: PT-02661
DRAWING NO. ---
SHEET 700-3
REV. 0

Attachment 2

Hydrologic Soil Map



Map Scale: 1:14,400 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 200, 400, 800, 1200

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Ottawa County, Michigan
Survey Area Data: Version 15, Jun 2, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Oct 20, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Ah	Houghton-Adrian mucks, 0 to 1 percent slopes	A/D	35.8	4.5%
CovabB	Covert-Pipestone sands, 0 to 6 percent slopes	A/D	206.7	26.2%
Gm	Granby loamy sand, lake plain, 0 to 2 percent slopes	A/D	17.7	2.2%
PlfabB	Plainfield sand, lake plain, 0 to 6 percent slopes	A	337.4	42.8%
PlfabD	Plainfield sand, lake plain, 6 to 18 percent slopes	A	100.6	12.8%
PlfabF	Plainfield sand, high ecological site, 30 to 50 percent slopes	A	6.9	0.9%
PlfacF	Plainfield sand, dunes, 18 to 60 percent slopes	A	22.3	2.8%
PpsaaA	Pipestone-Covert-Saugatuck sands, 0 to 3 percent slopes	A/D	23.5	3.0%
W	Water		35.3	4.5%
WuC	Wind eroded land, sloping		1.8	0.2%
Totals for Area of Interest			**788.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

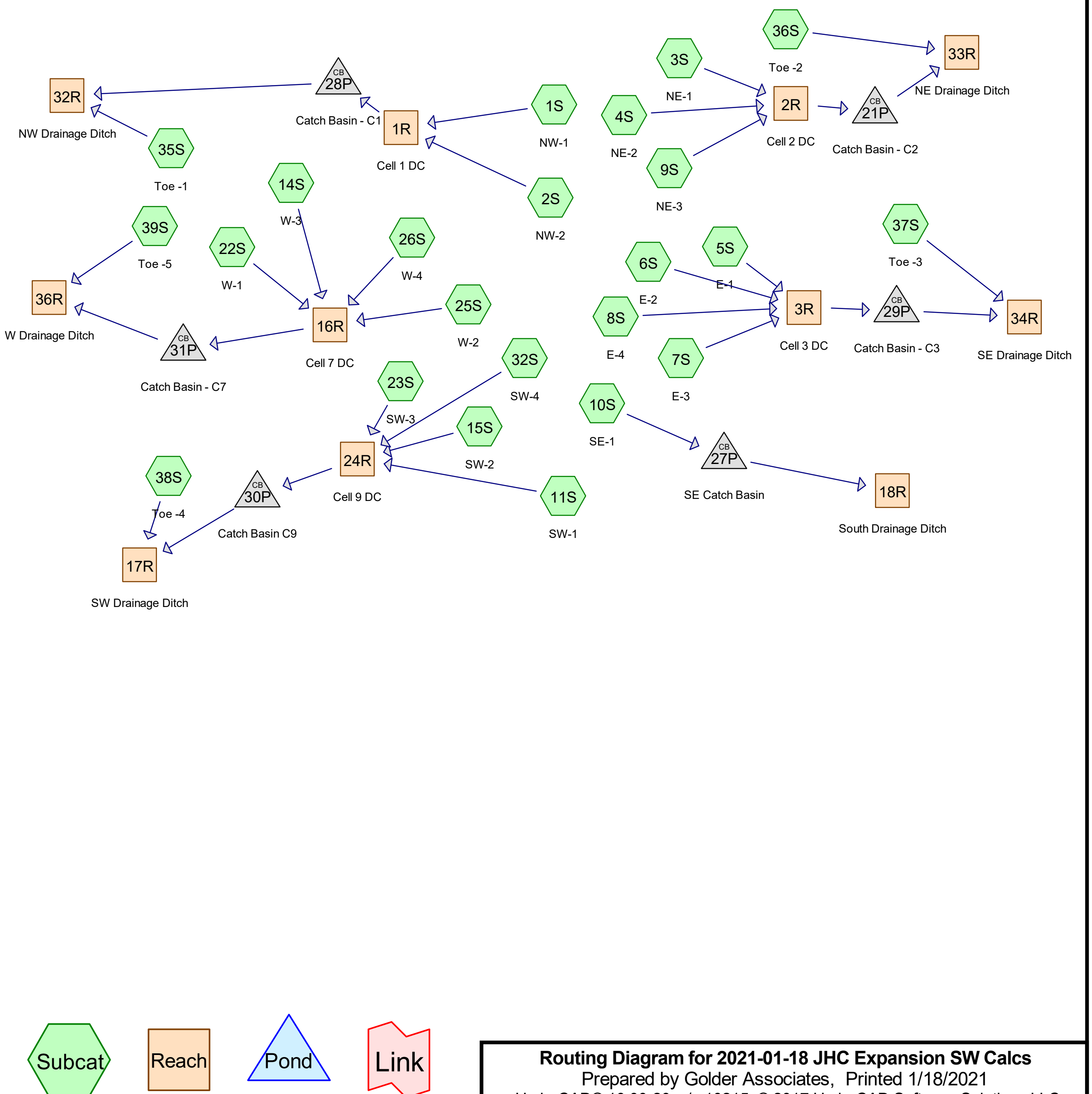
Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Attachment 3

HydroCAD 25-yr 24-hr Results



Routing Diagram for 2021-01-18 JHC Expansion SW Calcs
Prepared by Golder Associates, Printed 1/18/2021
HydroCAD® 10.00-20 s/n 10215 © 2017 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
5.900	49	50-75% Grass cover, Fair, HSG A (35S, 36S, 37S, 38S, 39S)
103.900	79	50-75% Grass cover, Fair, HSG C (1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S)
1.200	96	Gravel surface, HSG A (35S, 36S, 37S, 38S, 39S)
111.000	**78**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
7.100	HSG A	35S, 36S, 37S, 38S, 39S
0.000	HSG B	
103.900	HSG C	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S
0.000	HSG D	
0.000	Other	
111.000		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
5.900	0.000	103.900	0.000	0.000	109.800	50-75% Grass cover, Fair	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S
1.200	0.000	0.000	0.000	0.000	1.200	Gravel surface	35S, 36S, 37S, 38S, 39S
7.100	**0.000**	**103.900**	**0.000**	**0.000**	**111.000**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	21P	613.43	612.48	62.6	0.0152	0.013	42.0	0.0	0.0
2	27P	622.22	621.19	81.0	0.0127	0.012	30.0	0.0	0.0
3	28P	615.10	613.19	61.6	0.0310	0.013	42.0	0.0	0.0
4	29P	608.42	607.10	61.5	0.0215	0.013	42.0	0.0	0.0
5	30P	615.00	614.40	60.0	0.0100	0.013	42.0	0.0	0.0
6	31P	615.00	614.40	60.0	0.0100	0.013	42.0	0.0	0.0

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: NW-1 Runoff Area=3.800 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,708' Tc=9.7 min CN=79 Runoff=16.11 cfs 0.877 af

Subcatchment 2S: NW-2 Runoff Area=15.700 ac 0.00% Impervious Runoff Depth>2.75"
Flow Length=1,936' Tc=31.2 min CN=79 Runoff=36.80 cfs 3.603 af

Subcatchment 3S: NE-1 Runoff Area=3.300 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,318' Tc=8.7 min CN=79 Runoff=14.54 cfs 0.762 af

Subcatchment 4S: NE-2 Runoff Area=13.900 ac 0.00% Impervious Runoff Depth>2.75"
Flow Length=1,666' Tc=30.6 min CN=79 Runoff=32.94 cfs 3.191 af

Subcatchment 5S: E-1 Runoff Area=0.900 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=535' Tc=4.4 min CN=79 Runoff=4.58 cfs 0.208 af

Subcatchment 6S: E-2 Runoff Area=5.400 ac 0.00% Impervious Runoff Depth>2.76"
Flow Length=1,382' Tc=27.4 min CN=79 Runoff=13.77 cfs 1.241 af

Subcatchment 7S: E-3 Runoff Area=2.300 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,166' Tc=7.0 min CN=79 Runoff=10.72 cfs 0.531 af

Subcatchment 8S: E-4 Runoff Area=21.700 ac 0.00% Impervious Runoff Depth>2.75"
Flow Length=2,663' Tc=32.3 min CN=79 Runoff=49.74 cfs 4.979 af

Subcatchment 9S: NE-3 Runoff Area=1.000 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=455' Tc=4.3 min CN=79 Runoff=5.11 cfs 0.231 af

Subcatchment 10S: SE-1 Runoff Area=2.600 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,112' Tc=6.2 min CN=79 Runoff=12.25 cfs 0.601 af

Subcatchment 11S: SW-1 Runoff Area=3.300 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=1,696' Tc=7.9 min CN=79 Runoff=14.96 cfs 0.762 af

Subcatchment 14S: W-3 Runoff Area=1.300 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=664' Tc=5.1 min CN=79 Runoff=6.42 cfs 0.300 af

Subcatchment 15S: SW-2 Runoff Area=14.700 ac 0.00% Impervious Runoff Depth>2.75"
Flow Length=2,031' Tc=30.6 min CN=79 Runoff=34.84 cfs 3.374 af

Subcatchment 22S: W-1 Runoff Area=0.800 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=473' Tc=4.7 min CN=79 Runoff=4.02 cfs 0.185 af

Subcatchment 23S: SW-3 Runoff Area=0.700 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=381' Tc=4.5 min CN=79 Runoff=3.55 cfs 0.162 af

Subcatchment 25S: W-2 Runoff Area=5.000 ac 0.00% Impervious Runoff Depth>2.76"
Flow Length=578' Tc=26.3 min CN=79 Runoff=13.07 cfs 1.149 af

Subcatchment 26S: W-4 Runoff Area=3.700 ac 0.00% Impervious Runoff Depth>2.77"
Flow Length=566' Tc=7.3 min CN=79 Runoff=17.09 cfs 0.855 af

Subcatchment 32S: SW-4 Runoff Area=1.800 ac 0.00% Impervious Runoff Depth>2.76"
Flow Length=700' Tc=19.6 min CN=79 Runoff=5.60 cfs 0.414 af

Subcatchment 35S: Toe -1 Runoff Area=2.200 ac 0.00% Impervious Runoff Depth>1.28"
Flow Length=100' Tc=4.2 min CN=60 Runoff=5.09 cfs 0.235 af

Subcatchment 36S: Toe -2 Runoff Area=2.800 ac 0.00% Impervious Runoff Depth>1.22"
Flow Length=120' Tc=5.0 min CN=59 Runoff=5.83 cfs 0.284 af

Subcatchment 37S: Toe -3 Runoff Area=1.300 ac 0.00% Impervious Runoff Depth>1.49"
Flow Length=120' Tc=5.0 min CN=63 Runoff=3.42 cfs 0.161 af

Subcatchment 38S: Toe -4 Runoff Area=2.000 ac 0.00% Impervious Runoff Depth>1.42"
Flow Length=120' Tc=5.0 min CN=62 Runoff=4.98 cfs 0.236 af

Subcatchment 39S: Toe -5 Runoff Area=0.800 ac 0.00% Impervious Runoff Depth>2.34"
Flow Length=100' Tc=4.2 min CN=74 Runoff=3.50 cfs 0.156 af

Reach 1R: Cell 1 DC Avg. Flow Depth=0.58' Max Vel=8.93 fps Inflow=40.28 cfs 4.480 af
n=0.050 L=105.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=40.24 cfs 4.479 af

Reach 2R: Cell 2 DC Avg. Flow Depth=0.55' Max Vel=8.64 fps Inflow=36.34 cfs 4.184 af
n=0.050 L=140.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=36.28 cfs 4.182 af

Reach 3R: Cell 3 DC Avg. Flow Depth=0.76' Max Vel=10.36 fps Inflow=65.15 cfs 6.959 af
n=0.050 L=74.1' S=0.2502 '/' Capacity=615.98 cfs Outflow=65.08 cfs 6.958 af

Reach 16R: Cell 7 DC Avg. Flow Depth=0.52' Max Vel=8.37 fps Inflow=33.03 cfs 2.489 af
n=0.050 L=76.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=32.89 cfs 2.488 af

Reach 17R: SW Drainage Ditch Avg. Flow Depth=0.96' Max Vel=2.49 fps Inflow=43.01 cfs 4.948 af
n=0.030 L=262.0' S=0.0035 '/' Capacity=365.06 cfs Outflow=42.64 cfs 4.936 af

Reach 18R: South Drainage Ditch Avg. Flow Depth=0.58' Max Vel=1.20 fps Inflow=12.25 cfs 0.601 af
n=0.030 L=217.0' S=0.0014 '/' Capacity=1,451.43 cfs Outflow=11.57 cfs 0.598 af

Reach 24R: Cell 9 DC Avg. Flow Depth=0.60' Max Vel=9.06 fps Inflow=42.28 cfs 4.713 af
n=0.050 L=76.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=42.23 cfs 4.712 af

Reach 32R: NW Drainage Ditch Avg. Flow Depth=0.60' Max Vel=1.72 fps Inflow=40.99 cfs 4.714 af
n=0.030 L=390.0' S=0.0035 '/' Capacity=470.81 cfs Outflow=40.43 cfs 4.691 af

Reach 33R: NE Drainage Ditch Avg. Flow Depth=0.70' Max Vel=2.44 fps Inflow=38.22 cfs 4.466 af
n=0.030 L=876.0' S=0.0046 '/' Capacity=5,887.54 cfs Outflow=36.57 cfs 4.430 af

Reach 34R: SE Drainage Ditch Avg. Flow Depth=0.98' Max Vel=4.18 fps Inflow=65.59 cfs 7.119 af
n=0.030 L=364.0' S=0.0100 '/' Capacity=1,650.65 cfs Outflow=64.98 cfs 7.105 af

Reach 36R: W Drainage Ditch Avg. Flow Depth=0.40' Max Vel=2.01 fps Inflow=35.91 cfs 2.644 af
n=0.030 L=143.0' S=0.0070 '/' Capacity=190.26 cfs Outflow=34.35 cfs 2.639 af

Pond 21P: Catch Basin - C2 Peak Elev=616.19' Inflow=36.28 cfs 4.182 af
42.0" Round Culvert n=0.013 L=62.6' S=0.0152 '/' Outflow=36.28 cfs 4.182 af

Pond 27P: SE Catch Basin Peak Elev=623.56' Inflow=12.25 cfs 0.601 af
30.0" Round Culvert n=0.012 L=81.0' S=0.0127 '/' Outflow=12.25 cfs 0.601 af

Pond 28P: Catch Basin - C1 Peak Elev=618.07' Inflow=40.24 cfs 4.479 af
42.0" Round Culvert n=0.013 L=61.6' S=0.0310 '/' Outflow=40.24 cfs 4.479 af

Pond 29P: Catch Basin - C3 Peak Elev=613.34' Inflow=65.08 cfs 6.958 af
42.0" Round Culvert n=0.013 L=61.5' S=0.0215 '/' Outflow=65.08 cfs 6.958 af

Pond 30P: Catch Basin C9 Peak Elev=618.08' Inflow=42.23 cfs 4.712 af
42.0" Round Culvert n=0.013 L=60.0' S=0.0100 '/' Outflow=42.23 cfs 4.712 af

Pond 31P: Catch Basin - C7 Peak Elev=617.59' Inflow=32.89 cfs 2.488 af
42.0" Round Culvert n=0.013 L=60.0' S=0.0100 '/' Outflow=32.89 cfs 2.488 af

Total Runoff Area = 111.000 ac Runoff Volume = 24.497 af Average Runoff Depth = 2.65"
100.00% Pervious = 111.000 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: NW-1

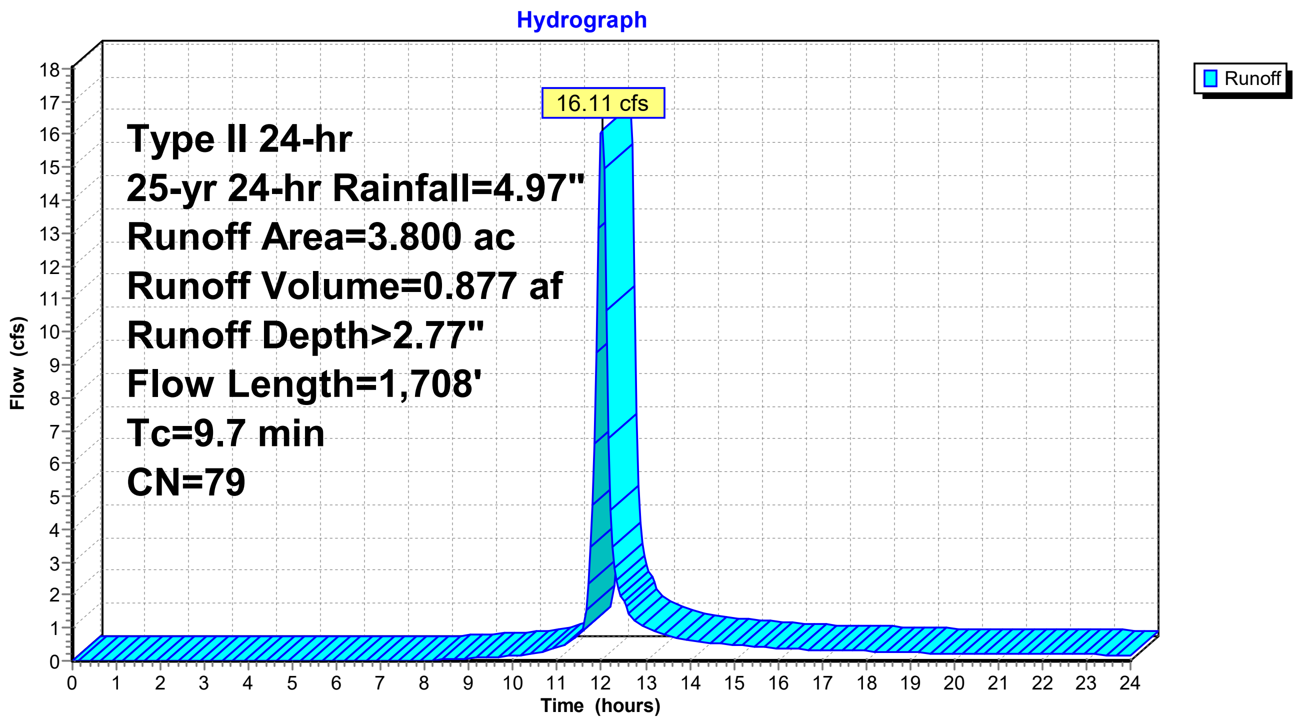
Runoff = 16.11 cfs @ 12.01 hrs, Volume= 0.877 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
3.800	79	50-75% Grass cover, Fair, HSG C
3.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
5.9	1,600	0.0060	4.48	62.76	**Trap/Vee/Rect Channel Flow, TB-1** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025 Earth, grassed & winding
9.7	1,708	Total			

Subcatchment 1S: NW-1



Summary for Subcatchment 2S: NW-2

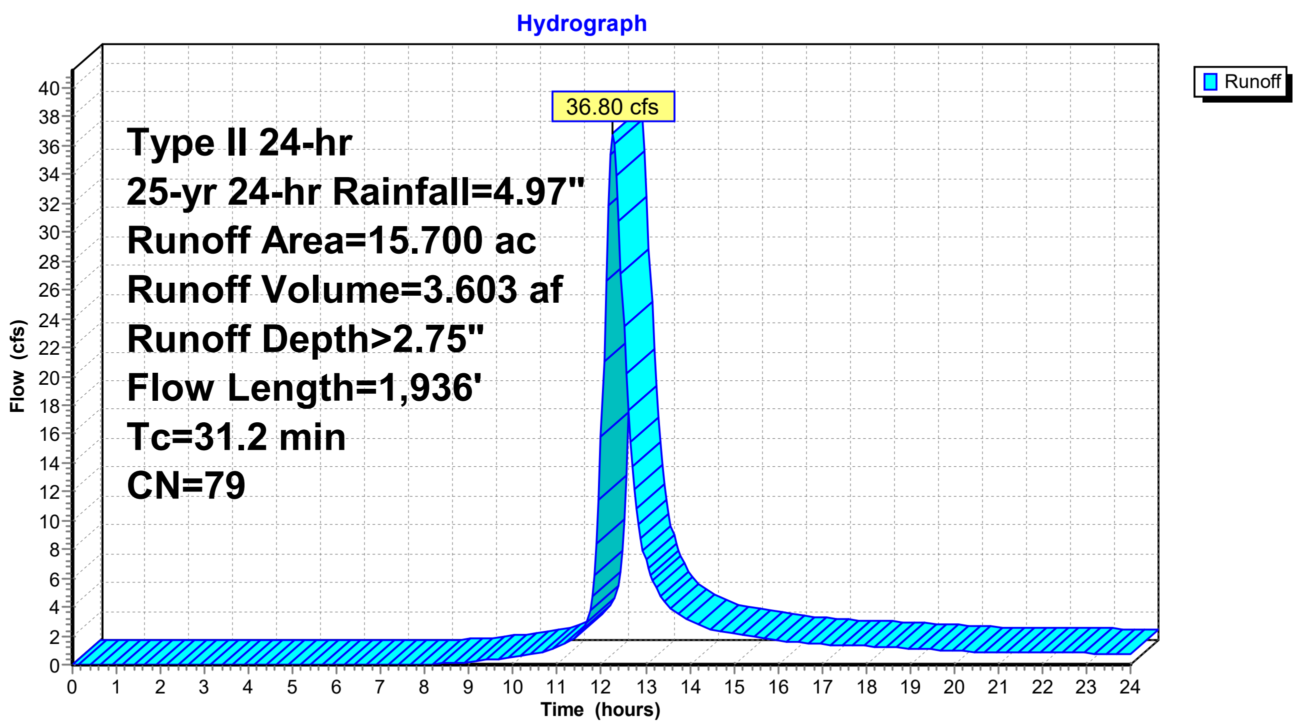
Runoff = 36.80 cfs @ 12.26 hrs, Volume= 3.603 af, Depth> 2.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
15.700	79	50-75% Grass cover, Fair, HSG C
15.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	158	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.7	1,370	0.0060	4.90	58.75	**Trap/Vee/Rect Channel Flow, TB-2** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
31.2	1,936	Total			

Subcatchment 2S: NW-2



Summary for Subcatchment 3S: NE-1

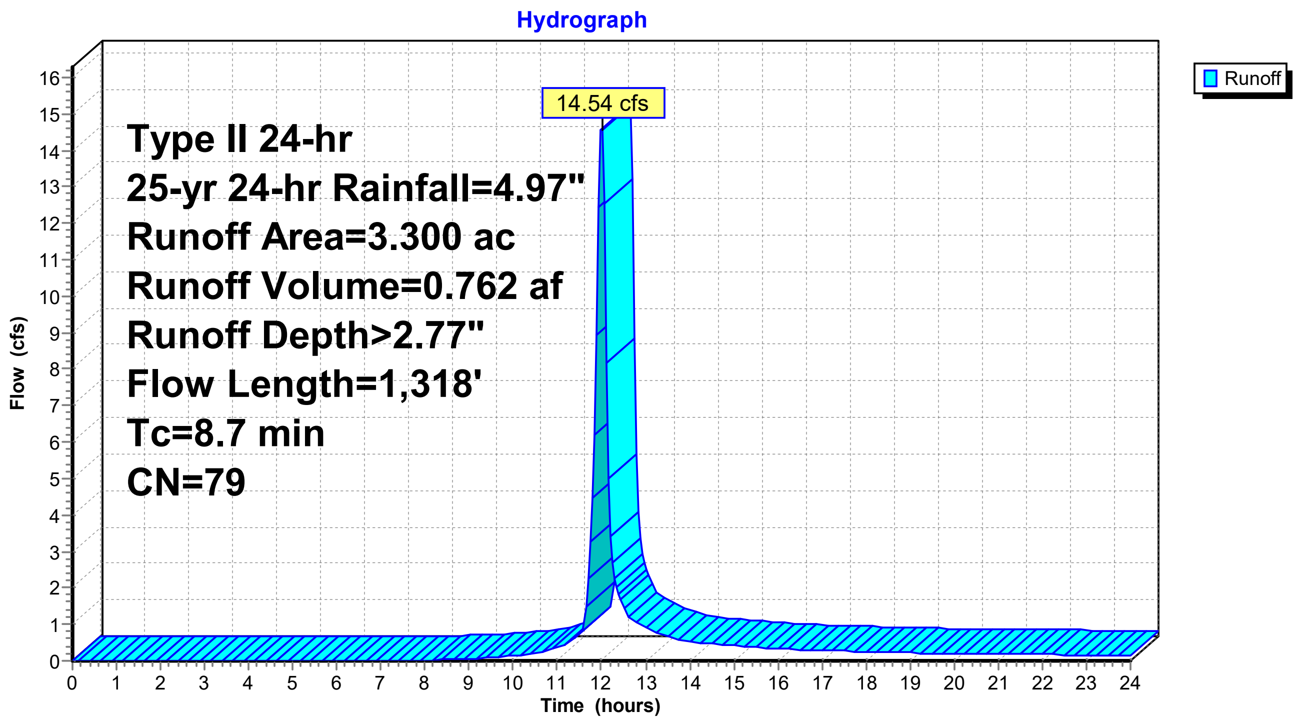
Runoff = 14.54 cfs @ 12.00 hrs, Volume= 0.762 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
3.300	79	50-75% Grass cover, Fair, HSG C
3.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
4.9	1,210	0.0050	4.09	57.30	**Trap/Vee/Rect Channel Flow, TB-3** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
8.7	1,318	Total			

Subcatchment 3S: NE-1



Summary for Subcatchment 4S: NE-2

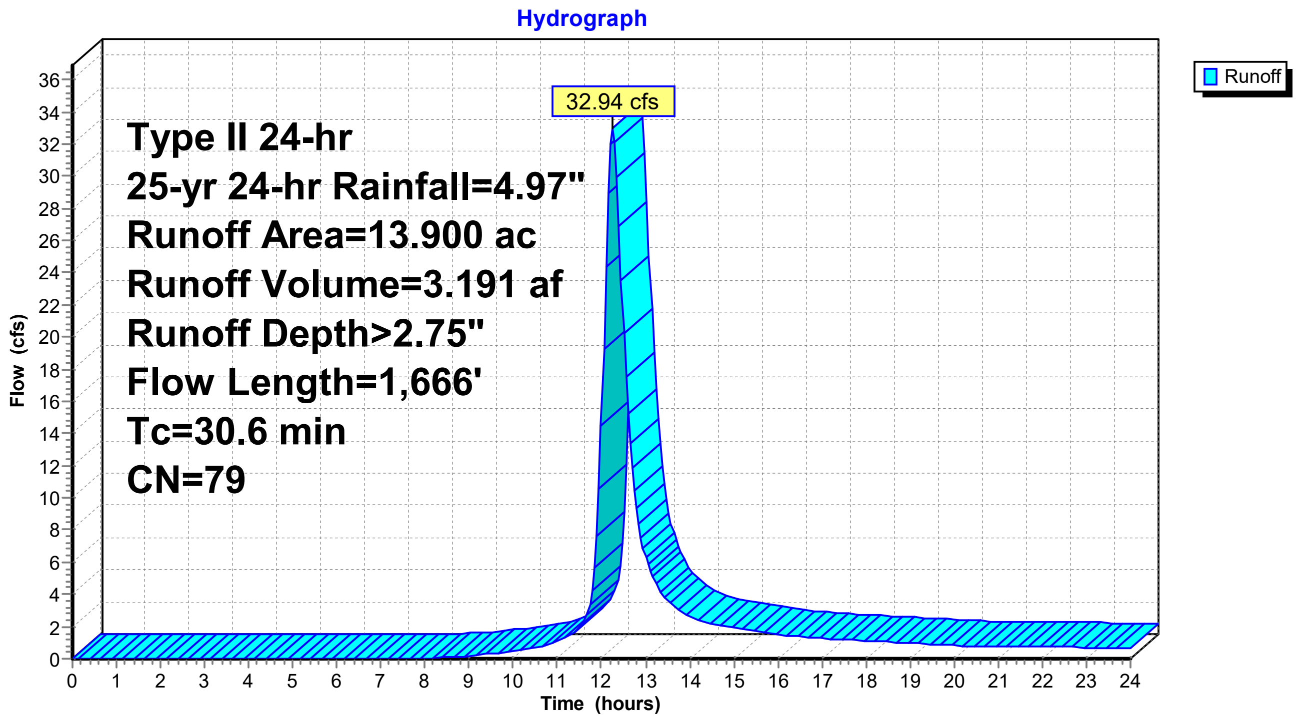
Runoff = 32.94 cfs @ 12.25 hrs, Volume= 3.191 af, Depth> 2.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
13.900	79	50-75% Grass cover, Fair, HSG C
13.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	158	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.1	1,100	0.0050	4.47	53.63	**Trap/Vee/Rect Channel Flow, TB-4** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
30.6	1,666	Total			

Subcatchment 4S: NE-2



Summary for Subcatchment 5S: E-1

[49] Hint: Tc<2dt may require smaller dt

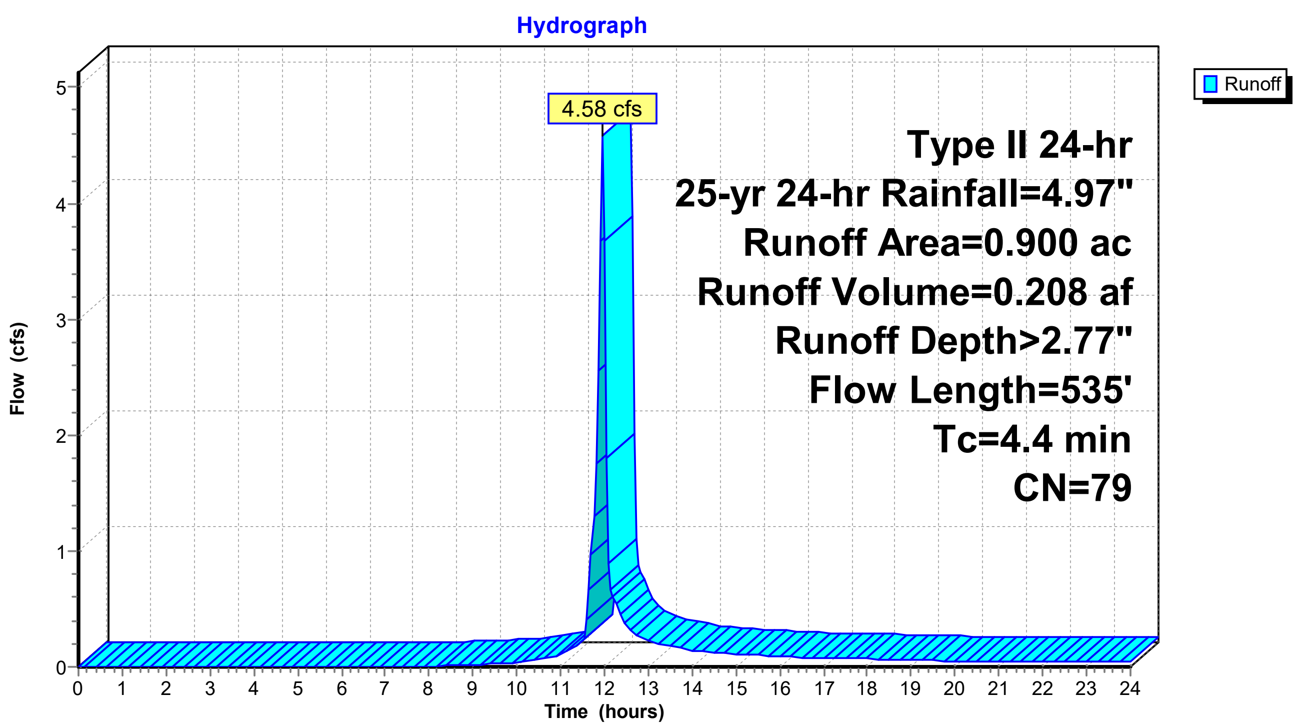
Runoff = 4.58 cfs @ 11.95 hrs, Volume= 0.208 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.900	79	50-75% Grass cover, Fair, HSG C
0.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.47		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.9	435	0.0180	7.77	108.71	**Trap/Vee/Rect Channel Flow, TB-7** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.4	535	Total			

Subcatchment 5S: E-1



Summary for Subcatchment 6S: E-2

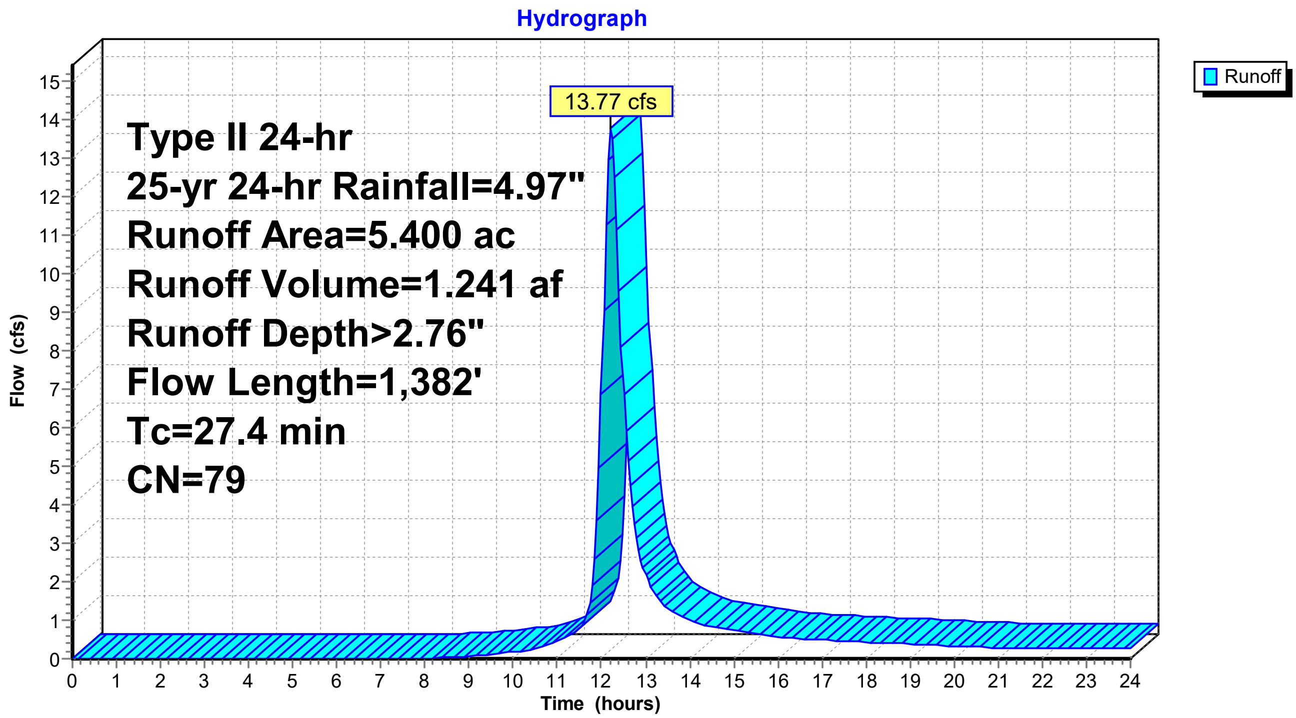
Runoff = 13.77 cfs @ 12.21 hrs, Volume= 1.241 af, Depth> 2.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
5.400	79	50-75% Grass cover, Fair, HSG C
5.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.5	270	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
3.7	222	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.8	175	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.4	715	0.0180	8.48	101.76	**Trap/Vee/Rect Channel Flow, TB-6** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
27.4	1,382	Total			

Subcatchment 6S: E-2



Summary for Subcatchment 7S: E-3

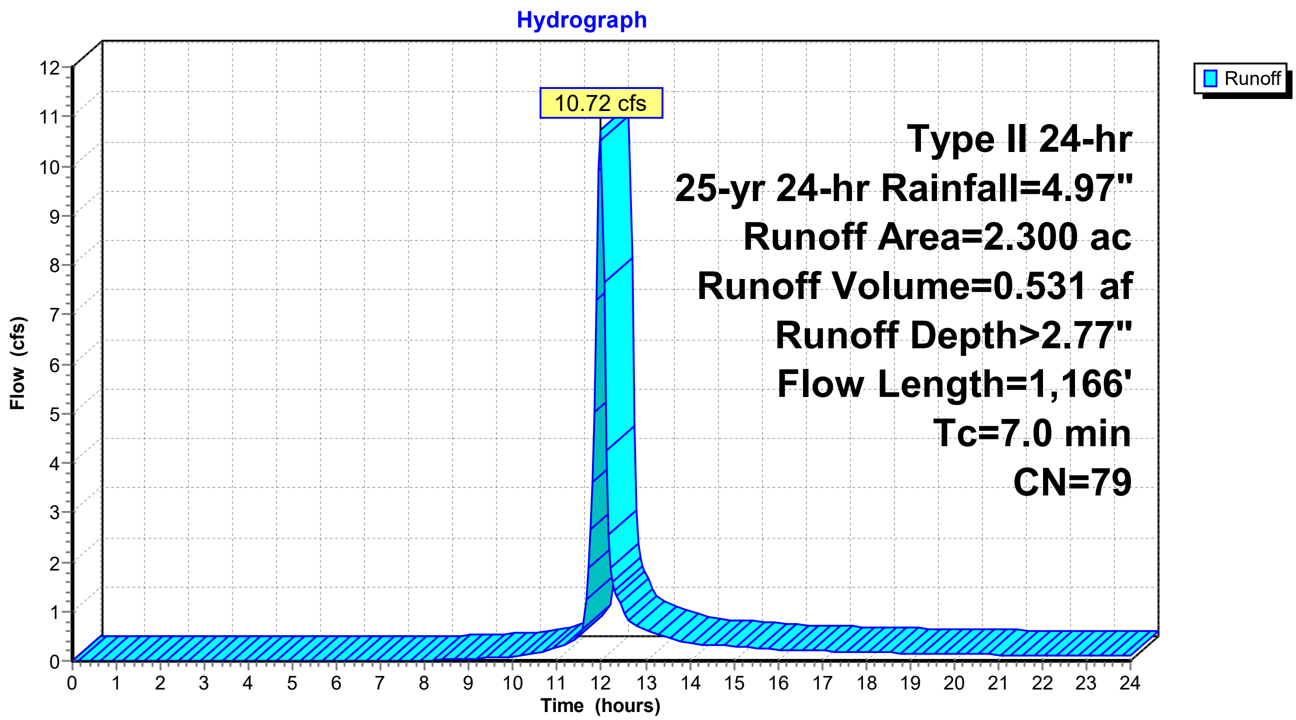
Runoff = 10.72 cfs @ 11.98 hrs, Volume= 0.531 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
2.300	79	50-75% Grass cover, Fair, HSG C
2.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0	116	0.2500	0.49		**Sheet Flow,** Range n= 0.130 P2= 2.60"
3.0	1,050	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-8** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
7.0	1,166	Total			

Subcatchment 7S: E-3



Summary for Subcatchment 8S: E-4

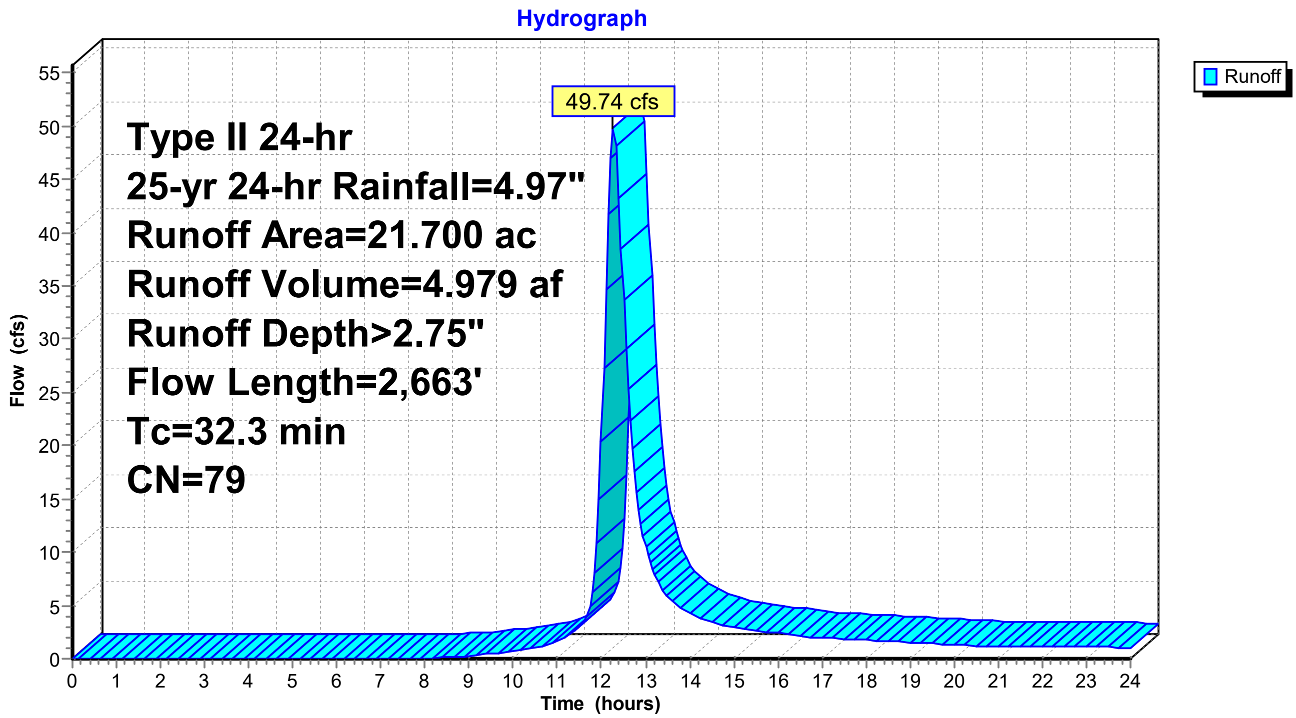
Runoff = 49.74 cfs @ 12.27 hrs, Volume= 4.979 af, Depth> 2.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
21.700	79	50-75% Grass cover, Fair, HSG C
21.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	170	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	153	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.4	2,040	0.0100	6.32	75.84	**Trap/Vee/Rect Channel Flow, TB-9 and TB-12** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
32.3	2,663	Total			

Subcatchment 8S: E-4



Summary for Subcatchment 9S: NE-3

[49] Hint: Tc<2dt may require smaller dt

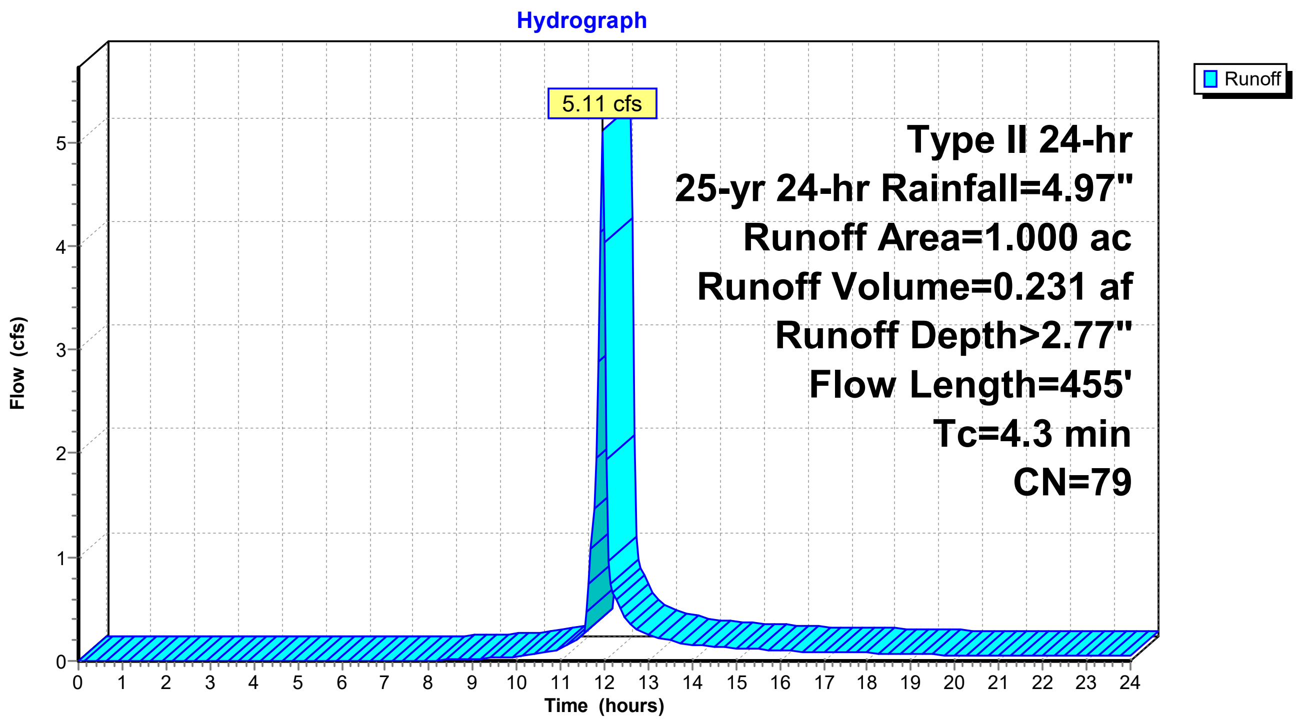
Runoff = 5.11 cfs @ 11.95 hrs, Volume= 0.231 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
1.000	79	50-75% Grass cover, Fair, HSG C
1.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.47		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.8	355	0.0180	7.77	108.71	**Trap/Vee/Rect Channel Flow, TB-5** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.3	455	Total			

Subcatchment 9S: NE-3



Summary for Subcatchment 10S: SE-1

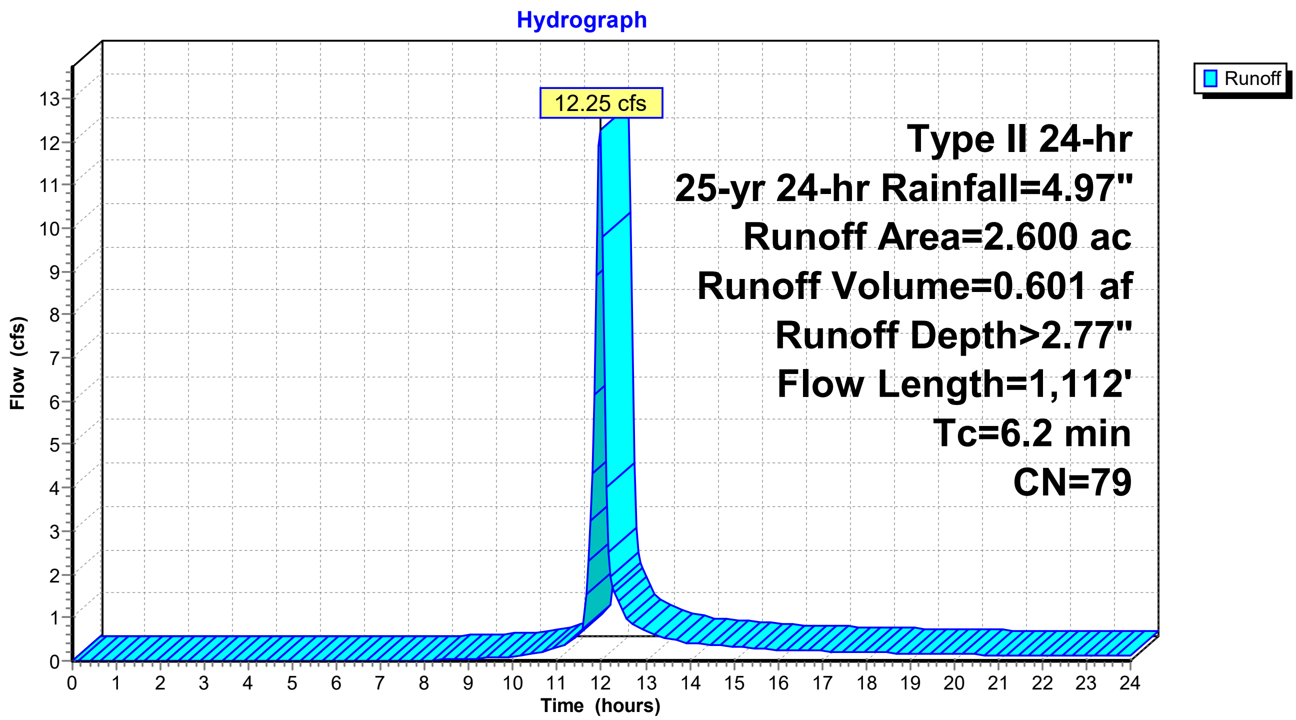
Runoff = 12.25 cfs @ 11.97 hrs, Volume= 0.601 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
2.600	79	50-75% Grass cover, Fair, HSG C
2.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	92	0.2500	0.46		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	1,020	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-11** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
6.2	1,112	Total			

Subcatchment 10S: SE-1



Summary for Subcatchment 11S: SW-1

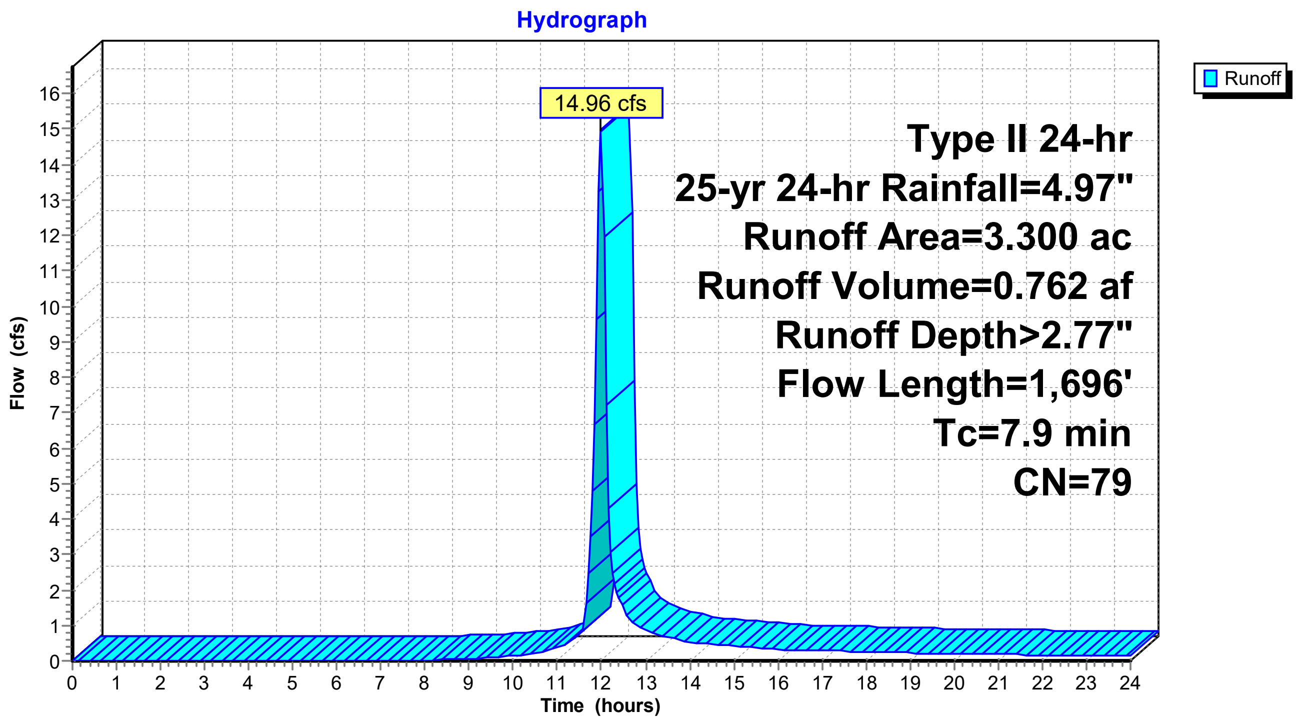
Runoff = 14.96 cfs @ 11.99 hrs, Volume= 0.762 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
3.300	79	50-75% Grass cover, Fair, HSG C
3.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	92	0.2500	0.46		**Sheet Flow,** Range n= 0.130 P2= 2.60"
4.6	1,604	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-13** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
7.9	1,696	Total			

Subcatchment 11S: SW-1



Summary for Subcatchment 14S: W-3

[49] Hint: Tc<2dt may require smaller dt

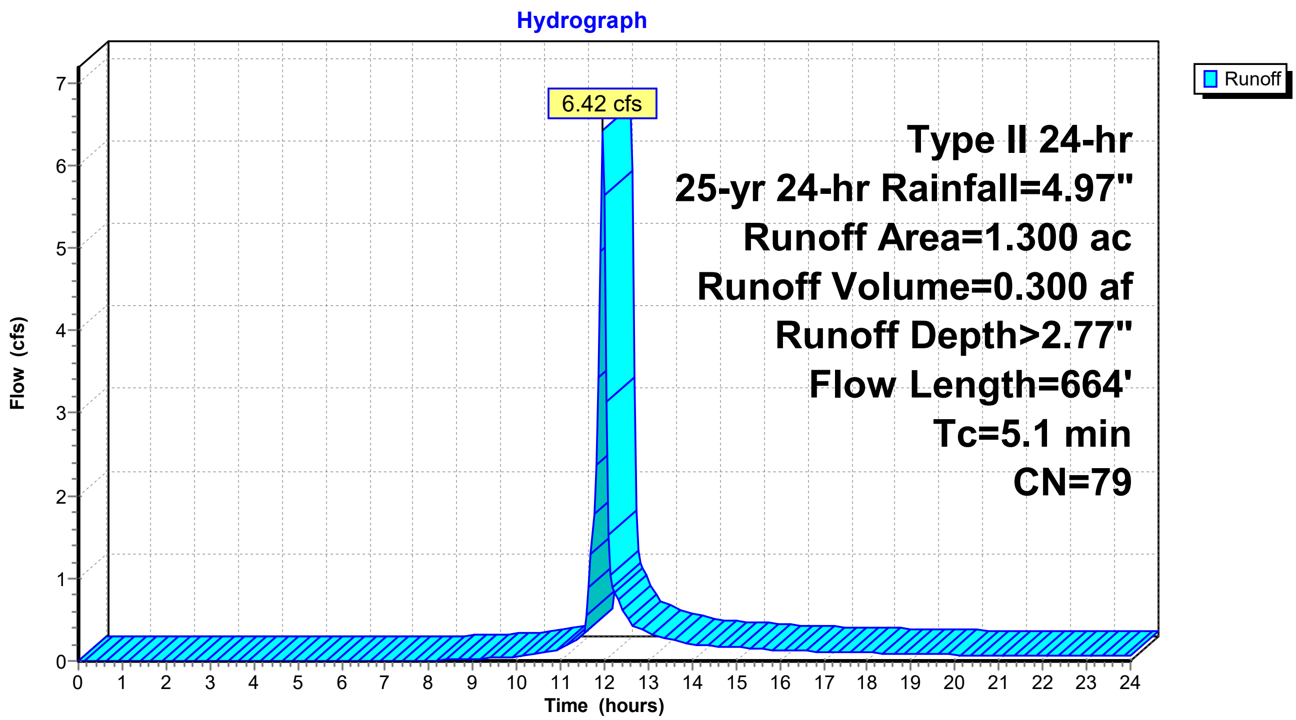
Runoff = 6.42 cfs @ 11.96 hrs, Volume= 0.300 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
1.300	79	50-75% Grass cover, Fair, HSG C
1.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	106	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
1.4	558	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-19** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
5.1	664	Total			

Subcatchment 14S: W-3



Summary for Subcatchment 15S: SW-2

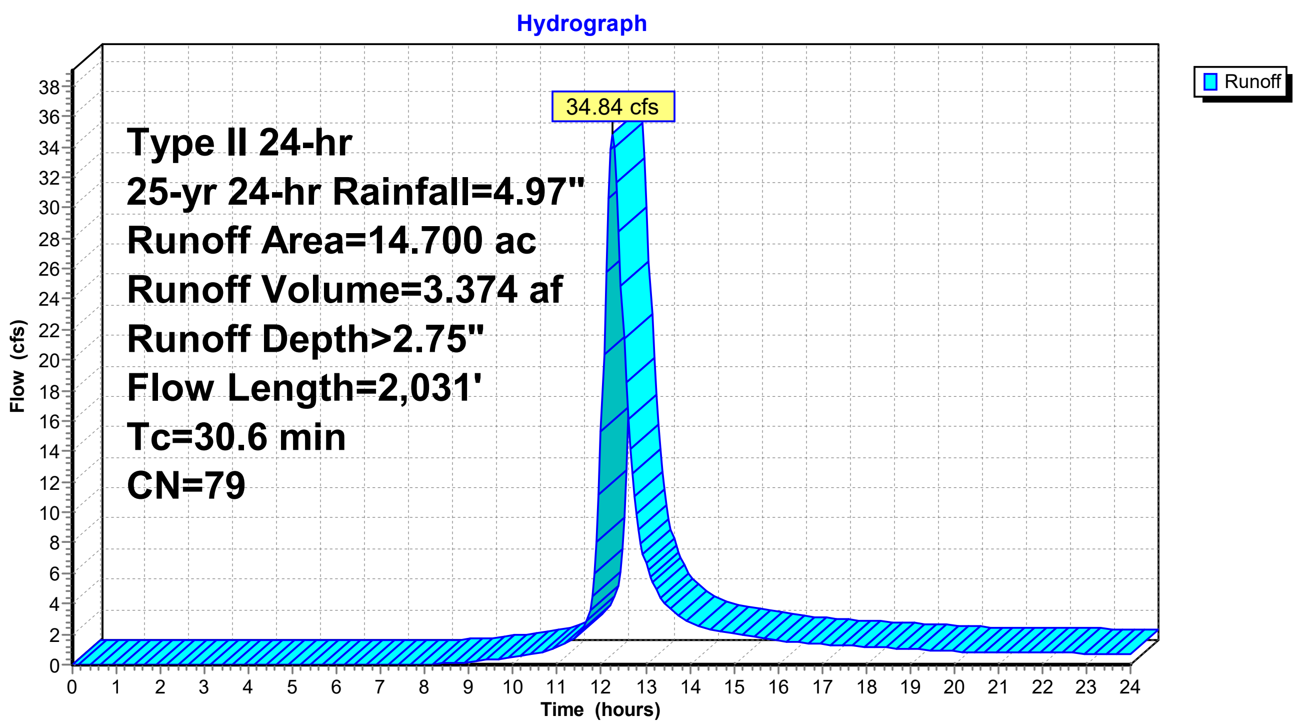
Runoff = 34.84 cfs @ 12.25 hrs, Volume= 3.374 af, Depth> 2.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
14.700	79	50-75% Grass cover, Fair, HSG C
14.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	170	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	153	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	1,408	0.0100	6.32	75.84	**Trap/Vee/Rect Channel Flow, TB-14** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
30.6	2,031	Total			

Subcatchment 15S: SW-2



Summary for Subcatchment 22S: W-1

[49] Hint: Tc<2dt may require smaller dt

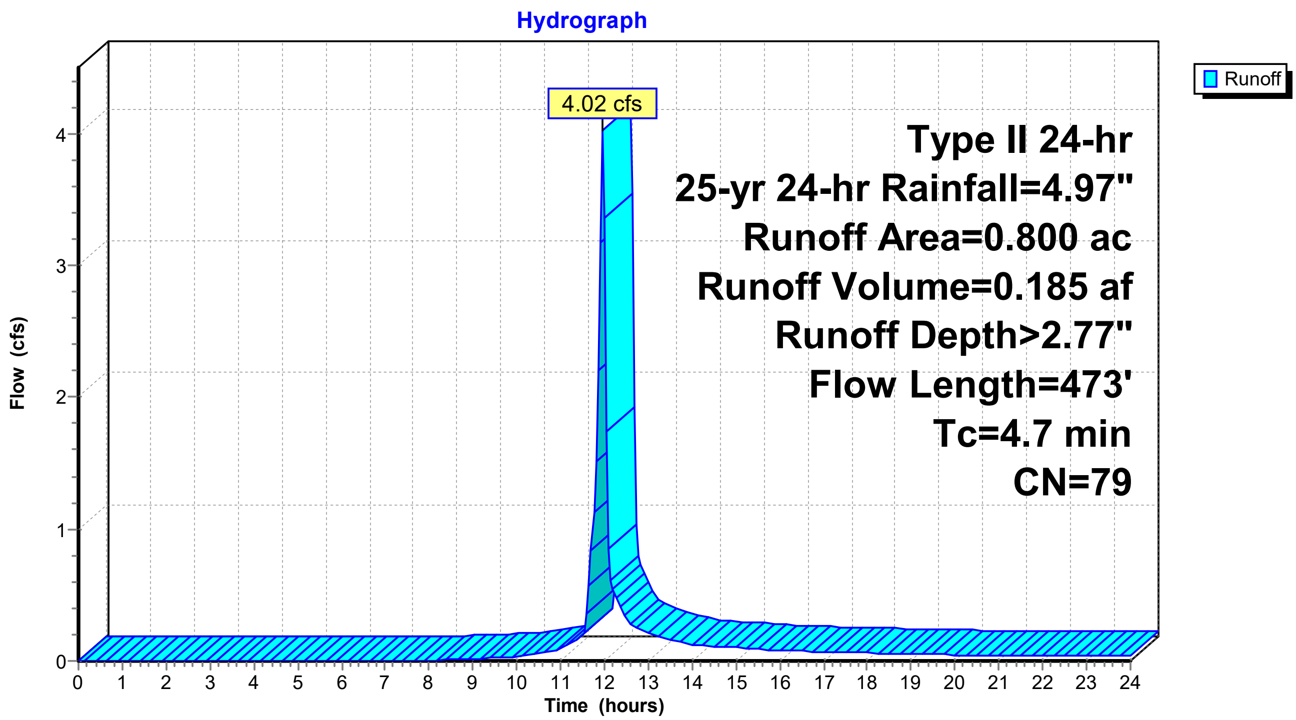
Runoff = 4.02 cfs @ 11.95 hrs, Volume= 0.185 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.800	79	50-75% Grass cover, Fair, HSG C
0.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.9	365	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-17** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.7	473	Total			

Subcatchment 22S: W-1



Summary for Subcatchment 23S: SW-3

[49] Hint: Tc<2dt may require smaller dt

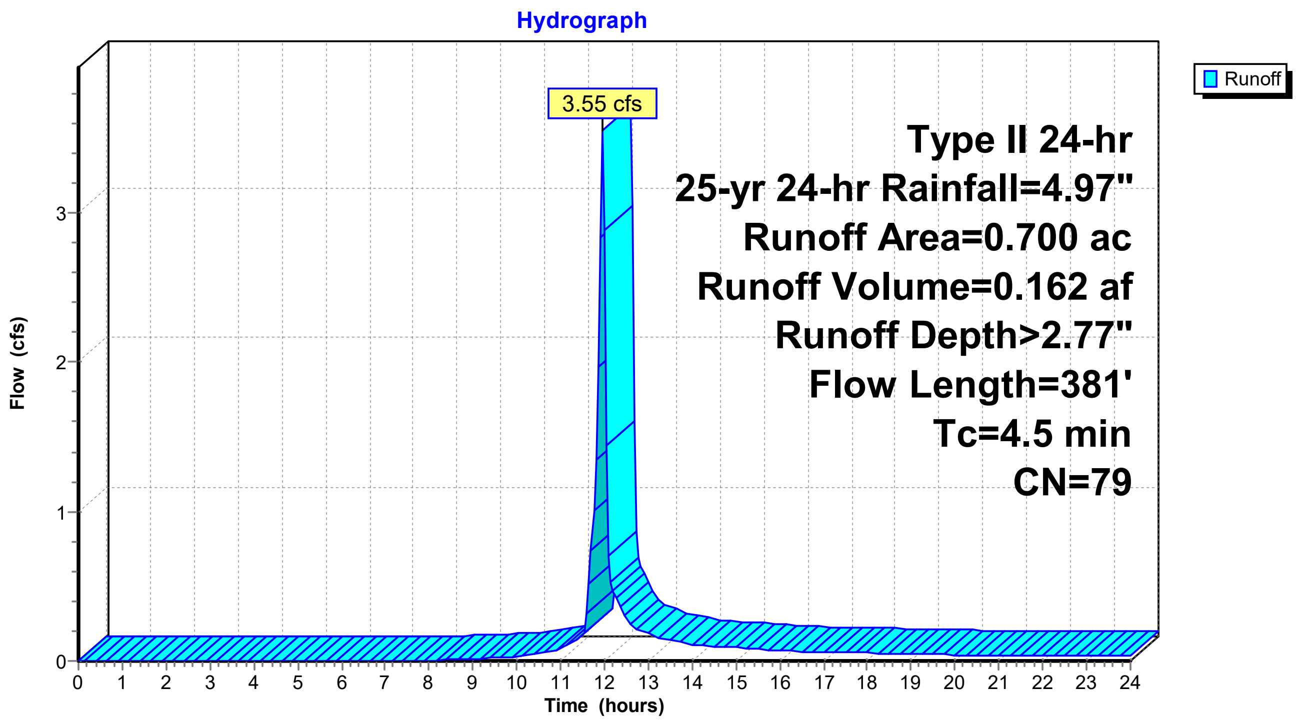
Runoff = 3.55 cfs @ 11.95 hrs, Volume= 0.162 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.700	79	50-75% Grass cover, Fair, HSG C
0.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.7	273	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-15** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.5	381	Total			

Subcatchment 23S: SW-3



Summary for Subcatchment 25S: W-2

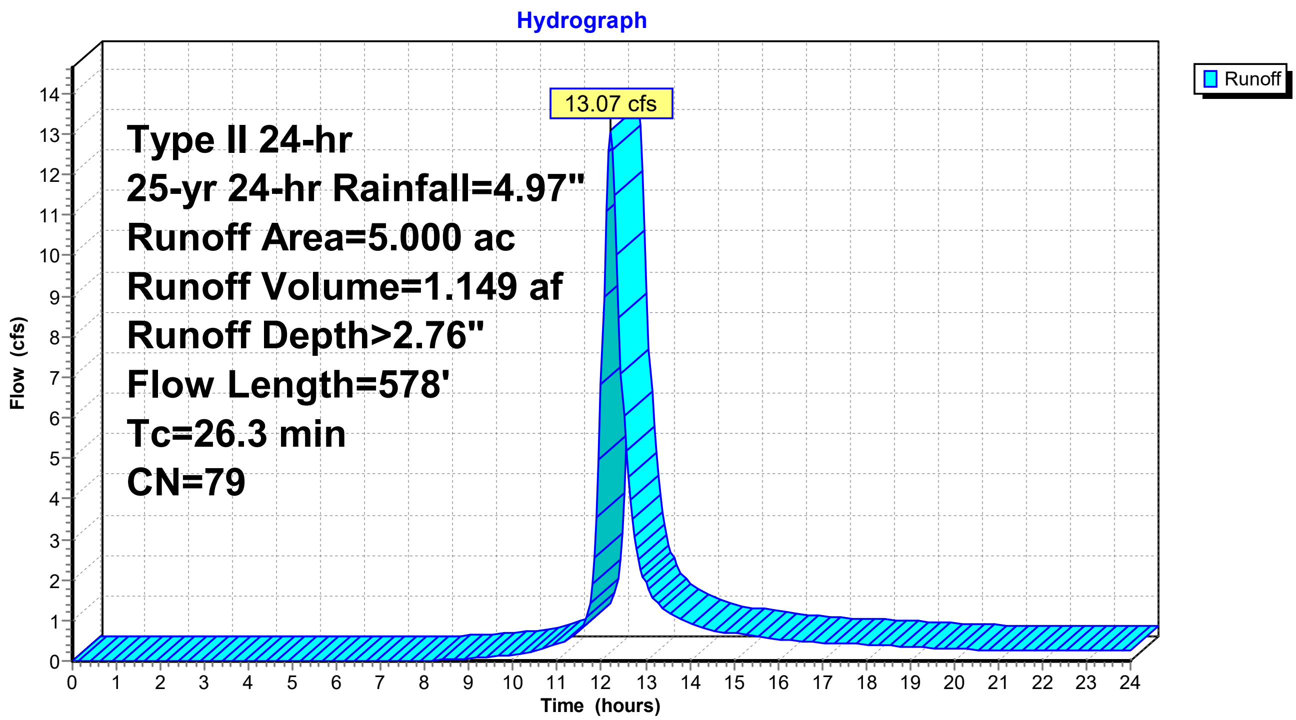
Runoff = 13.07 cfs @ 12.20 hrs, Volume= 1.149 af, Depth> 2.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
5.000	79	50-75% Grass cover, Fair, HSG C
5.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	160	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.3	118	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-18** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
26.3	578	Total			

Subcatchment 25S: W-2



Summary for Subcatchment 26S: W-4

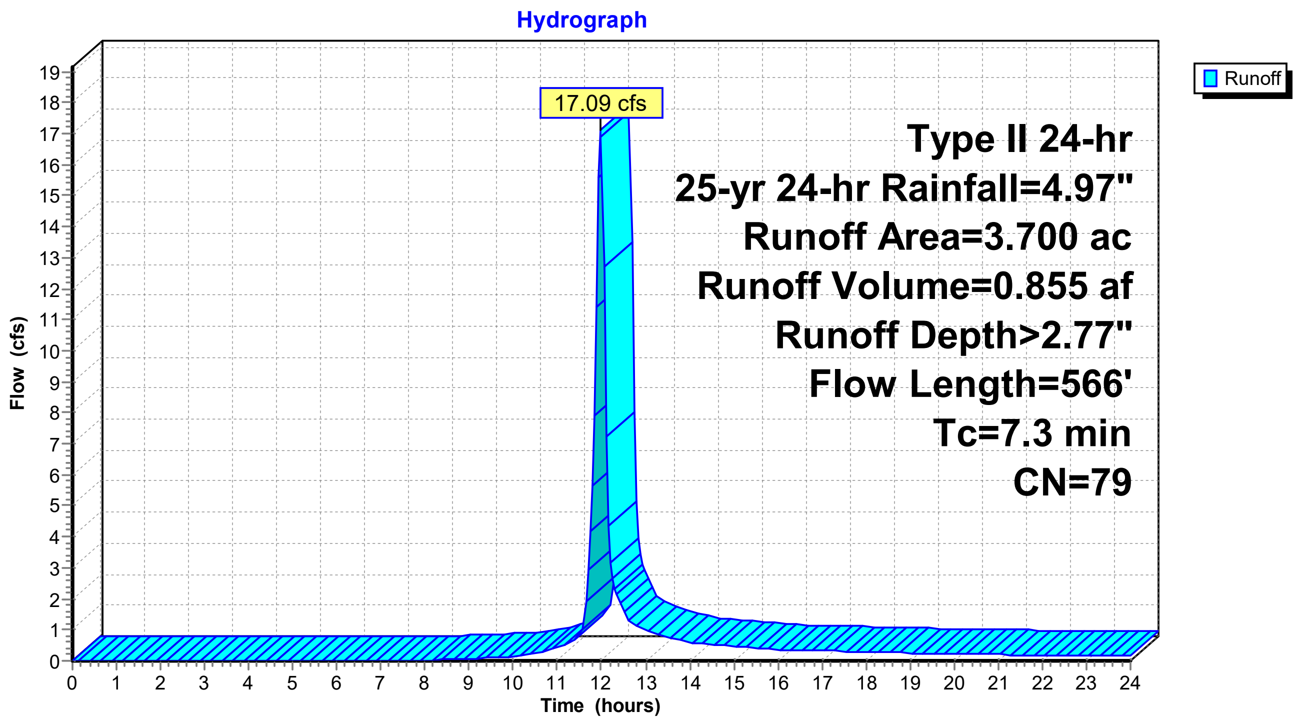
Runoff = 17.09 cfs @ 11.99 hrs, Volume= 0.855 af, Depth> 2.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
3.700	79	50-75% Grass cover, Fair, HSG C
3.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	214	0.2500	0.55		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.8	352	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-19** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
7.3	566	Total			

Subcatchment 26S: W-4



Summary for Subcatchment 32S: SW-4

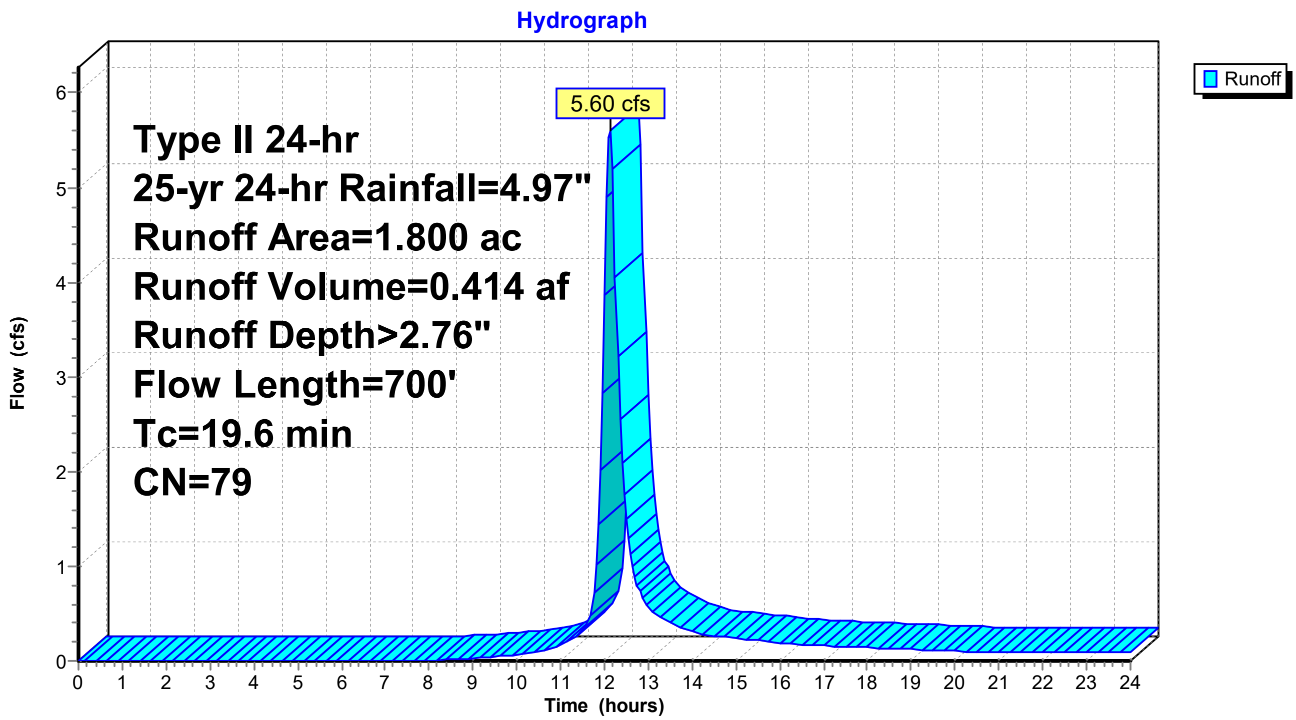
Runoff = 5.60 cfs @ 12.12 hrs, Volume= 0.414 af, Depth> 2.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
1.800	79	50-75% Grass cover, Fair, HSG C
1.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	216	0.0200	0.20		**Sheet Flow,** Range n= 0.130 P2= 2.60"
1.0	208	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	276	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-16** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
19.6	700	Total			

Subcatchment 32S: SW-4



Summary for Subcatchment 35S: Toe -1

[49] Hint: Tc<2dt may require smaller dt

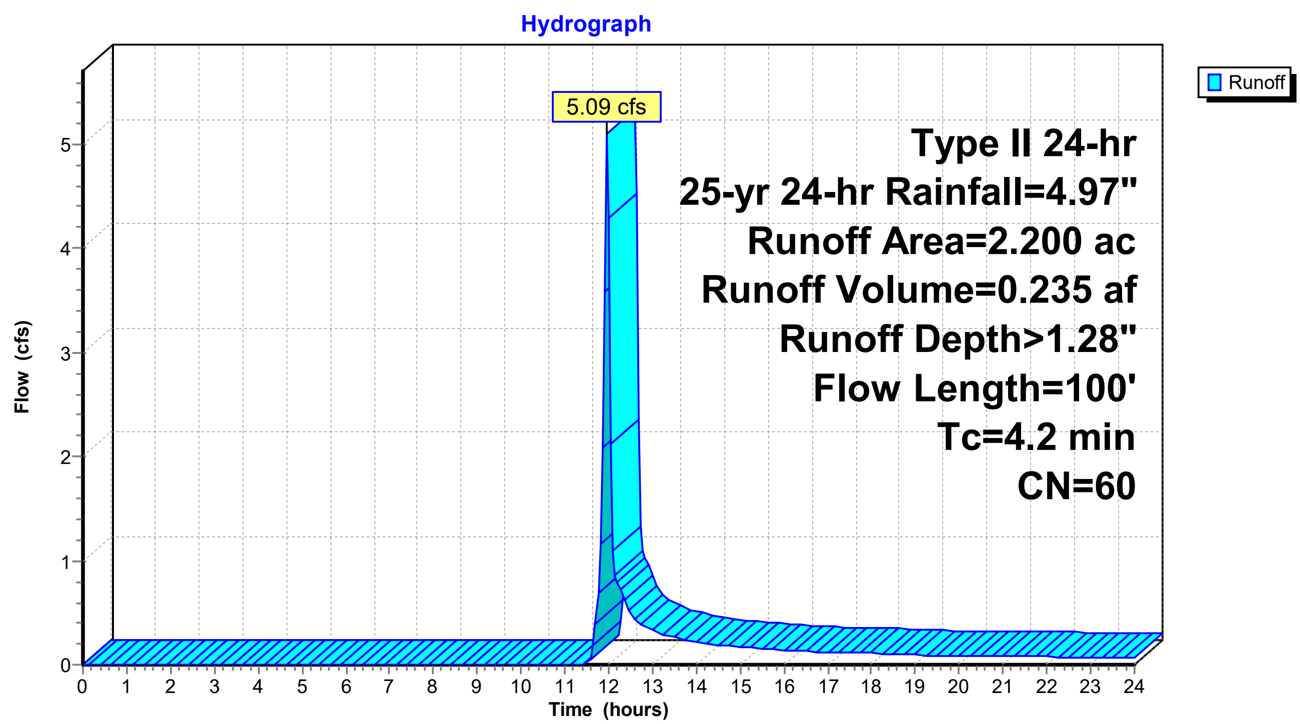
Runoff = 5.09 cfs @ 11.96 hrs, Volume= 0.235 af, Depth> 1.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.300	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
1.600	49	50-75% Grass cover, Fair, HSG A
2.200	60	Weighted Average
2.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	20	0.2500	0.31		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
4.2	100	Total			

Subcatchment 35S: Toe -1



Summary for Subcatchment 36S: Toe -2

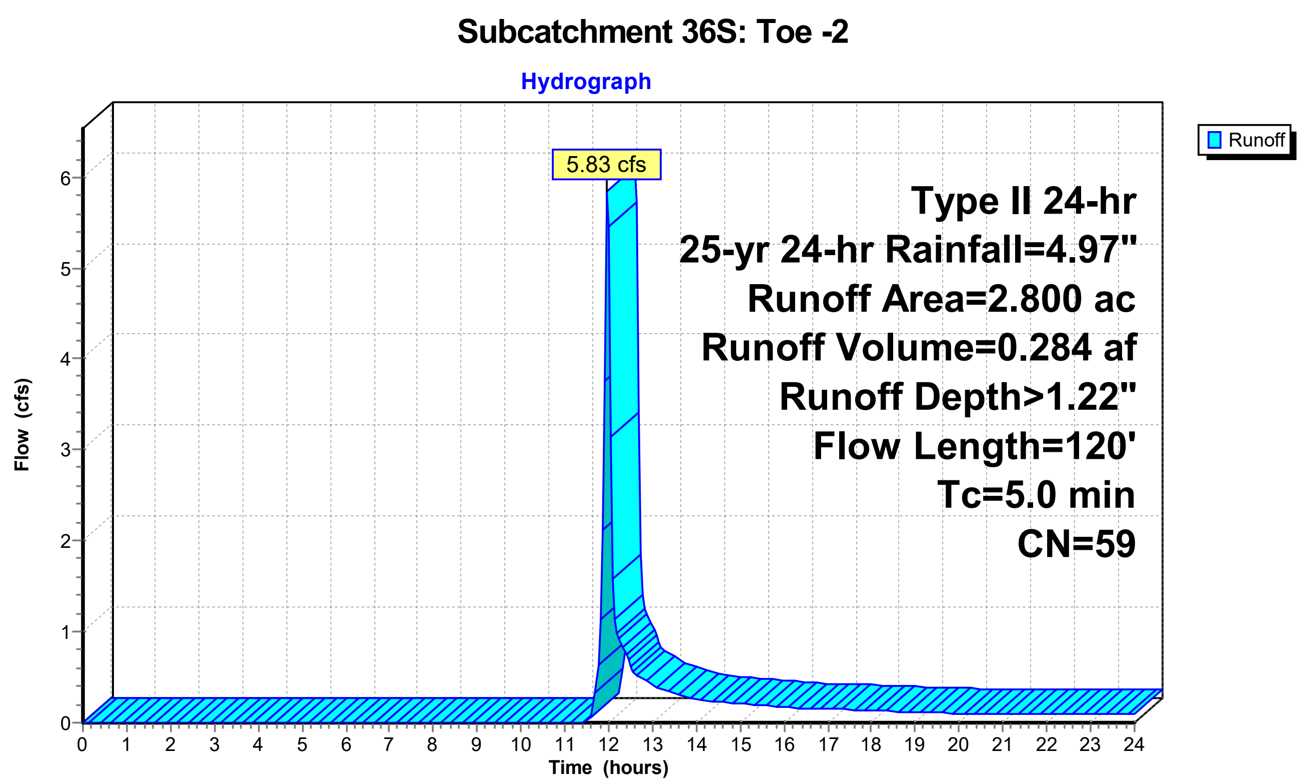
[49] Hint: Tc<2dt may require smaller dt

Runoff = 5.83 cfs @ 11.97 hrs, Volume= 0.284 af, Depth> 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.500	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
2.000	49	50-75% Grass cover, Fair, HSG A
2.800	59	Weighted Average
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			



Summary for Subcatchment 37S: Toe -3

[49] Hint: Tc<2dt may require smaller dt

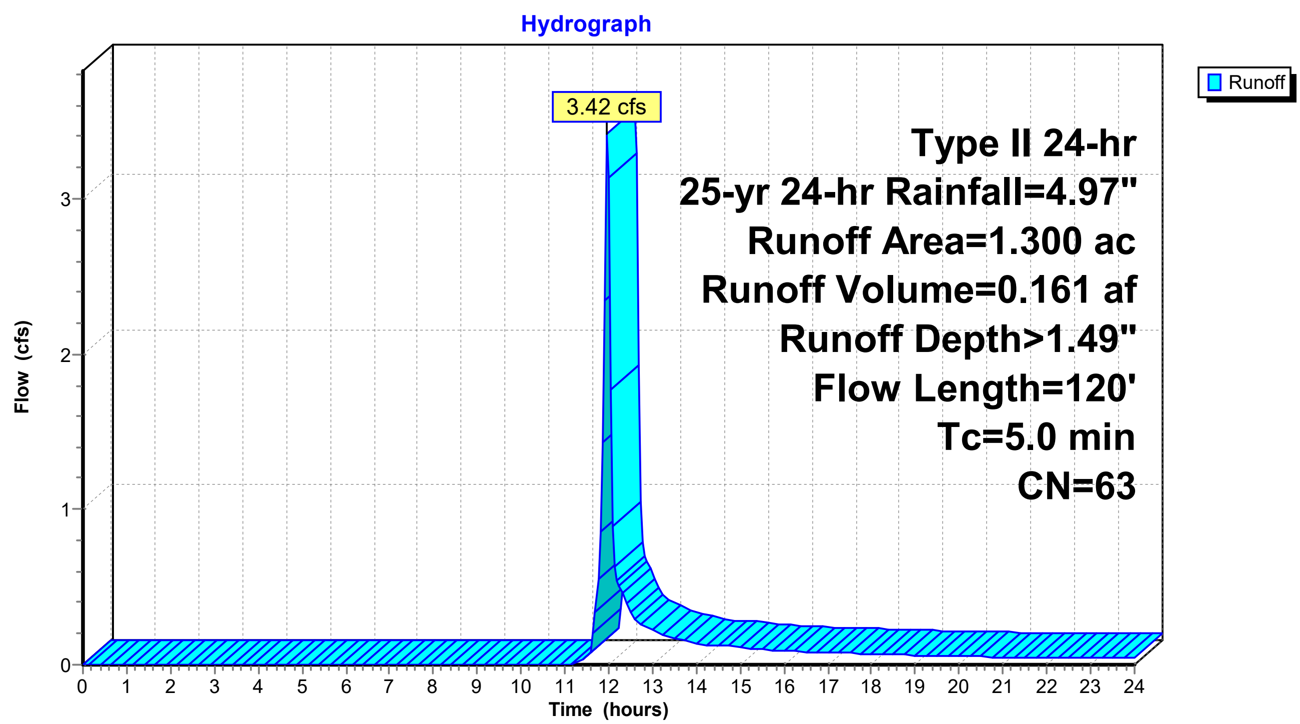
Runoff = 3.42 cfs @ 11.97 hrs, Volume= 0.161 af, Depth> 1.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.300	79	50-75% Grass cover, Fair, HSG C
0.200	96	Gravel surface, HSG A
0.800	49	50-75% Grass cover, Fair, HSG A
1.300	63	Weighted Average
1.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			

Subcatchment 37S: Toe -3



Summary for Subcatchment 38S: Toe -4

[49] Hint: Tc<2dt may require smaller dt

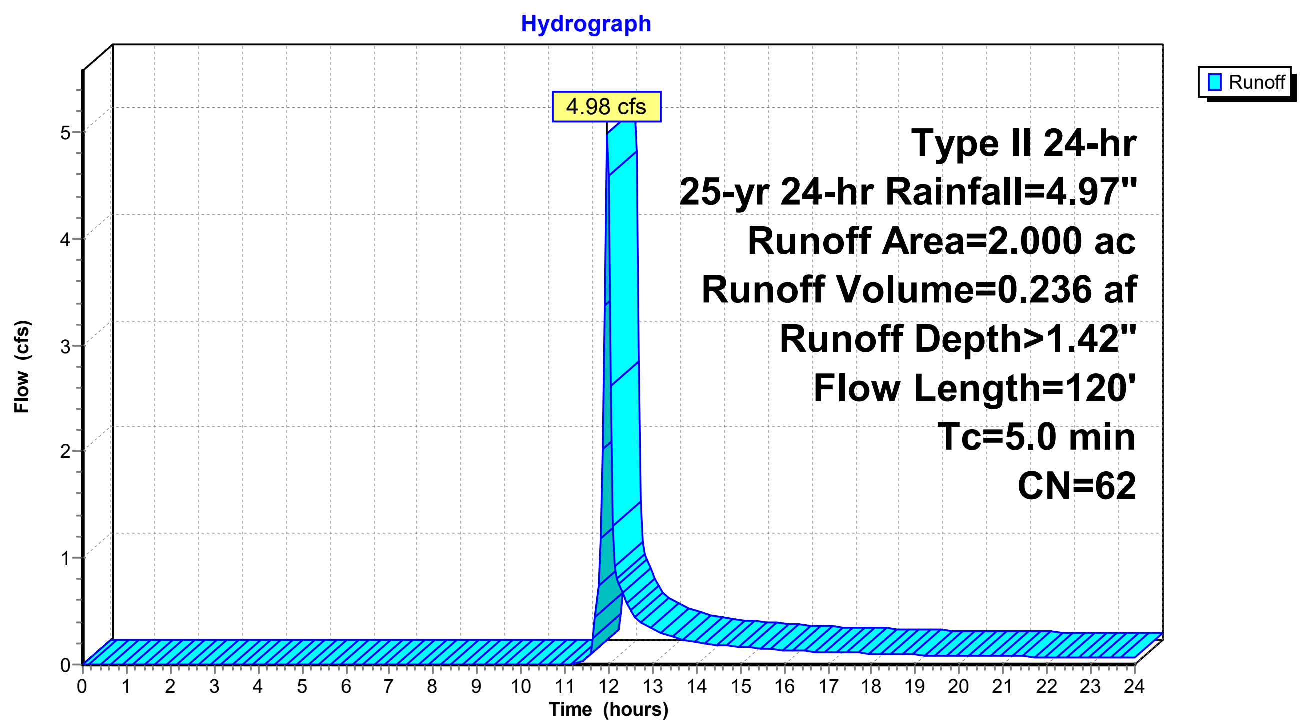
Runoff = 4.98 cfs @ 11.97 hrs, Volume= 0.236 af, Depth> 1.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.400	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
1.300	49	50-75% Grass cover, Fair, HSG A
2.000	62	Weighted Average
2.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			

Subcatchment 38S: Toe -4



Summary for Subcatchment 39S: Toe -5

[49] Hint: Tc<2dt may require smaller dt

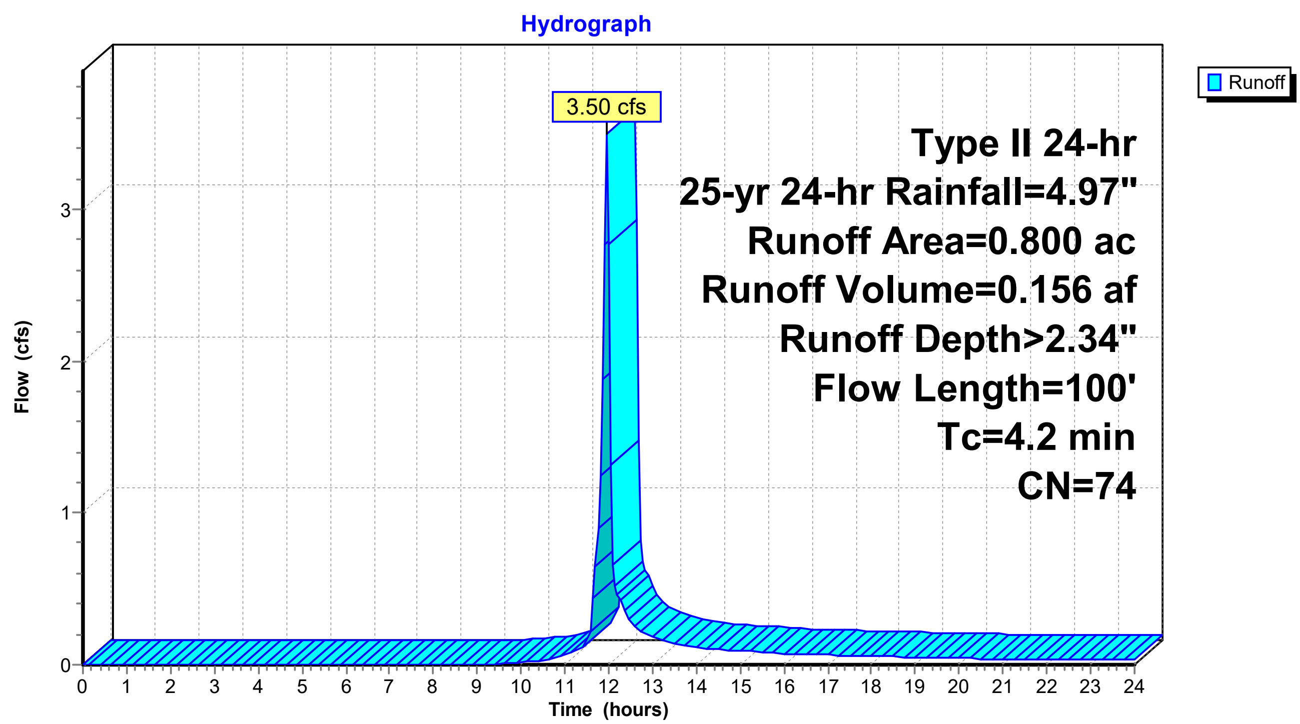
Runoff = 3.50 cfs @ 11.95 hrs, Volume= 0.156 af, Depth> 2.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr 24-hr Rainfall=4.97"

Area (ac)	CN	Description
0.500	79	50-75% Grass cover, Fair, HSG C
0.100	96	Gravel surface, HSG A
0.200	49	50-75% Grass cover, Fair, HSG A
0.800	74	Weighted Average
0.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	20	0.2500	0.31		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
4.2	100	Total			

Subcatchment 39S: Toe -5



Summary for Reach 1R: Cell 1 DC

Inflow Area = 19.500 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 40.28 cfs @ 12.24 hrs, Volume= 4.480 af
Outflow = 40.24 cfs @ 12.24 hrs, Volume= 4.479 af, Atten= 0%, Lag= 0.3 min

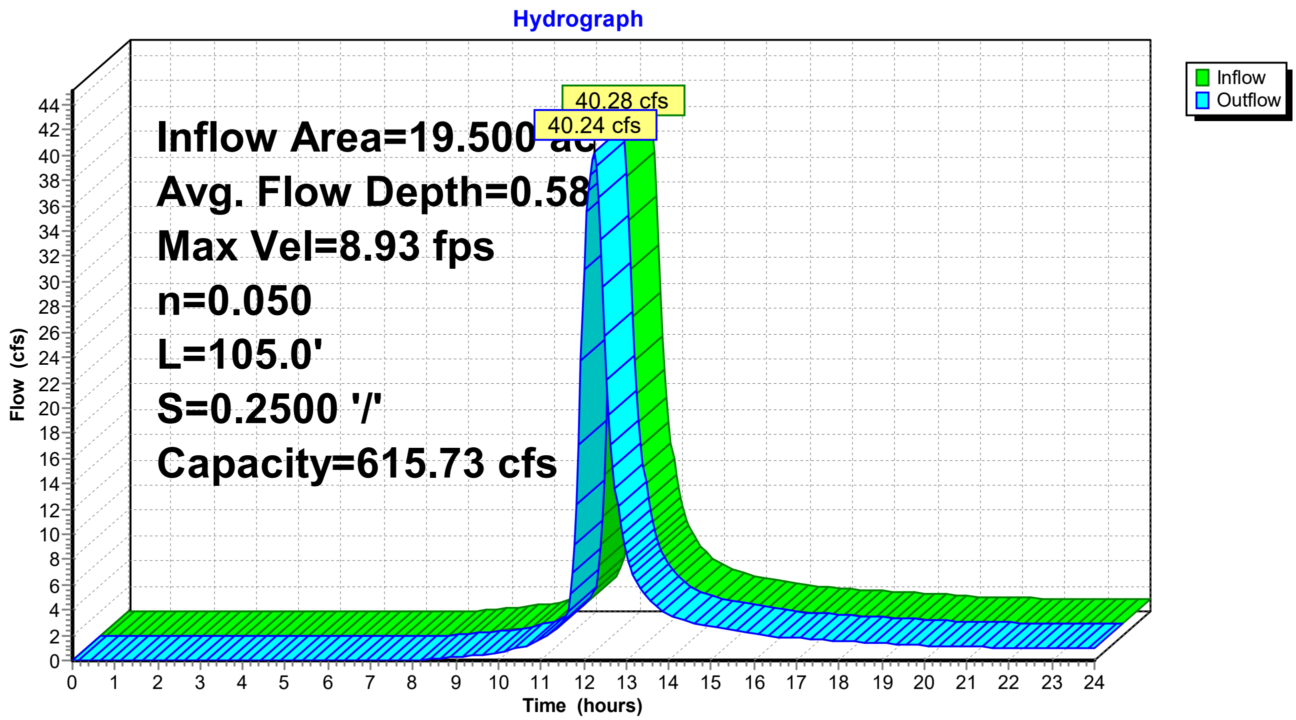
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.93 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 3.05 fps, Avg. Travel Time= 0.6 min

Peak Storage= 474 cf @ 12.24 hrs
Average Depth at Peak Storage= 0.58'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 105.0' Slope= 0.2500 '/'
Inlet Invert= 648.48', Outlet Invert= 622.23'

‡

Reach 1R: Cell 1 DC



Summary for Reach 2R: Cell 2 DC

Inflow Area = 18.200 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 36.34 cfs @ 12.23 hrs, Volume= 4.184 af
Outflow = 36.28 cfs @ 12.24 hrs, Volume= 4.182 af, Atten= 0%, Lag= 0.4 min

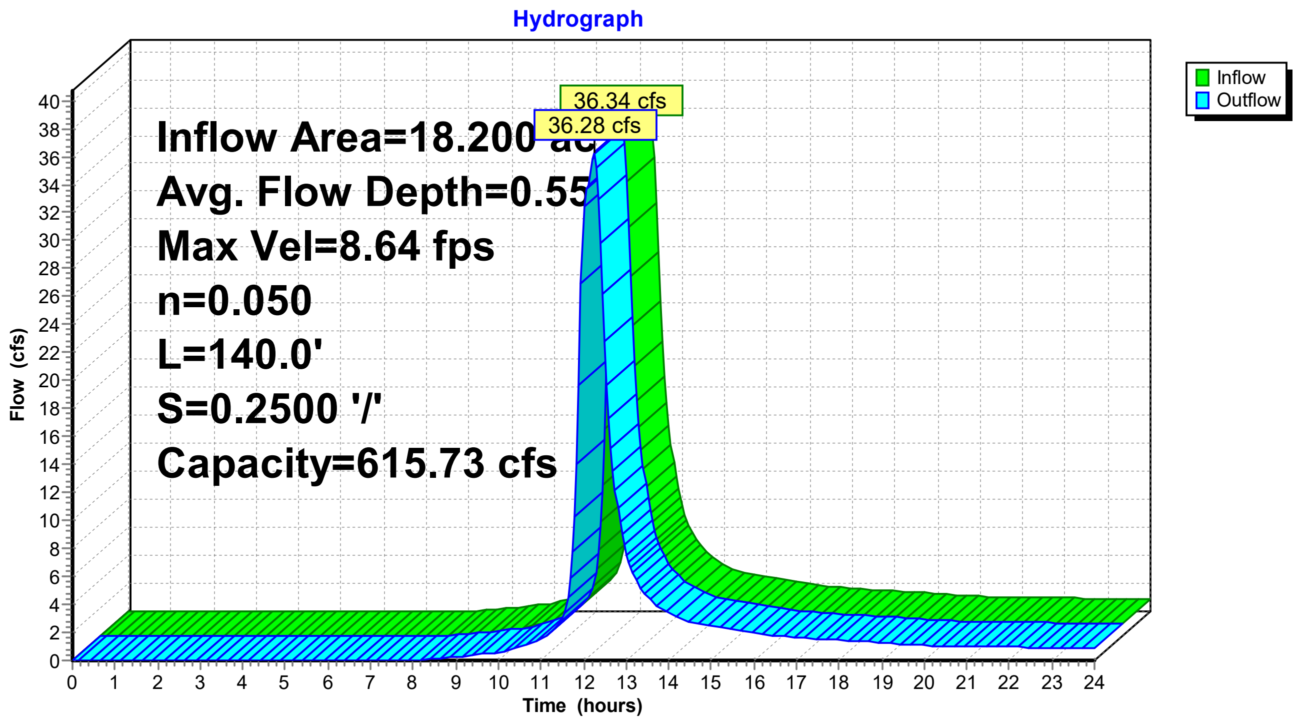
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.64 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 2.98 fps, Avg. Travel Time= 0.8 min

Peak Storage= 589 cf @ 12.23 hrs
Average Depth at Peak Storage= 0.55'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 140.0' Slope= 0.2500 '/'
Inlet Invert= 654.34', Outlet Invert= 619.34'

‡

Reach 2R: Cell 2 DC



Summary for Reach 3R: Cell 3 DC

Inflow Area = 30.300 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 65.15 cfs @ 12.25 hrs, Volume= 6.959 af
Outflow = 65.08 cfs @ 12.26 hrs, Volume= 6.958 af, Atten= 0%, Lag= 0.2 min

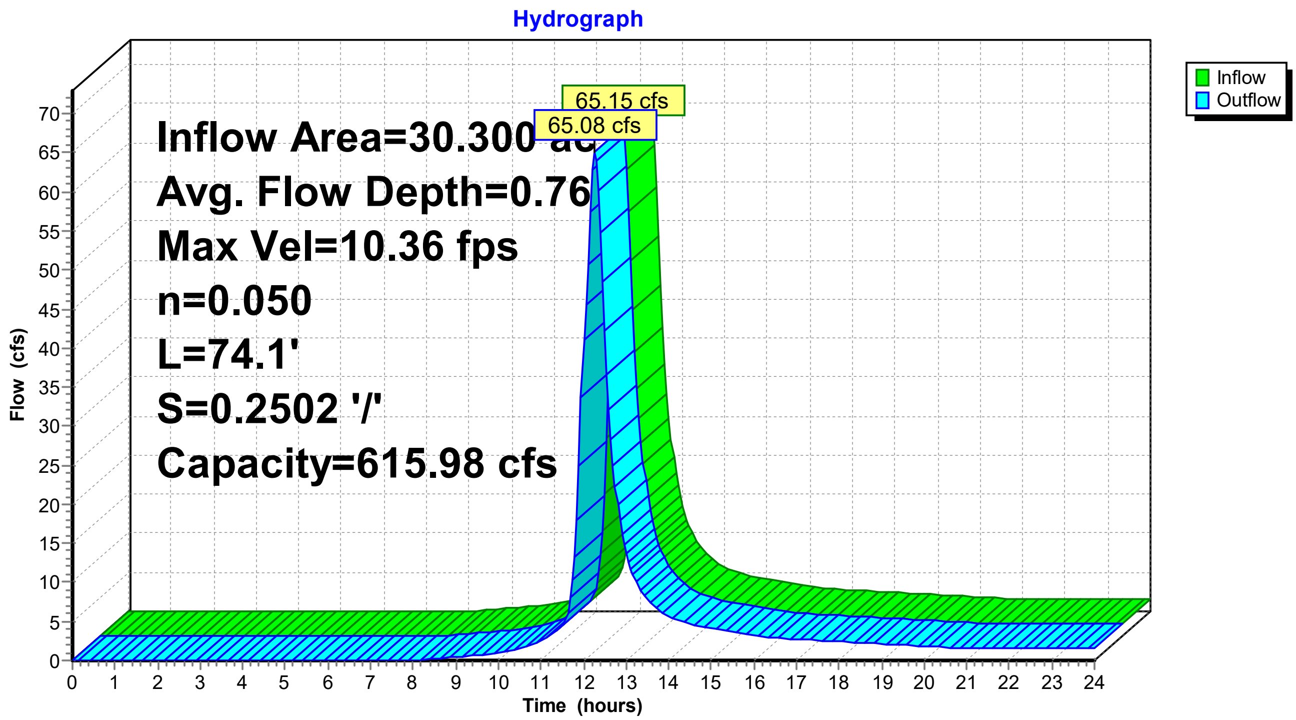
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.36 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.57 fps, Avg. Travel Time= 0.3 min

Peak Storage= 466 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.76'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.98 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 74.1' Slope= 0.2502 '/'
Inlet Invert= 637.53', Outlet Invert= 618.99'

‡

Reach 3R: Cell 3 DC



Summary for Reach 16R: Cell 7 DC

Inflow Area = 10.800 ac, 0.00% Impervious, Inflow Depth > 2.77" for 25-yr 24-hr event
Inflow = 33.03 cfs @ 11.99 hrs, Volume= 2.489 af
Outflow = 32.89 cfs @ 11.99 hrs, Volume= 2.488 af, Atten= 0%, Lag= 0.2 min

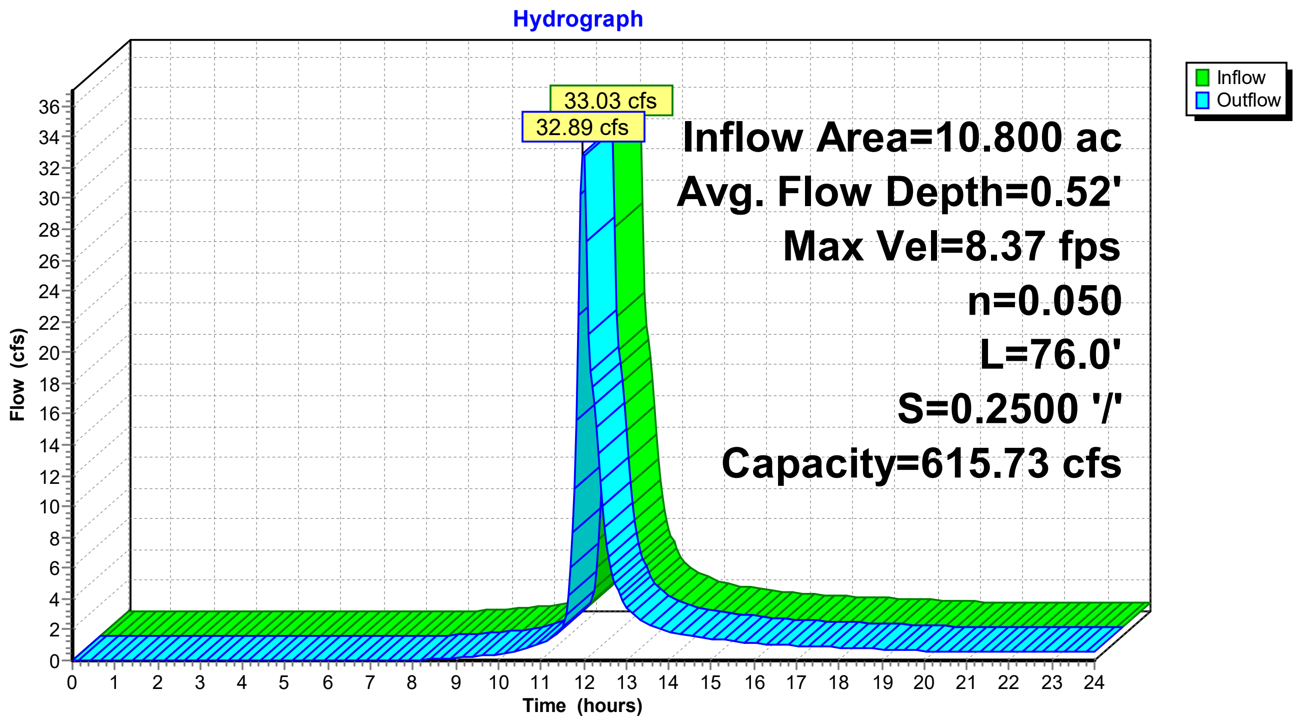
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.37 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 2.47 fps, Avg. Travel Time= 0.5 min

Peak Storage= 300 cf @ 11.99 hrs
Average Depth at Peak Storage= 0.52'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 76.0' Slope= 0.2500 '/'
Inlet Invert= 640.00', Outlet Invert= 621.00'

‡

Reach 16R: Cell 7 DC



Summary for Reach 17R: SW Drainage Ditch

Inflow Area = 22.500 ac, 0.00% Impervious, Inflow Depth > 2.64" for 25-yr 24-hr event
Inflow = 43.01 cfs @ 12.21 hrs, Volume= 4.948 af
Outflow = 42.64 cfs @ 12.26 hrs, Volume= 4.936 af, Atten= 1%, Lag= 2.8 min

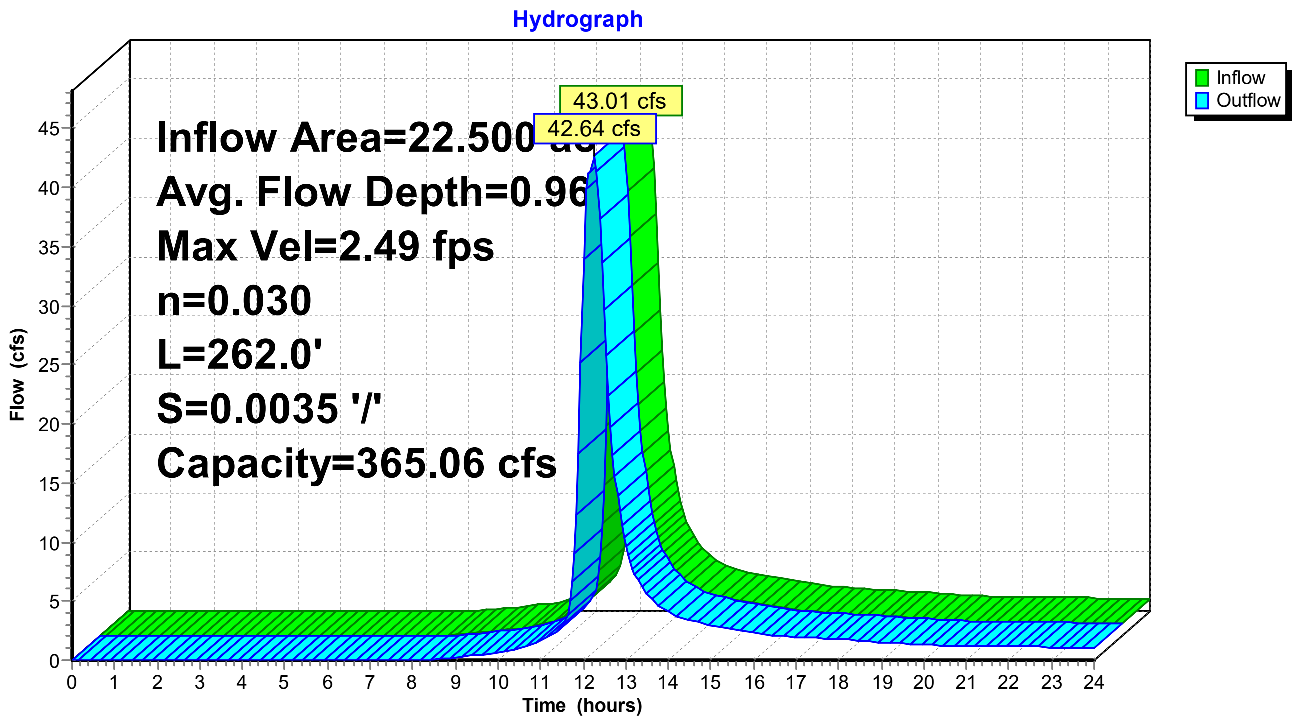
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.49 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.85 fps, Avg. Travel Time= 5.1 min

Peak Storage= 4,504 cf @ 12.24 hrs
Average Depth at Peak Storage= 0.96'
Bank-Full Depth= 3.00' Flow Area= 78.0 sf, Capacity= 365.06 cfs

14.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 38.00'
Length= 262.0' Slope= 0.0035 '/'
Inlet Invert= 605.00', Outlet Invert= 604.08'

‡

Reach 17R: SW Drainage Ditch



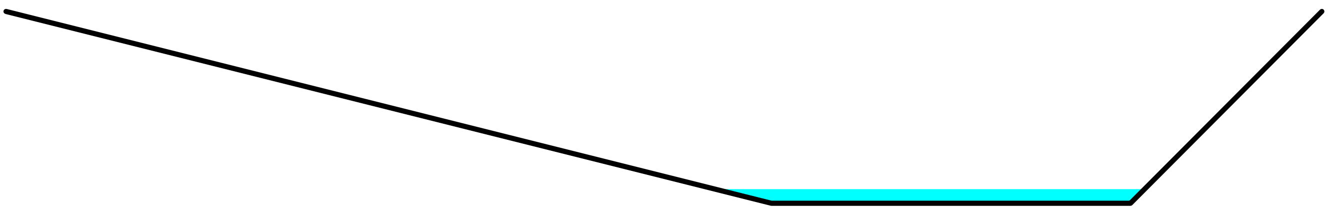
Summary for Reach 18R: South Drainage Ditch

Inflow Area = 2.600 ac, 0.00% Impervious, Inflow Depth > 2.77" for 25-yr 24-hr event
Inflow = 12.25 cfs @ 11.97 hrs, Volume= 0.601 af
Outflow = 11.57 cfs @ 12.05 hrs, Volume= 0.598 af, Atten= 6%, Lag= 4.7 min

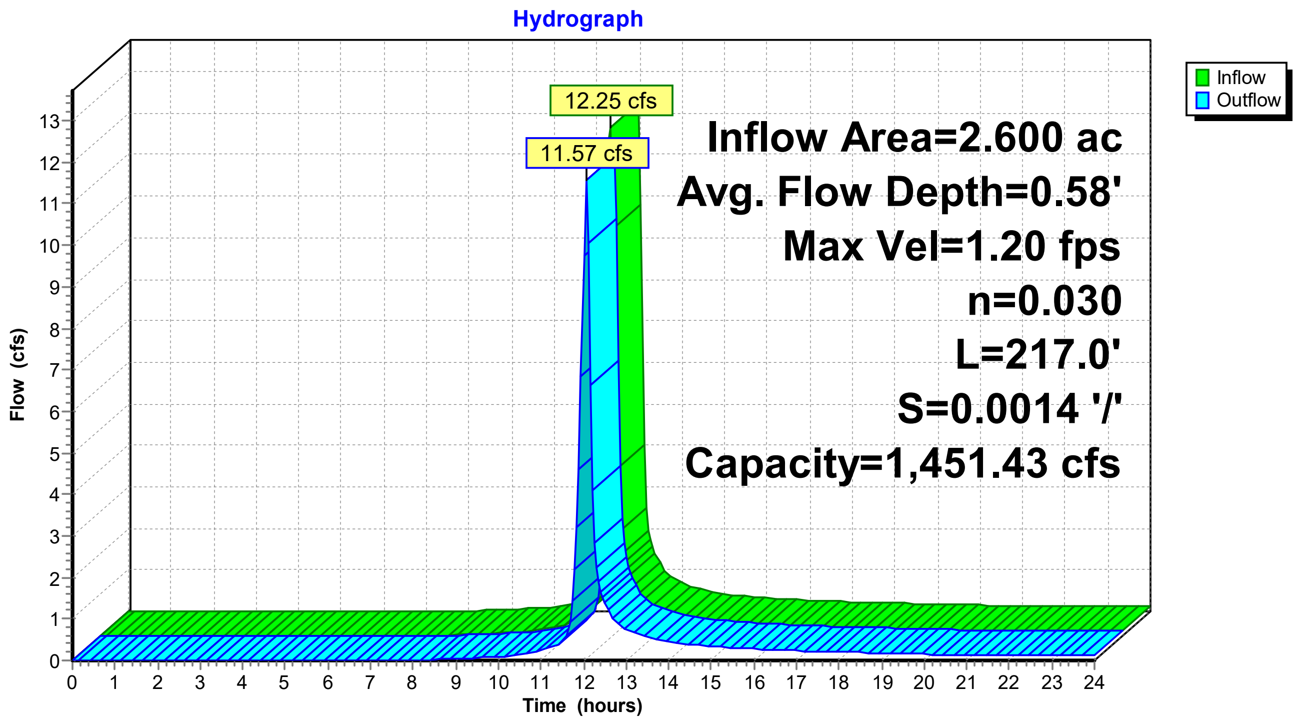
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.20 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 0.37 fps, Avg. Travel Time= 9.8 min

Peak Storage= 2,086 cf @ 12.00 hrs
Average Depth at Peak Storage= 0.58'
Bank-Full Depth= 8.00' Flow Area= 280.0 sf, Capacity= 1,451.43 cfs

15.00' x 8.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 1.0 '/' Top Width= 55.00'
Length= 217.0' Slope= 0.0014 '/'
Inlet Invert= 610.00', Outlet Invert= 609.70'



Reach 18R: South Drainage Ditch



Summary for Reach 24R: Cell 9 DC

Inflow Area = 20.500 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 42.28 cfs @ 12.21 hrs, Volume= 4.713 af
Outflow = 42.23 cfs @ 12.22 hrs, Volume= 4.712 af, Atten= 0%, Lag= 0.2 min

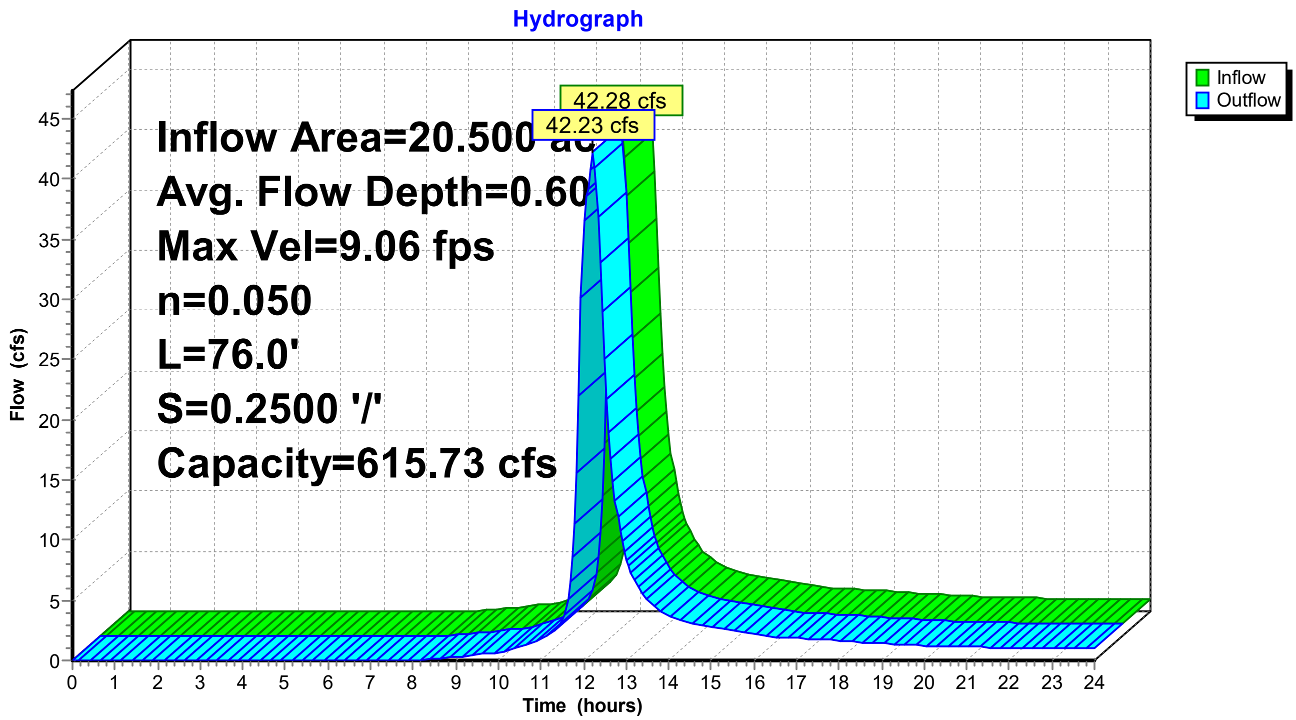
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.06 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.11 fps, Avg. Travel Time= 0.4 min

Peak Storage= 354 cf @ 12.21 hrs
Average Depth at Peak Storage= 0.60'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 76.0' Slope= 0.2500 '/'
Inlet Invert= 641.00', Outlet Invert= 622.00'

‡

Reach 24R: Cell 9 DC



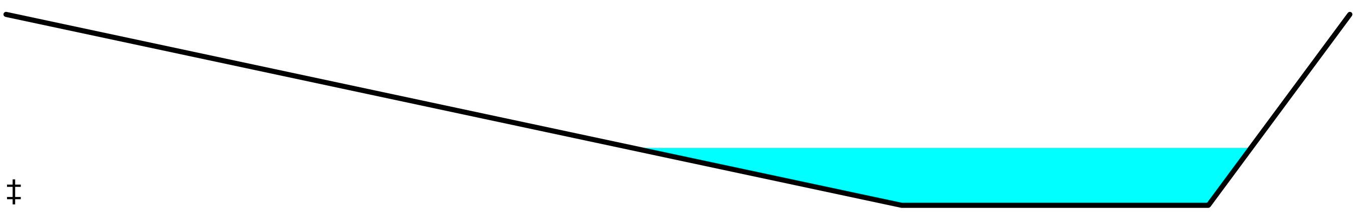
Summary for Reach 32R: NW Drainage Ditch

Inflow Area = 21.700 ac, 0.00% Impervious, Inflow Depth > 2.61" for 25-yr 24-hr event
Inflow = 40.99 cfs @ 12.24 hrs, Volume= 4.714 af
Outflow = 40.43 cfs @ 12.34 hrs, Volume= 4.691 af, Atten= 1%, Lag= 5.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.72 fps, Min. Travel Time= 3.8 min
Avg. Velocity = 0.63 fps, Avg. Travel Time= 10.4 min

Peak Storage= 9,187 cf @ 12.28 hrs
Average Depth at Peak Storage= 0.60'
Bank-Full Depth= 2.00' Flow Area= 140.0 sf, Capacity= 470.81 cfs

26.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 38.0 6.0 '/' Top Width= 114.00'
Length= 390.0' Slope= 0.0035 '/'
Inlet Invert= 609.00', Outlet Invert= 607.63'



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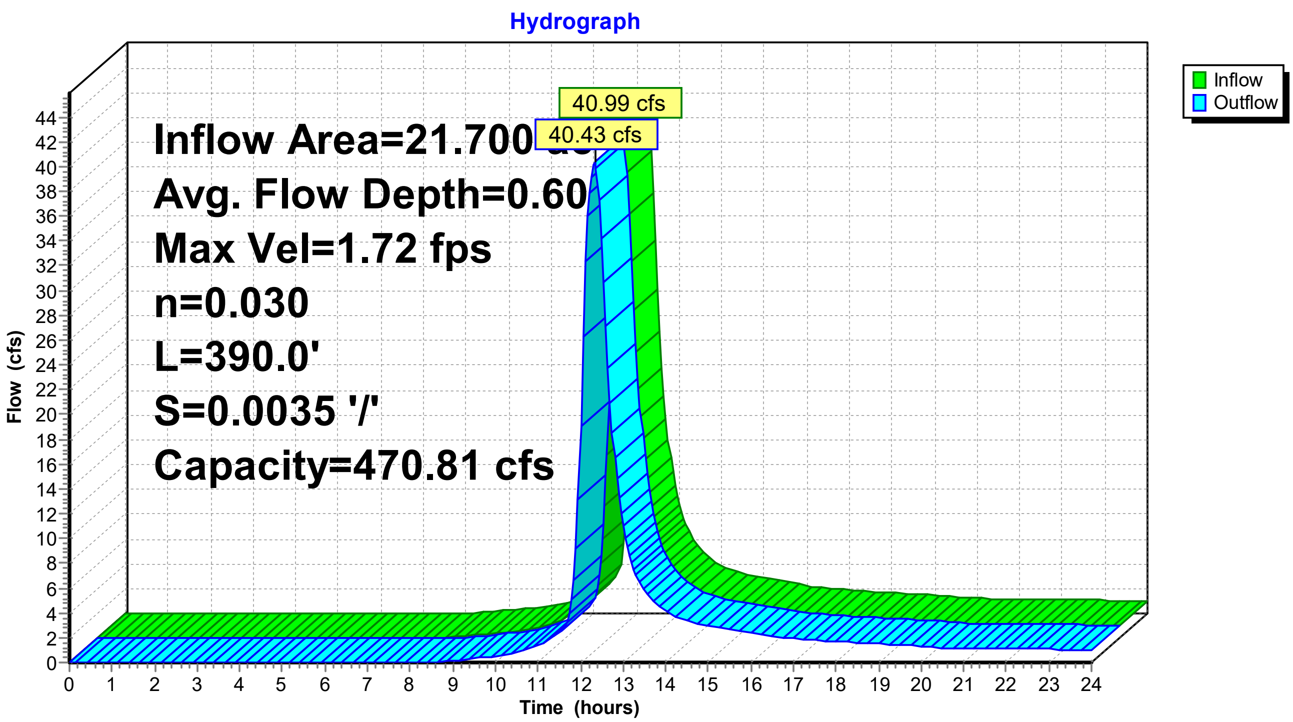
Reach 32R: NW Drainage Ditch



Summary for Reach 33R: NE Drainage Ditch

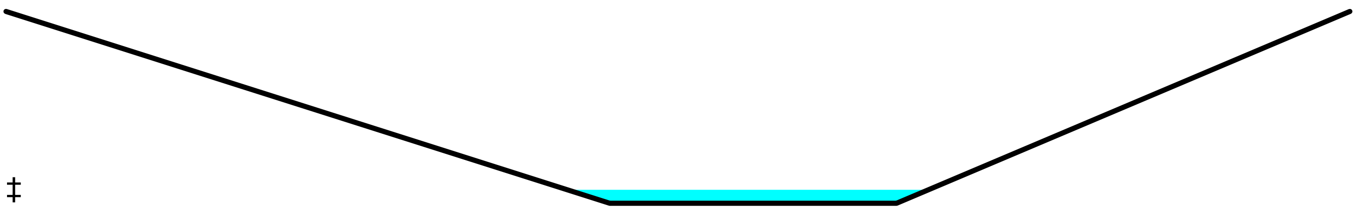
Inflow Area = 21.000 ac, 0.00% Impervious, Inflow Depth > 2.55" for 25-yr 24-hr event
Inflow = 38.22 cfs @ 12.02 hrs, Volume= 4.466 af
Outflow = 36.57 cfs @ 12.38 hrs, Volume= 4.430 af, Atten= 4%, Lag= 21.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.44 fps, Min. Travel Time= 6.0 min
Avg. Velocity = 0.90 fps, Avg. Travel Time= 16.3 min

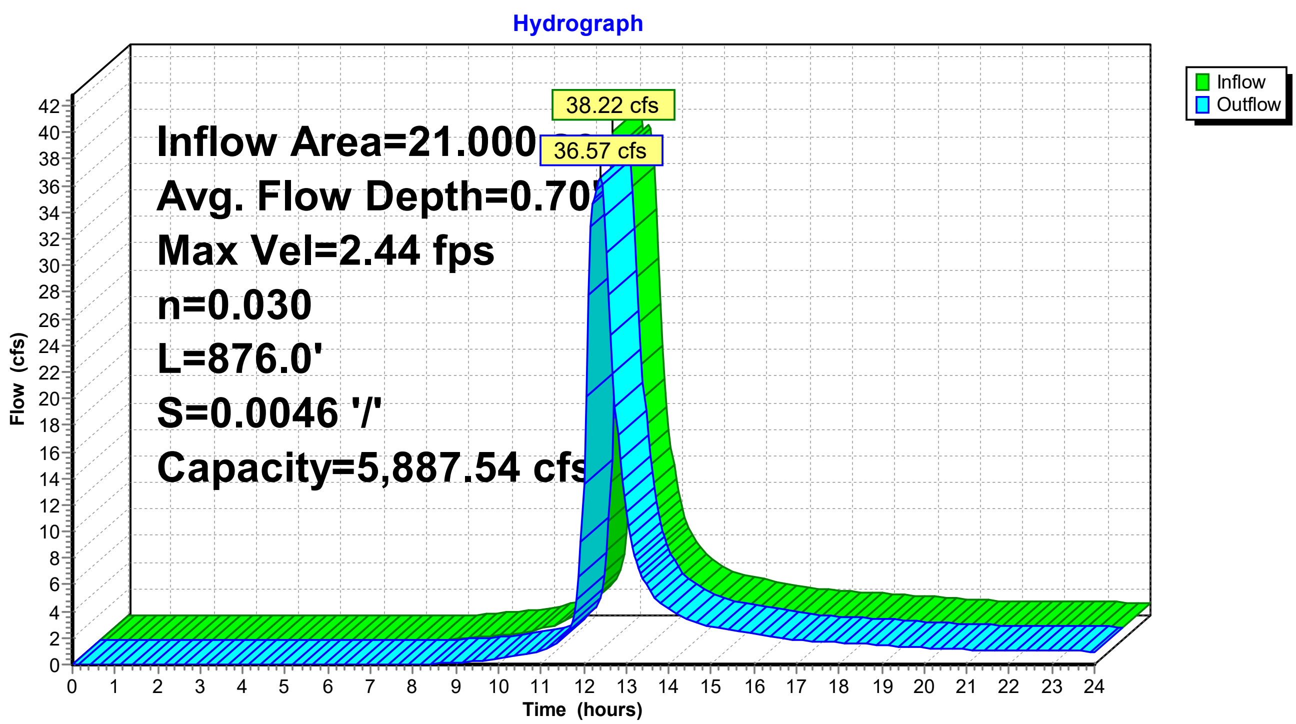
Peak Storage= 13,132 cf @ 12.28 hrs
Average Depth at Peak Storage= 0.70'
Bank-Full Depth= 10.00' Flow Area= 540.0 sf, Capacity= 5,887.54 cfs

19.00' x 10.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 89.00'
Length= 876.0' Slope= 0.0046 '/'
Inlet Invert= 610.00', Outlet Invert= 606.00'

‡



Reach 33R: NE Drainage Ditch



Summary for Reach 34R: SE Drainage Ditch

Inflow Area = 31.600 ac, 0.00% Impervious, Inflow Depth > 2.70" for 25-yr 24-hr event
Inflow = 65.59 cfs @ 12.26 hrs, Volume= 7.119 af
Outflow = 64.98 cfs @ 12.30 hrs, Volume= 7.105 af, Atten= 1%, Lag= 2.6 min

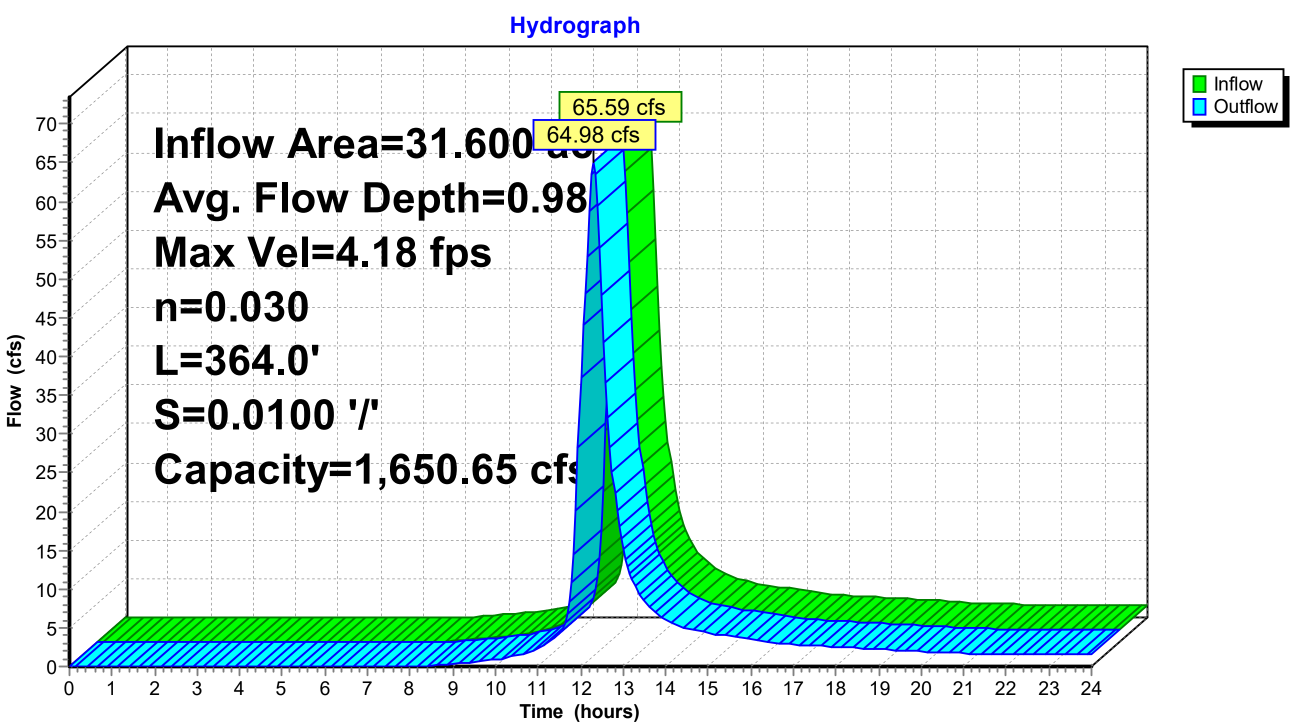
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.18 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 1.44 fps, Avg. Travel Time= 4.2 min

Peak Storage= 5,684 cf @ 12.27 hrs
Average Depth at Peak Storage= 0.98'
Bank-Full Depth= 5.00' Flow Area= 160.0 sf, Capacity= 1,650.65 cfs

12.00' x 5.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 52.00'
Length= 364.0' Slope= 0.0100 '/'
Inlet Invert= 606.00', Outlet Invert= 602.36'

‡

Reach 34R: SE Drainage Ditch



Summary for Reach 36R: W Drainage Ditch

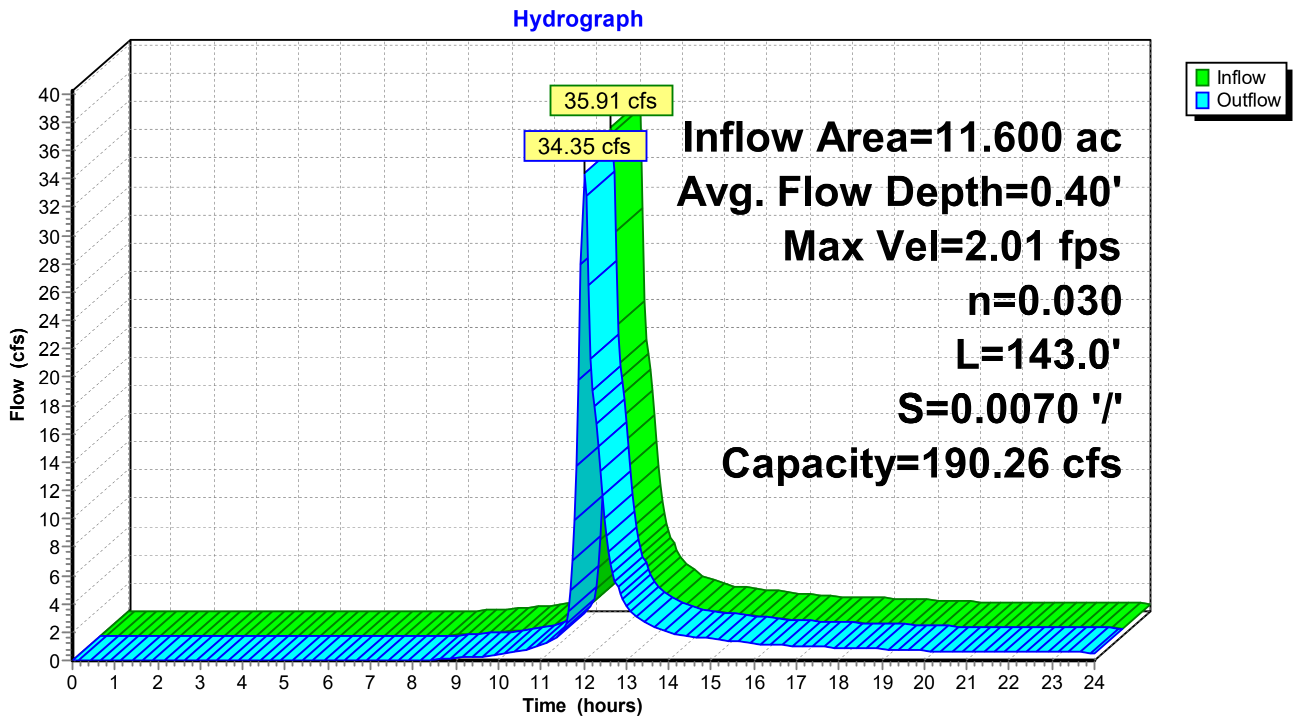
Inflow Area = 11.600 ac, 0.00% Impervious, Inflow Depth > 2.74" for 25-yr 24-hr event
Inflow = 35.91 cfs @ 11.98 hrs, Volume= 2.644 af
Outflow = 34.35 cfs @ 12.02 hrs, Volume= 2.639 af, Atten= 4%, Lag= 1.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.01 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 0.57 fps, Avg. Travel Time= 4.2 min

Peak Storage= 2,535 cf @ 12.00 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 1.00' Flow Area= 56.5 sf, Capacity= 190.26 cfs

36.00' x 1.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 33.0 8.0 '/' Top Width= 77.00'
Length= 143.0' Slope= 0.0070 '/'
Inlet Invert= 609.00', Outlet Invert= 608.00'

Reach 36R: W Drainage Ditch



Summary for Pond 21P: Catch Basin - C2

[57] Hint: Peaked at 616.19' (Flood elevation advised)

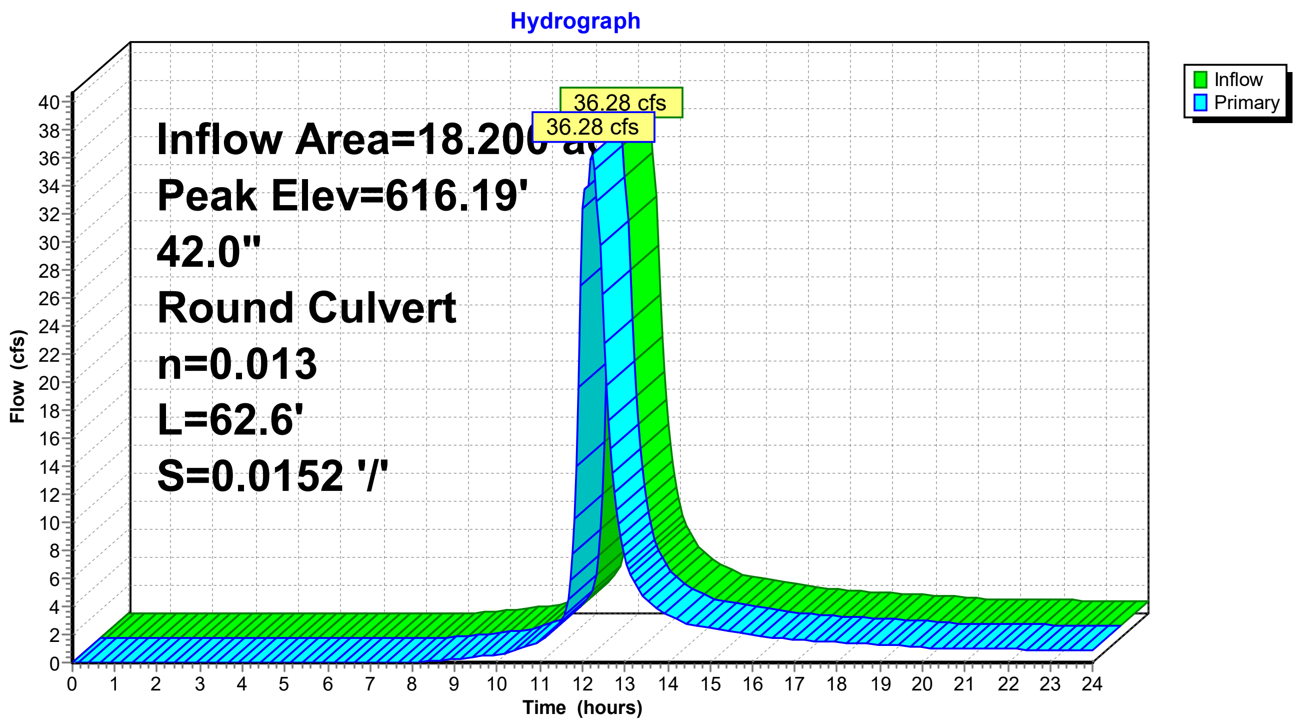
Inflow Area = 18.200 ac, 0.00% Impervious, Inflow Depth > 2.76" for 25-yr 24-hr event
Inflow = 36.28 cfs @ 12.24 hrs, Volume= 4.182 af
Outflow = 36.28 cfs @ 12.24 hrs, Volume= 4.182 af, Atten= 0%, Lag= 0.0 min
Primary = 36.28 cfs @ 12.24 hrs, Volume= 4.182 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 616.19' @ 12.24 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	613.43'	**42.0" Round Culvert** L= 62.6' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 613.43' / 612.48' S= 0.0152 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=36.15 cfs @ 12.24 hrs HW=616.18' (Free Discharge)
└**1=Culvert** (Inlet Controls 36.15 cfs @ 4.46 fps)

Pond 21P: Catch Basin - C2



Summary for Pond 27P: SE Catch Basin

[57] Hint: Peaked at 623.56' (Flood elevation advised)

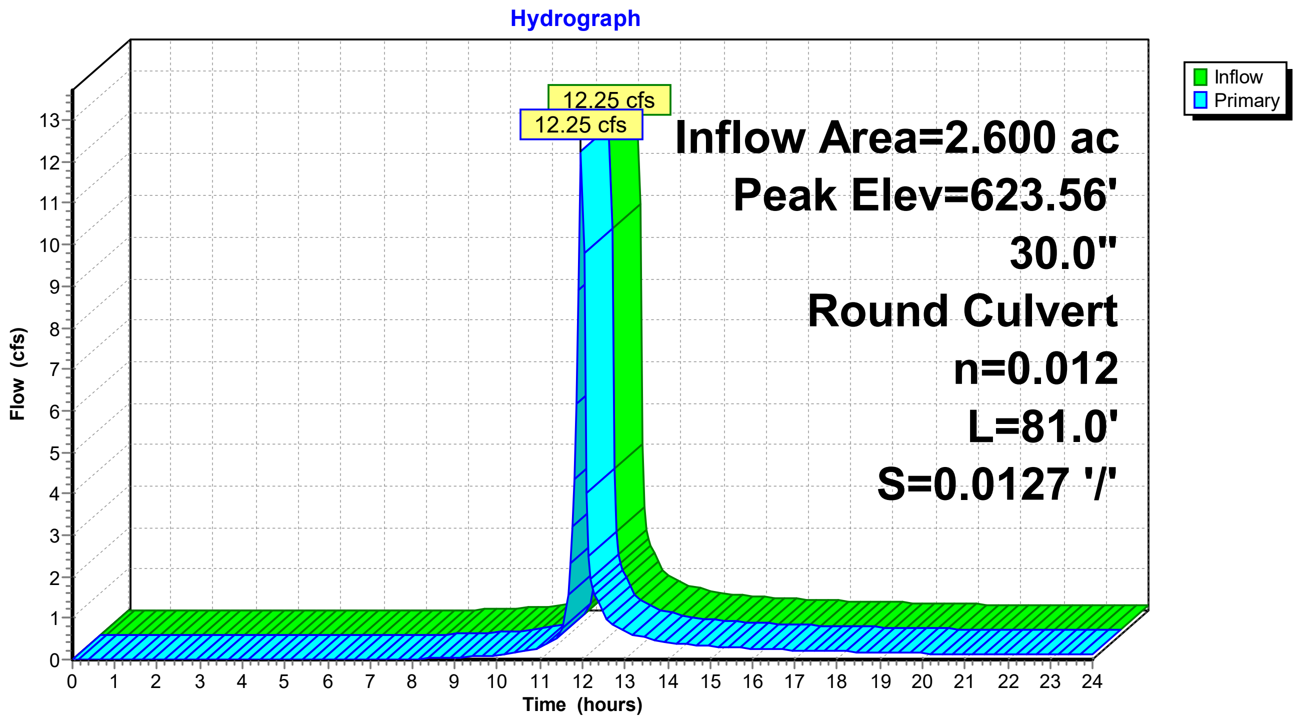
Inflow Area =	2.600 ac,	0.00% Impervious,	Inflow Depth > 2.77"	for 25-yr 24-hr event	
Inflow =	12.25 cfs @	11.97 hrs,	Volume=	0.601 af	
Outflow =	12.25 cfs @	11.97 hrs,	Volume=	0.601 af,	Atten= 0%, Lag= 0.0 min
Primary =	12.25 cfs @	11.97 hrs,	Volume=	0.601 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 623.56' @ 11.97 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	622.22'	**30.0" Round Culvert** L= 81.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 622.22' / 621.19' S= 0.0127 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 4.91 sf

Primary OutFlow Max=11.87 cfs @ 11.97 hrs HW=623.53' (Free Discharge)
1=Culvert (Barrel Controls 11.87 cfs @ 6.62 fps)

Pond 27P: SE Catch Basin



Summary for Pond 28P: Catch Basin - C1

[57] Hint: Peaked at 618.07' (Flood elevation advised)

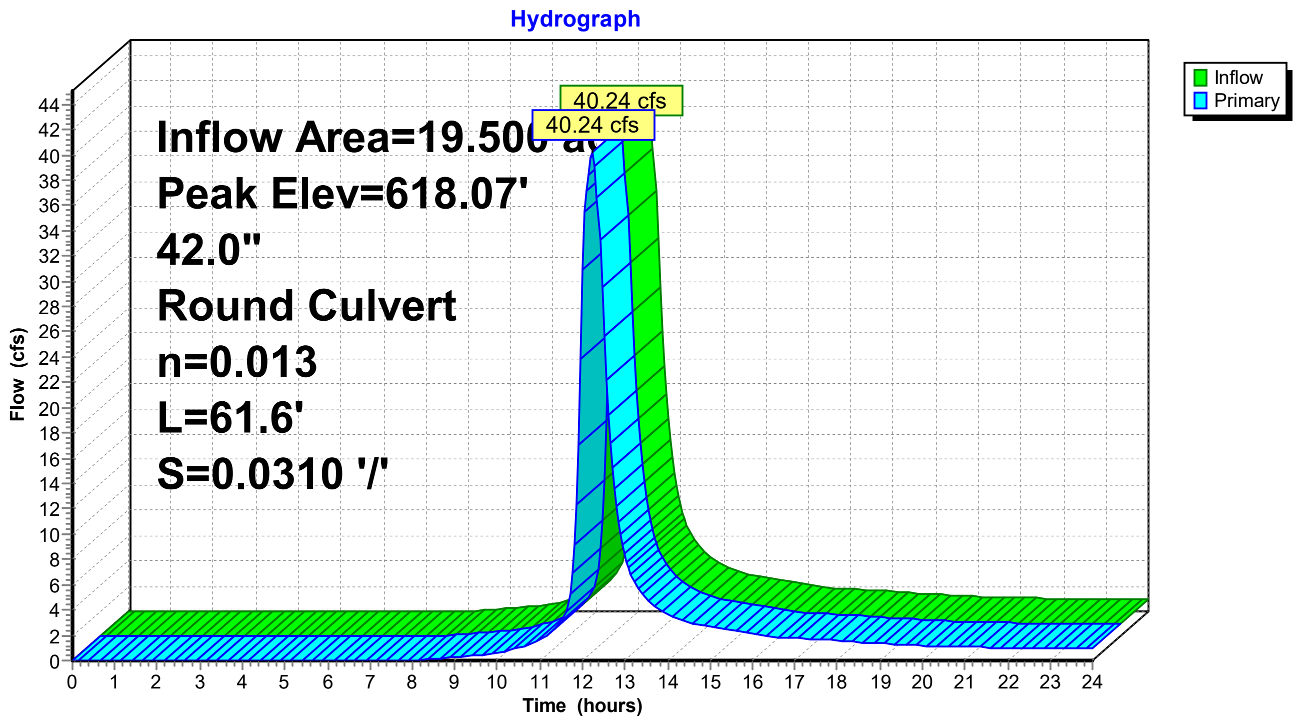
Inflow Area =	19.500 ac,	0.00% Impervious,	Inflow Depth > 2.76"	for 25-yr 24-hr event	
Inflow =	40.24 cfs @	12.24 hrs,	Volume=	4.479 af	
Outflow =	40.24 cfs @	12.24 hrs,	Volume=	4.479 af,	Atten= 0%, Lag= 0.0 min
Primary =	40.24 cfs @	12.24 hrs,	Volume=	4.479 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 618.07' @ 12.24 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.10'	**42.0" Round Culvert** L= 61.6' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.10' / 613.19' S= 0.0310 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=40.11 cfs @ 12.24 hrs HW=618.06' (Free Discharge)
1=Culvert (Inlet Controls 40.11 cfs @ 4.62 fps)

Pond 28P: Catch Basin - C1



Summary for Pond 29P: Catch Basin - C3

[57] Hint: Peaked at 613.34' (Flood elevation advised)

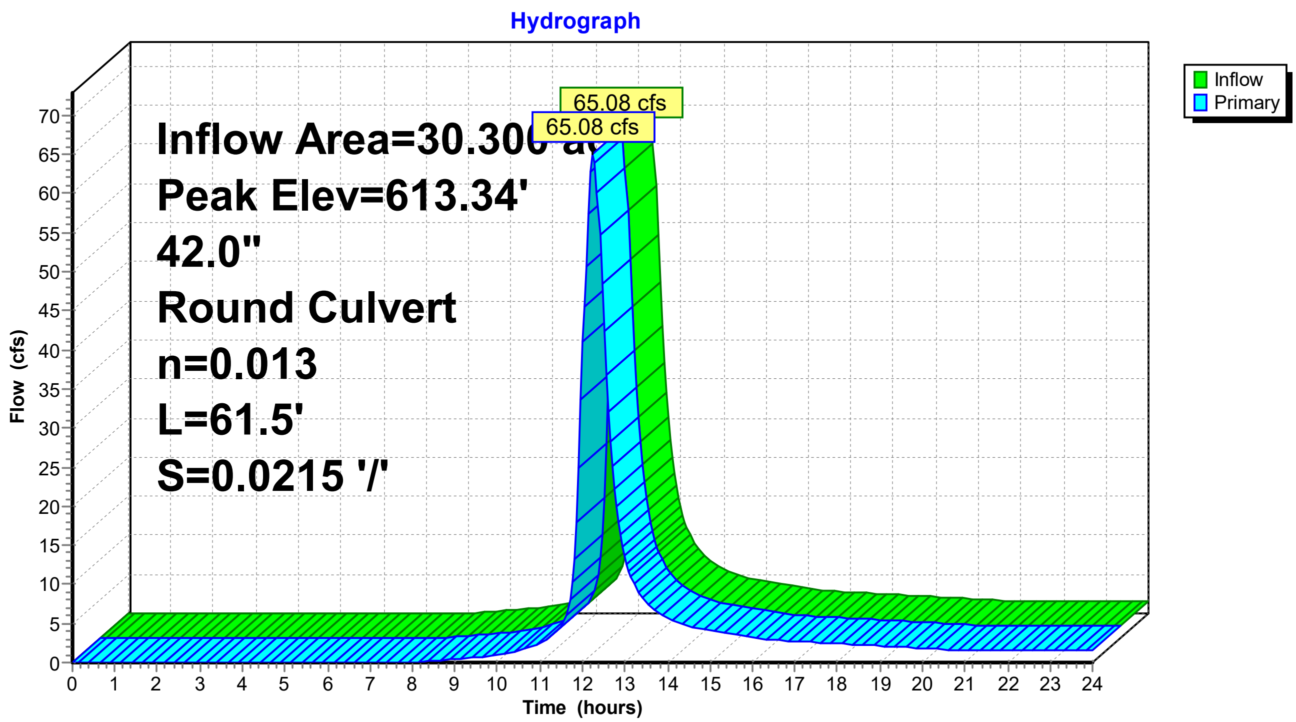
Inflow Area =	30.300 ac,	0.00% Impervious,	Inflow Depth > 2.76"	for 25-yr 24-hr event	
Inflow =	65.08 cfs @	12.26 hrs,	Volume=	6.958 af	
Outflow =	65.08 cfs @	12.26 hrs,	Volume=	6.958 af,	Atten= 0%, Lag= 0.0 min
Primary =	65.08 cfs @	12.26 hrs,	Volume=	6.958 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 613.34' @ 12.26 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	608.42'	**42.0" Round Culvert** L= 61.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 608.42' / 607.10' S= 0.0215 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=64.86 cfs @ 12.26 hrs HW=613.32' (Free Discharge)
↑**1=Culvert** (Inlet Controls 64.86 cfs @ 6.74 fps)

Pond 29P: Catch Basin - C3



Summary for Pond 30P: Catch Basin C9

[57] Hint: Peaked at 618.08' (Flood elevation advised)

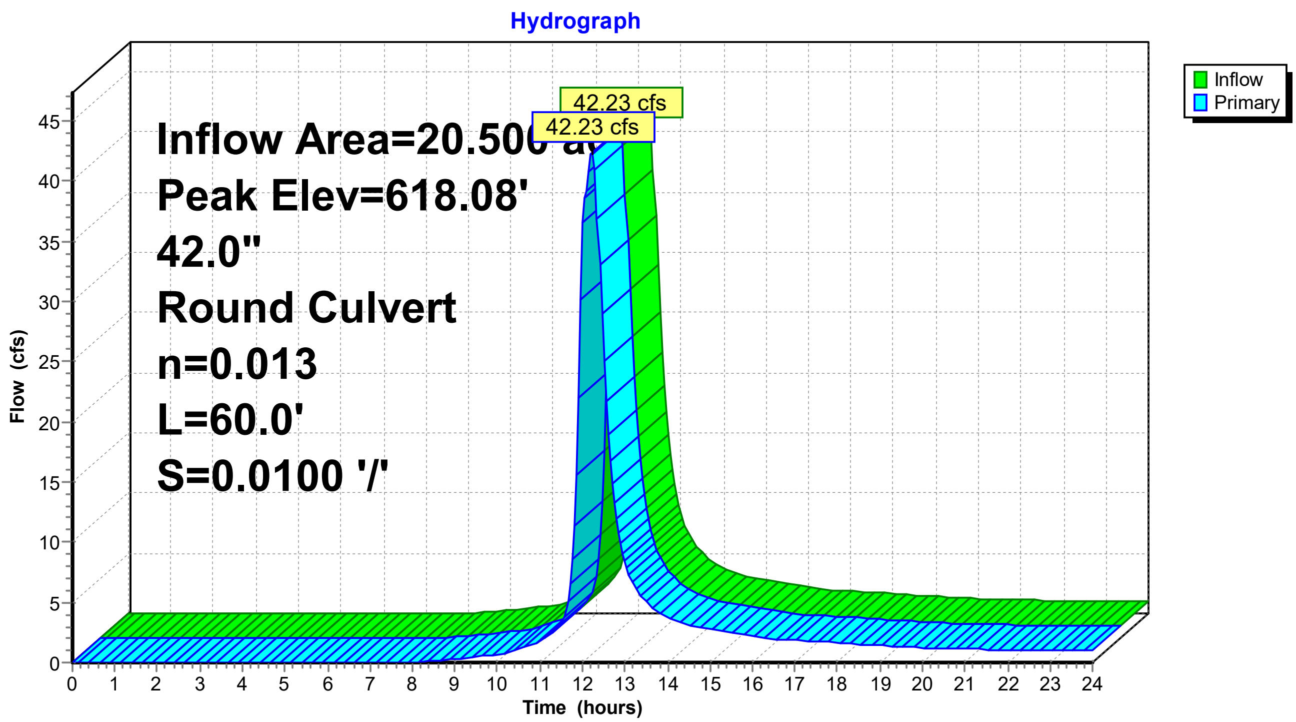
Inflow Area =	20.500 ac,	0.00% Impervious,	Inflow Depth > 2.76"	for 25-yr 24-hr event	
Inflow =	42.23 cfs @	12.22 hrs,	Volume=	4.712 af	
Outflow =	42.23 cfs @	12.22 hrs,	Volume=	4.712 af,	Atten= 0%, Lag= 0.0 min
Primary =	42.23 cfs @	12.22 hrs,	Volume=	4.712 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 618.08' @ 12.22 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.00'	**42.0" Round Culvert** L= 60.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.00' / 614.40' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=42.05 cfs @ 12.22 hrs HW=618.07' (Free Discharge)
1=Culvert (Inlet Controls 42.05 cfs @ 4.71 fps)

Pond 30P: Catch Basin C9



Summary for Pond 31P: Catch Basin - C7

[57] Hint: Peaked at 617.59' (Flood elevation advised)

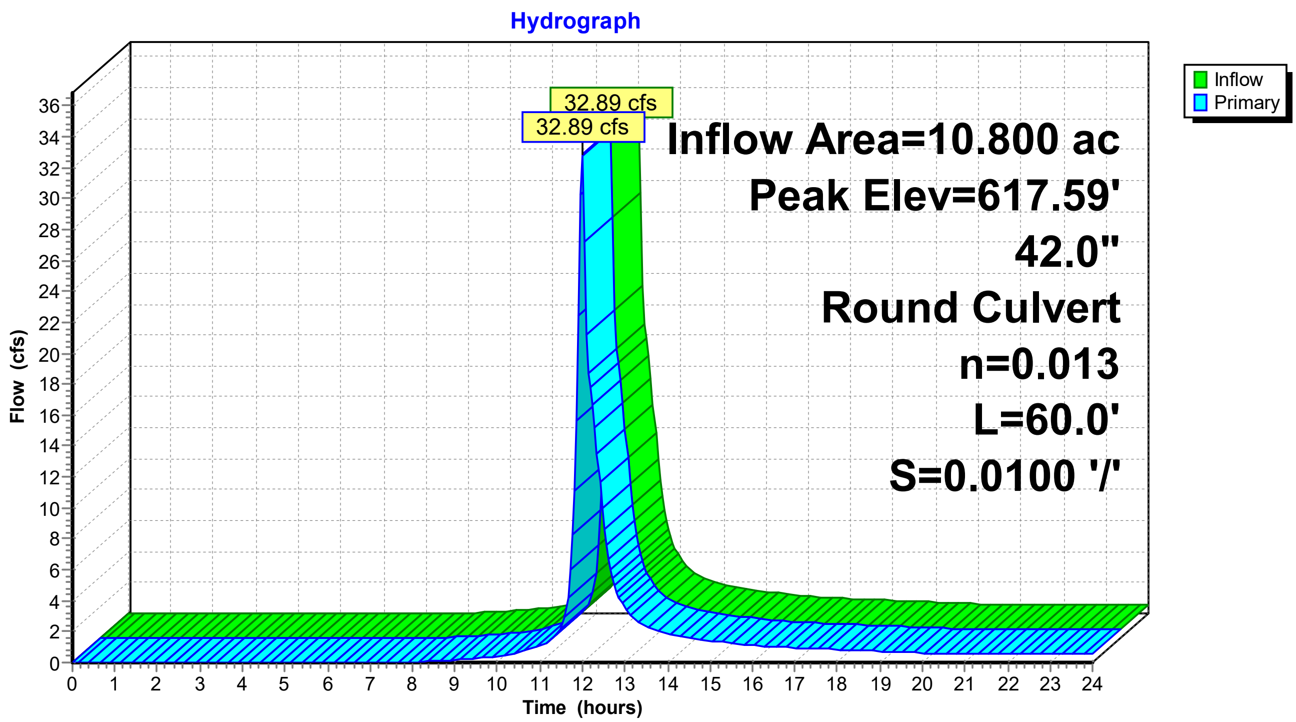
Inflow Area =	10.800 ac,	0.00% Impervious,	Inflow Depth > 2.76"	for 25-yr 24-hr event
Inflow =	32.89 cfs @	11.99 hrs, Volume=	2.488 af	
Outflow =	32.89 cfs @	11.99 hrs, Volume=	2.488 af,	Atten= 0%, Lag= 0.0 min
Primary =	32.89 cfs @	11.99 hrs, Volume=	2.488 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 617.59' @ 11.99 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.00'	**42.0" Round Culvert** L= 60.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.00' / 614.40' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=32.26 cfs @ 11.99 hrs HW=617.56' (Free Discharge)
1=Culvert (Barrel Controls 32.26 cfs @ 5.98 fps)

Pond 31P: Catch Basin - C7



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Jan 11 2021

SW-1 Culvert

Invert Elev Dn (ft)	=	630.00
Pipe Length (ft)	=	120.00
Slope (%)	=	1.00
Invert Elev Up (ft)	=	631.20
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	2
n-Value	=	0.011
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

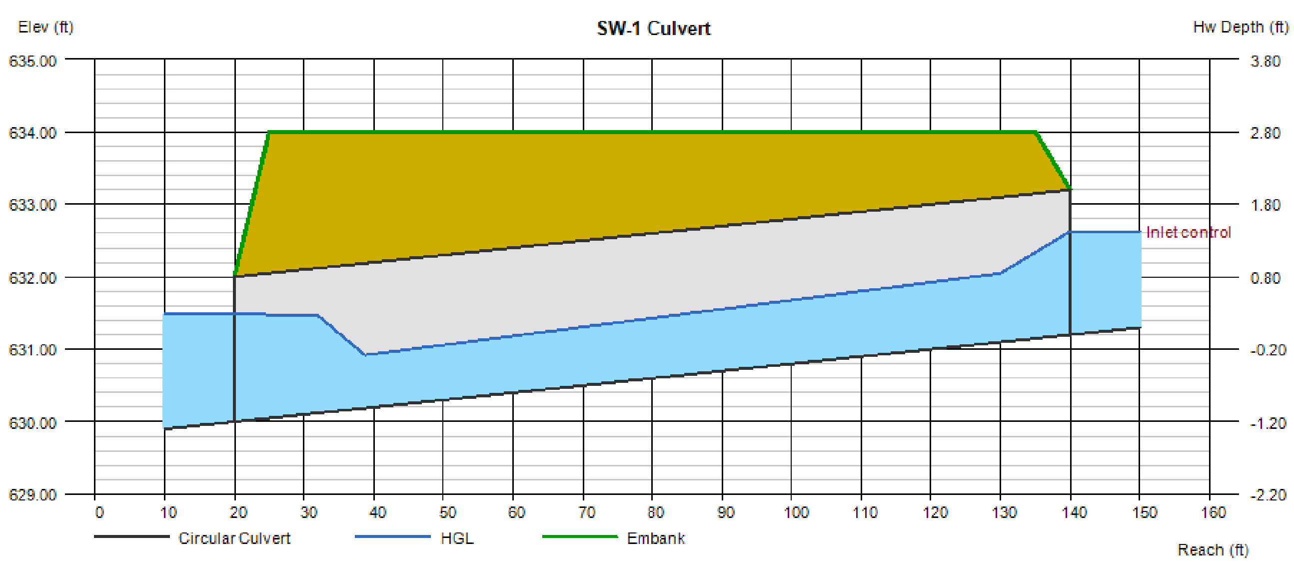
Top Elevation (ft)	=	634.00
Top Width (ft)	=	110.00
Crest Width (ft)	=	110.00

Calculations

Qmin (cfs)	=	15.00
Qmax (cfs)	=	15.00
Tailwater Elev (ft)	=	(dc+D)/2

Highlighted

Qtotal (cfs)	=	15.00
Qpipe (cfs)	=	15.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	3.00
Veloc Up (ft/s)	=	4.95
HGL Dn (ft)	=	631.49
HGL Up (ft)	=	632.17
Hw Elev (ft)	=	632.63
Hw/D (ft)	=	0.71
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Monday, Jan 11 2021

SW-2 Culvert

Invert Elev Dn (ft)	=	650.00
Pipe Length (ft)	=	120.00
Slope (%)	=	1.00
Invert Elev Up (ft)	=	651.20
Rise (in)	=	24.0
Shape	=	Circular
Span (in)	=	24.0
No. Barrels	=	2
n-Value	=	0.011
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

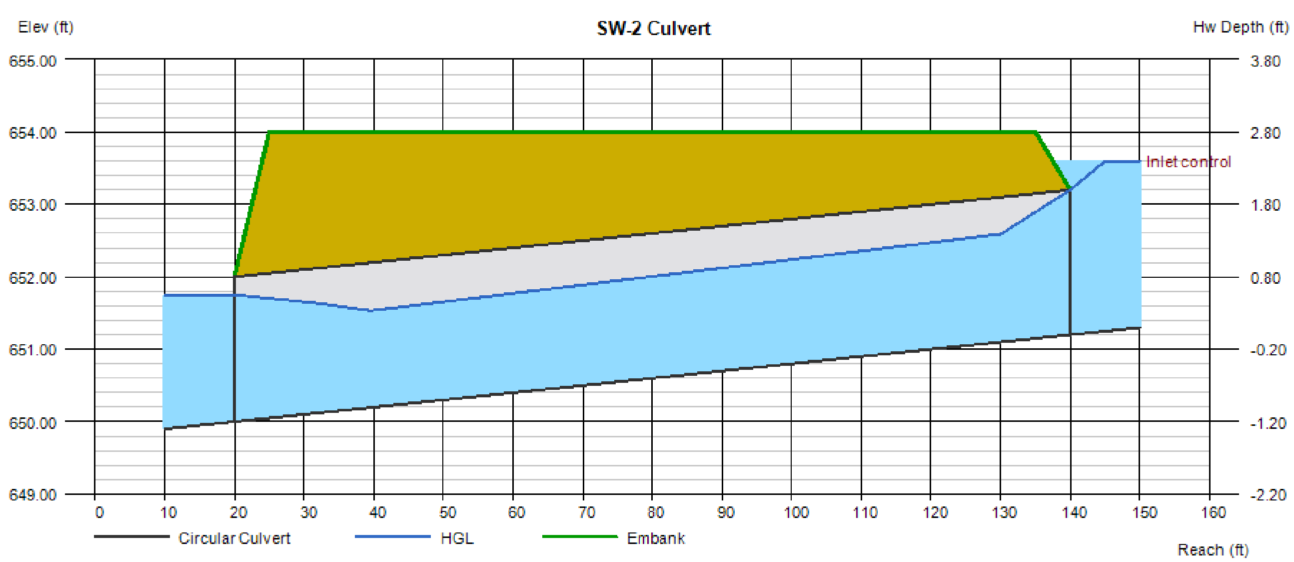
Top Elevation (ft)	=	654.00
Top Width (ft)	=	110.00
Crest Width (ft)	=	110.00

Calculations

Qmin (cfs)	=	35.00
Qmax (cfs)	=	35.00
Tailwater Elev (ft)	=	(dc+D)/2

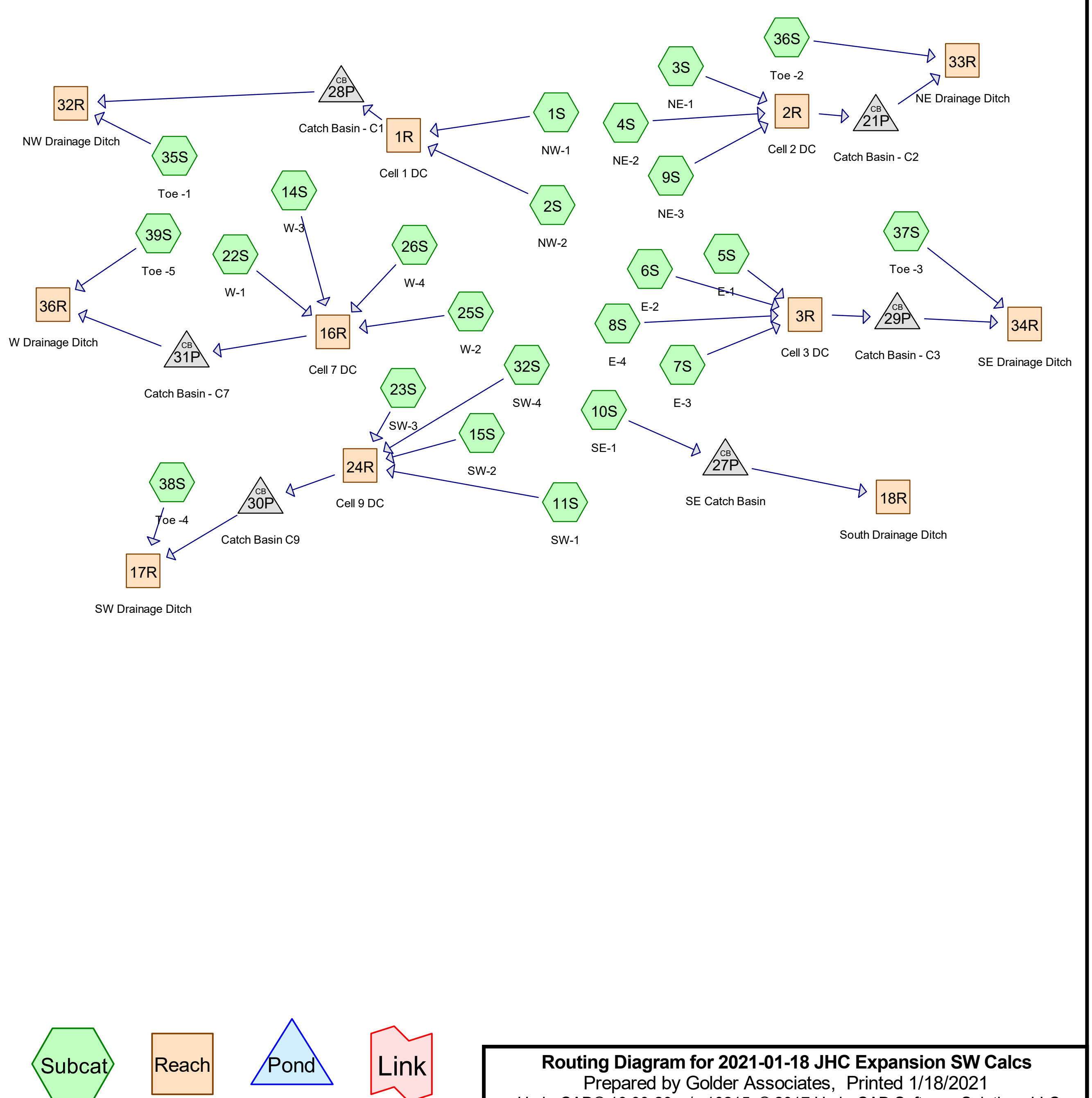
Highlighted

Qtotal (cfs)	=	35.00
Qpipe (cfs)	=	35.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	6.00
Veloc Up (ft/s)	=	6.90
HGL Dn (ft)	=	651.75
HGL Up (ft)	=	652.71
Hw Elev (ft)	=	653.60
Hw/D (ft)	=	1.20
Flow Regime	=	Inlet Control



Attachment 4

HydroCAD 100-yr 24-hr Results



Routing Diagram for 2021-01-18 JHC Expansion SW Calcs
Prepared by Golder Associates, Printed 1/18/2021
HydroCAD® 10.00-20 s/n 10215 © 2017 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
5.900	49	50-75% Grass cover, Fair, HSG A (35S, 36S, 37S, 38S, 39S)
103.900	79	50-75% Grass cover, Fair, HSG C (1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S)
1.200	96	Gravel surface, HSG A (35S, 36S, 37S, 38S, 39S)
111.000	**78**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
7.100	HSG A	35S, 36S, 37S, 38S, 39S
0.000	HSG B	
103.900	HSG C	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S
0.000	HSG D	
0.000	Other	
111.000		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
5.900	0.000	103.900	0.000	0.000	109.800	50-75% Grass cover, Fair	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 10S, 11S, 14S, 15S, 22S, 23S, 25S, 26S, 32S, 35S, 36S, 37S, 38S, 39S
1.200	0.000	0.000	0.000	0.000	1.200	Gravel surface	35S, 36S, 37S, 38S, 39S
7.100	**0.000**	**103.900**	**0.000**	**0.000**	**111.000**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	21P	613.43	612.48	62.6	0.0152	0.013	42.0	0.0	0.0
2	27P	622.22	621.19	81.0	0.0127	0.012	30.0	0.0	0.0
3	28P	615.10	613.19	61.6	0.0310	0.013	42.0	0.0	0.0
4	29P	608.42	607.10	61.5	0.0215	0.013	42.0	0.0	0.0
5	30P	615.00	614.40	60.0	0.0100	0.013	42.0	0.0	0.0
6	31P	615.00	614.40	60.0	0.0100	0.013	42.0	0.0	0.0

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: NW-1 Runoff Area=3.800 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=1,708' Tc=9.7 min CN=79 Runoff=25.92 cfs 1.432 af

Subcatchment 2S: NW-2 Runoff Area=15.700 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=1,936' Tc=31.2 min CN=79 Runoff=59.99 cfs 5.884 af

Subcatchment 3S: NE-1 Runoff Area=3.300 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=1,318' Tc=8.7 min CN=79 Runoff=23.35 cfs 1.244 af

Subcatchment 4S: NE-2 Runoff Area=13.900 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=1,666' Tc=30.6 min CN=79 Runoff=53.69 cfs 5.210 af

Subcatchment 5S: E-1 Runoff Area=0.900 ac 0.00% Impervious Runoff Depth>4.53"
Flow Length=535' Tc=4.4 min CN=79 Runoff=7.32 cfs 0.339 af

Subcatchment 6S: E-2 Runoff Area=5.400 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=1,382' Tc=27.4 min CN=79 Runoff=22.41 cfs 2.026 af

Subcatchment 7S: E-3 Runoff Area=2.300 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=1,166' Tc=7.0 min CN=79 Runoff=17.16 cfs 0.867 af

Subcatchment 8S: E-4 Runoff Area=21.700 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=2,663' Tc=32.3 min CN=79 Runoff=81.11 cfs 8.130 af

Subcatchment 9S: NE-3 Runoff Area=1.000 ac 0.00% Impervious Runoff Depth>4.53"
Flow Length=455' Tc=4.3 min CN=79 Runoff=8.16 cfs 0.377 af

Subcatchment 10S: SE-1 Runoff Area=2.600 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=1,112' Tc=6.2 min CN=79 Runoff=19.64 cfs 0.980 af

Subcatchment 11S: SW-1 Runoff Area=3.300 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=1,696' Tc=7.9 min CN=79 Runoff=23.98 cfs 1.244 af

Subcatchment 14S: W-3 Runoff Area=1.300 ac 0.00% Impervious Runoff Depth>4.53"
Flow Length=664' Tc=5.1 min CN=79 Runoff=10.27 cfs 0.490 af

Subcatchment 15S: SW-2 Runoff Area=14.700 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=2,031' Tc=30.6 min CN=79 Runoff=56.78 cfs 5.510 af

Subcatchment 22S: W-1 Runoff Area=0.800 ac 0.00% Impervious Runoff Depth>4.53"
Flow Length=473' Tc=4.7 min CN=79 Runoff=6.43 cfs 0.302 af

Subcatchment 23S: SW-3 Runoff Area=0.700 ac 0.00% Impervious Runoff Depth>4.53"
Flow Length=381' Tc=4.5 min CN=79 Runoff=5.67 cfs 0.264 af

Subcatchment 25S: W-2 Runoff Area=5.000 ac 0.00% Impervious Runoff Depth>4.50"
Flow Length=578' Tc=26.3 min CN=79 Runoff=21.27 cfs 1.876 af

Subcatchment 26S: W-4 Runoff Area=3.700 ac 0.00% Impervious Runoff Depth>4.52"
Flow Length=566' Tc=7.3 min CN=79 Runoff=27.38 cfs 1.395 af

Subcatchment 32S: SW-4 Runoff Area=1.800 ac 0.00% Impervious Runoff Depth>4.51"
Flow Length=700' Tc=19.6 min CN=79 Runoff=9.08 cfs 0.676 af

Subcatchment 35S: Toe -1 Runoff Area=2.200 ac 0.00% Impervious Runoff Depth>2.56"
Flow Length=100' Tc=4.2 min CN=60 Runoff=10.51 cfs 0.469 af

Subcatchment 36S: Toe -2 Runoff Area=2.800 ac 0.00% Impervious Runoff Depth>2.46"
Flow Length=120' Tc=5.0 min CN=59 Runoff=12.36 cfs 0.574 af

Subcatchment 37S: Toe -3 Runoff Area=1.300 ac 0.00% Impervious Runoff Depth>2.85"
Flow Length=120' Tc=5.0 min CN=63 Runoff=6.69 cfs 0.309 af

Subcatchment 38S: Toe -4 Runoff Area=2.000 ac 0.00% Impervious Runoff Depth>2.75"
Flow Length=120' Tc=5.0 min CN=62 Runoff=9.93 cfs 0.459 af

Subcatchment 39S: Toe -5 Runoff Area=0.800 ac 0.00% Impervious Runoff Depth>3.99"
Flow Length=100' Tc=4.2 min CN=74 Runoff=5.88 cfs 0.266 af

Reach 1R: Cell 1 DC Avg. Flow Depth=0.76' Max Vel=10.37 fps Inflow=65.58 cfs 7.315 af
n=0.050 L=105.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=65.52 cfs 7.314 af

Reach 2R: Cell 2 DC Avg. Flow Depth=0.72' Max Vel=10.04 fps Inflow=59.05 cfs 6.831 af
n=0.050 L=140.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=59.02 cfs 6.829 af

Reach 3R: Cell 3 DC Avg. Flow Depth=0.99' Max Vel=11.98 fps Inflow=106.08 cfs 11.362 af
n=0.050 L=74.1' S=0.2502 '/' Capacity=615.98 cfs Outflow=105.98 cfs 11.361 af

Reach 16R: Cell 7 DC Avg. Flow Depth=0.68' Max Vel=9.73 fps Inflow=53.47 cfs 4.063 af
n=0.050 L=76.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=53.29 cfs 4.062 af

Reach 17R: SW Drainage Ditch Avg. Flow Depth=1.26' Max Vel=2.90 fps Inflow=70.21 cfs 8.152 af
n=0.030 L=262.0' S=0.0035 '/' Capacity=365.06 cfs Outflow=69.70 cfs 8.136 af

Reach 18R: South Drainage Ditch Avg. Flow Depth=0.78' Max Vel=1.43 fps Inflow=19.64 cfs 0.980 af
n=0.030 L=217.0' S=0.0014 '/' Capacity=1,451.43 cfs Outflow=18.47 cfs 0.977 af

Reach 24R: Cell 9 DC Avg. Flow Depth=0.78' Max Vel=10.53 fps Inflow=68.82 cfs 7.694 af
n=0.050 L=76.0' S=0.2500 '/' Capacity=615.73 cfs Outflow=68.76 cfs 7.693 af

Reach 32R: NW Drainage Ditch Avg. Flow Depth=0.78' Max Vel=1.98 fps Inflow=66.95 cfs 7.783 af
n=0.030 L=390.0' S=0.0035 '/' Capacity=470.81 cfs Outflow=66.27 cfs 7.753 af

Reach 33R: NE Drainage Ditch Avg. Flow Depth=0.93' Max Vel=2.90 fps Inflow=65.22 cfs 7.403 af
n=0.030 L=876.0' S=0.0046 '/' Capacity=5,887.54 cfs Outflow=60.02 cfs 7.353 af

Reach 34R: SE Drainage Ditch Avg. Flow Depth=1.28' Max Vel=4.86 fps Inflow=106.89 cfs 11.670 af
n=0.030 L=364.0' S=0.0100 '/' Capacity=1,650.65 cfs Outflow=105.98 cfs 11.652 af

Reach 36R: W Drainage Ditch Avg. Flow Depth=0.53' Max Vel=2.35 fps Inflow=58.37 cfs 4.328 af
n=0.030 L=143.0' S=0.0070 '/' Capacity=190.26 cfs Outflow=56.35 cfs 4.321 af

Pond 21P: Catch Basin - C2 Peak Elev=617.78' Inflow=59.02 cfs 6.829 af
42.0" Round Culvert n=0.013 L=62.6' S=0.0152 '/' Outflow=59.02 cfs 6.829 af

Pond 27P: SE Catch Basin Peak Elev=624.02' Inflow=19.64 cfs 0.980 af
30.0" Round Culvert n=0.012 L=81.0' S=0.0127 '/' Outflow=19.64 cfs 0.980 af

Pond 28P: Catch Basin - C1 Peak Elev=620.06' Inflow=65.52 cfs 7.314 af
42.0" Round Culvert n=0.013 L=61.6' S=0.0310 '/' Outflow=65.52 cfs 7.314 af

Pond 29P: Catch Basin - C3 Peak Elev=618.57' Inflow=105.98 cfs 11.361 af
42.0" Round Culvert n=0.013 L=61.5' S=0.0215 '/' Outflow=105.98 cfs 11.361 af

Pond 30P: Catch Basin C9 Peak Elev=620.28' Inflow=68.76 cfs 7.693 af
42.0" Round Culvert n=0.013 L=60.0' S=0.0100 '/' Outflow=68.76 cfs 7.693 af

Pond 31P: Catch Basin - C7 Peak Elev=618.87' Inflow=53.29 cfs 4.062 af
42.0" Round Culvert n=0.013 L=60.0' S=0.0100 '/' Outflow=53.29 cfs 4.062 af

Total Runoff Area = 111.000 ac Runoff Volume = 40.323 af Average Runoff Depth = 4.36"
100.00% Pervious = 111.000 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: NW-1

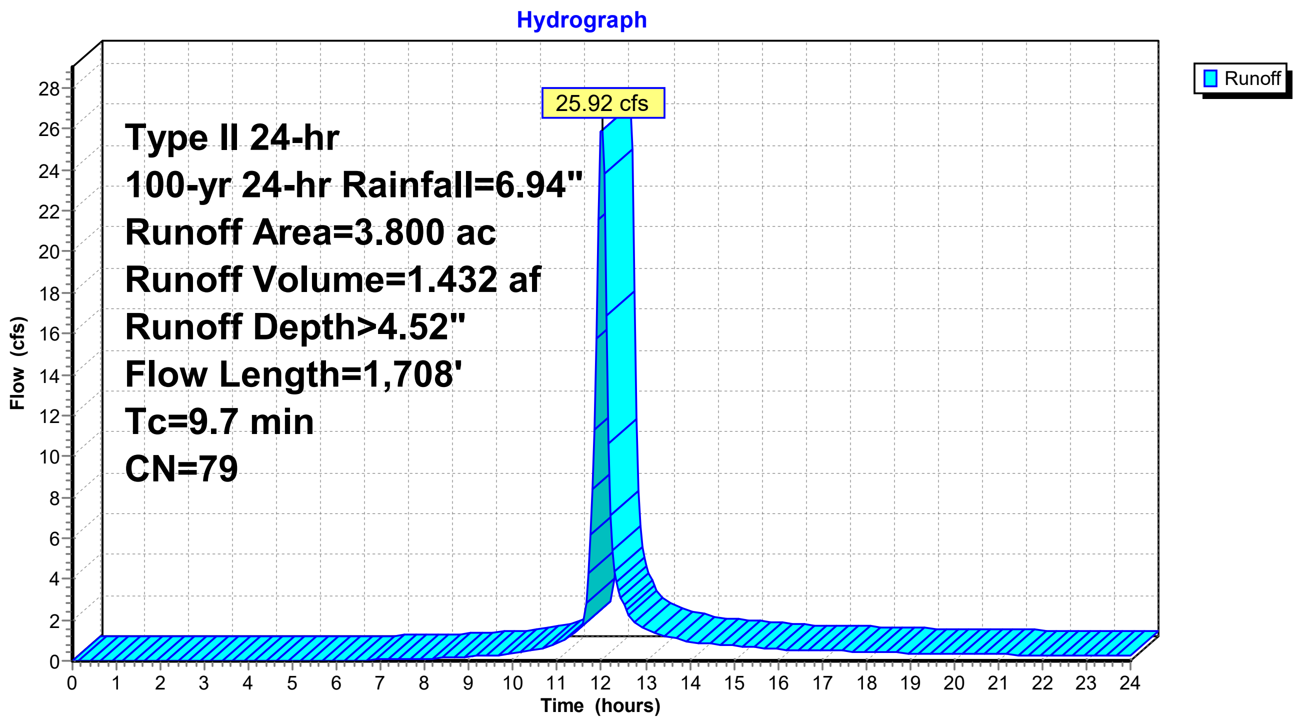
Runoff = 25.92 cfs @ 12.01 hrs, Volume= 1.432 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
3.800	79	50-75% Grass cover, Fair, HSG C
3.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
5.9	1,600	0.0060	4.48	62.76	**Trap/Vee/Rect Channel Flow, TB-1** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025 Earth, grassed & winding
9.7	1,708	Total			

Subcatchment 1S: NW-1



Summary for Subcatchment 2S: NW-2

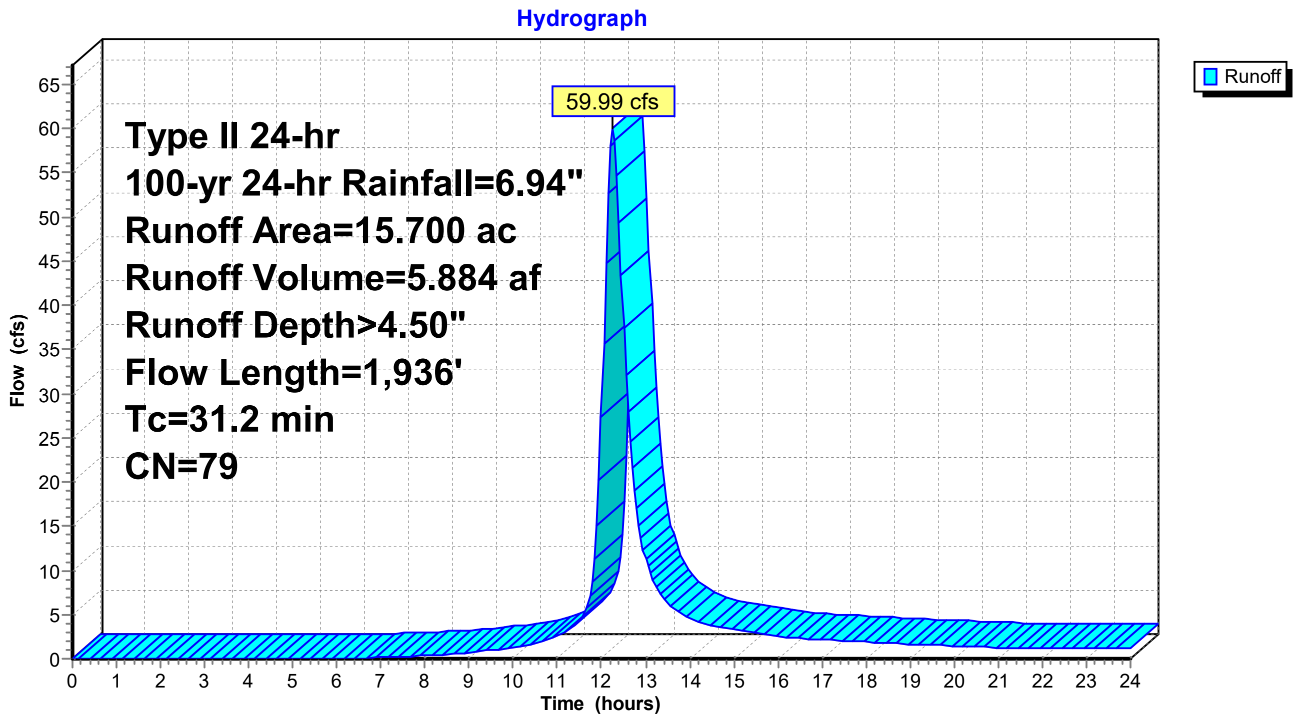
Runoff = 59.99 cfs @ 12.25 hrs, Volume= 5.884 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
15.700	79	50-75% Grass cover, Fair, HSG C
15.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	158	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.7	1,370	0.0060	4.90	58.75	**Trap/Vee/Rect Channel Flow, TB-2** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
31.2	1,936	Total			

Subcatchment 2S: NW-2



Summary for Subcatchment 3S: NE-1

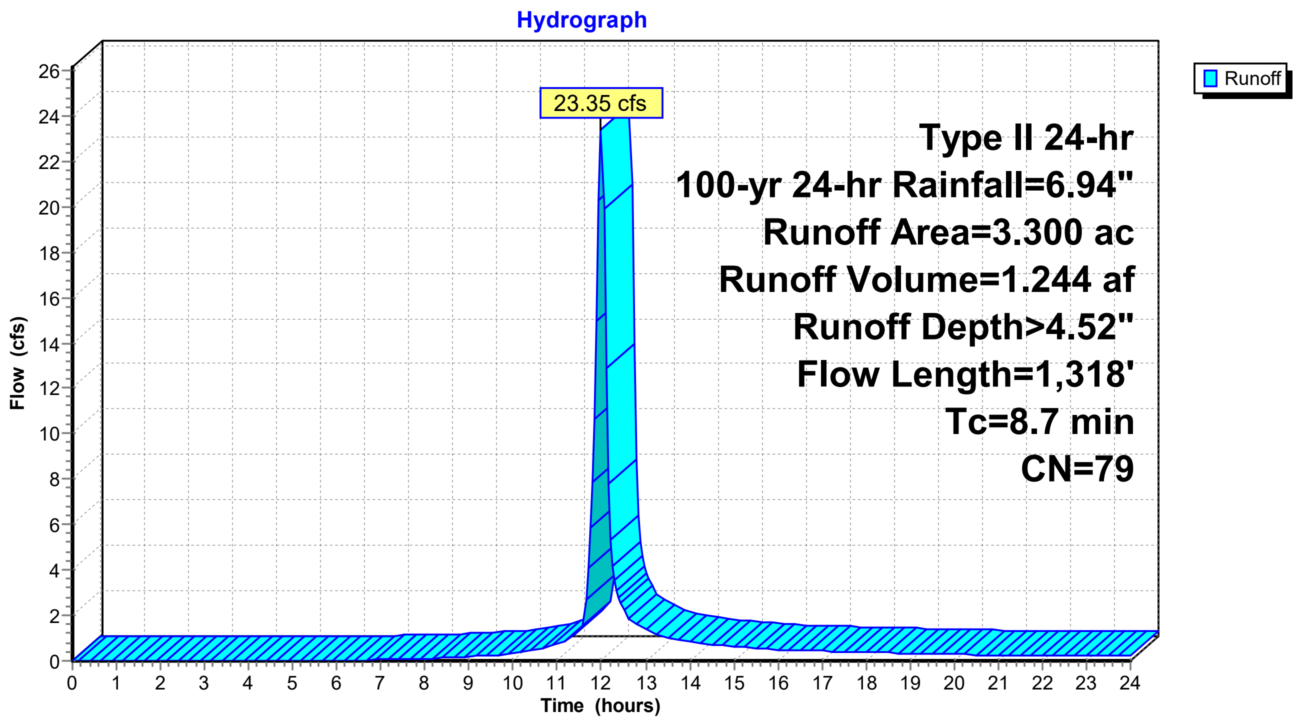
Runoff = 23.35 cfs @ 12.00 hrs, Volume= 1.244 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
3.300	79	50-75% Grass cover, Fair, HSG C
3.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
4.9	1,210	0.0050	4.09	57.30	**Trap/Vee/Rect Channel Flow, TB-3** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
8.7	1,318	Total			

Subcatchment 3S: NE-1



Summary for Subcatchment 4S: NE-2

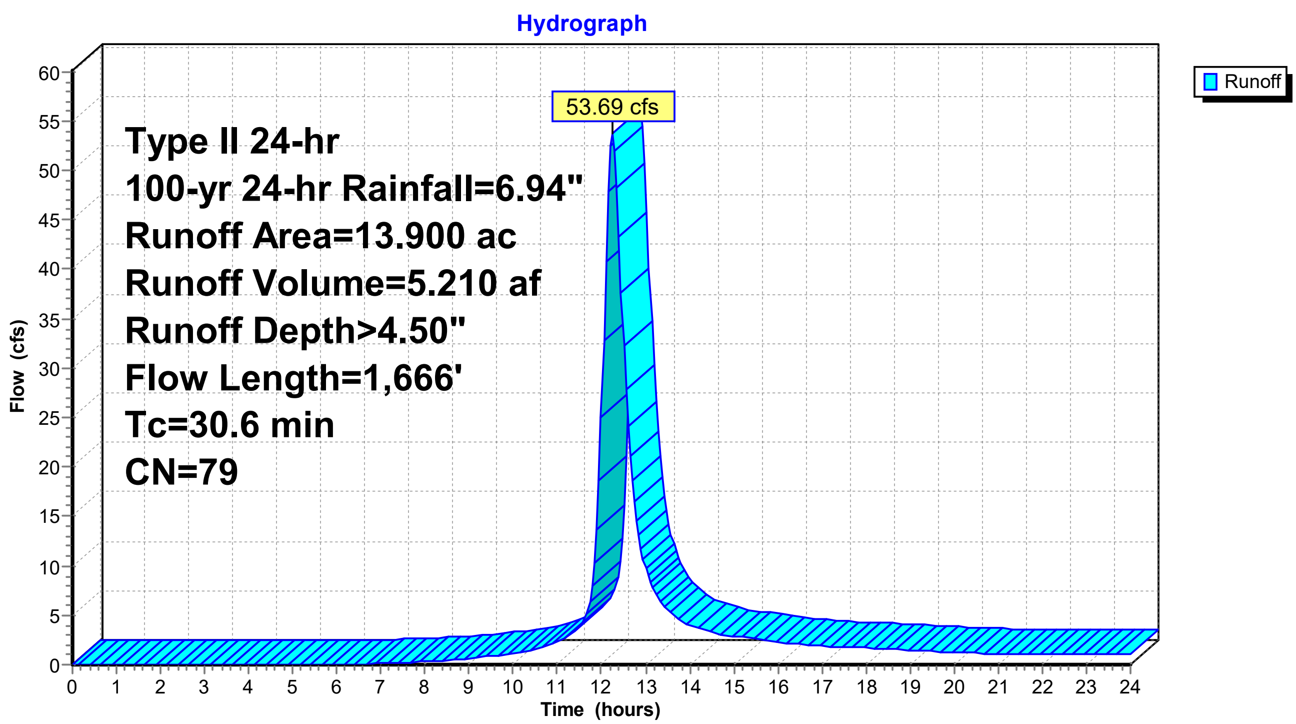
Runoff = 53.69 cfs @ 12.25 hrs, Volume= 5.210 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
13.900	79	50-75% Grass cover, Fair, HSG C
13.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	158	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
4.1	1,100	0.0050	4.47	53.63	**Trap/Vee/Rect Channel Flow, TB-4** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
30.6	1,666	Total			

Subcatchment 4S: NE-2



Summary for Subcatchment 5S: E-1

[49] Hint: Tc<2dt may require smaller dt

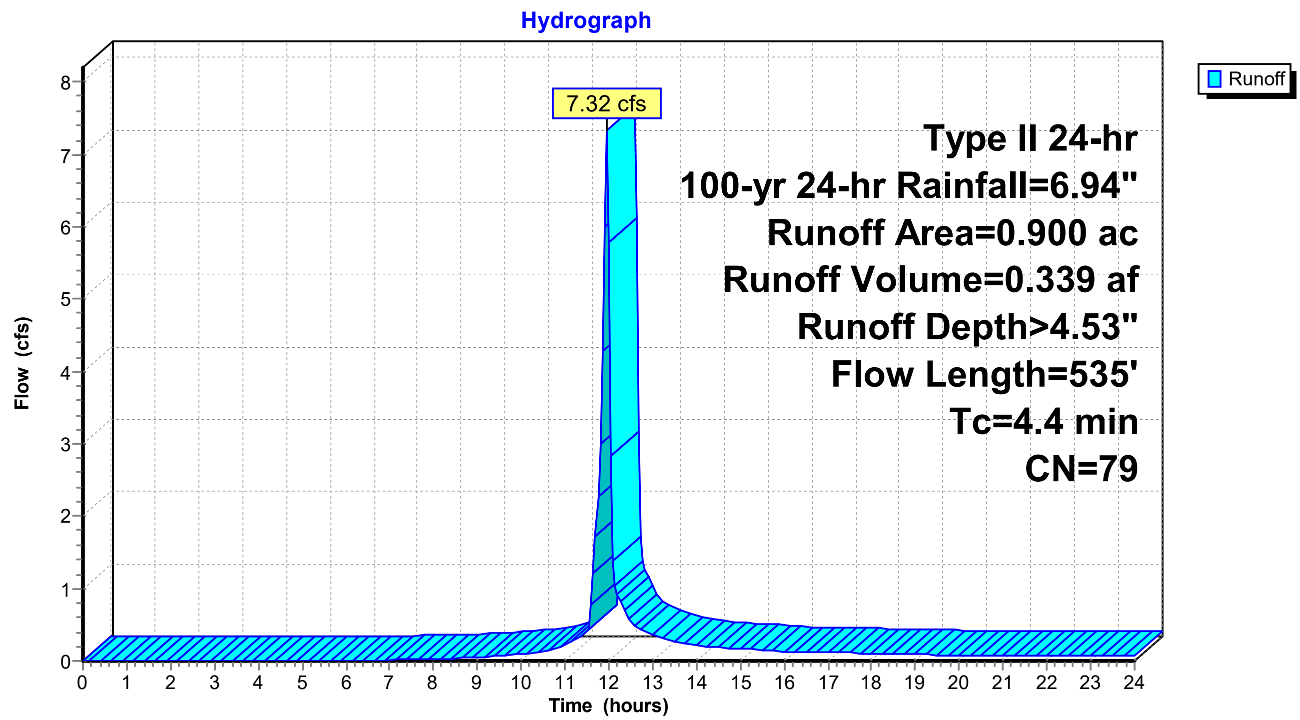
Runoff = 7.32 cfs @ 11.95 hrs, Volume= 0.339 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.900	79	50-75% Grass cover, Fair, HSG C
0.900		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.47		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.9	435	0.0180	7.77	108.71	**Trap/Vee/Rect Channel Flow, TB-7** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.4	535	Total			

Subcatchment 5S: E-1



Summary for Subcatchment 6S: E-2

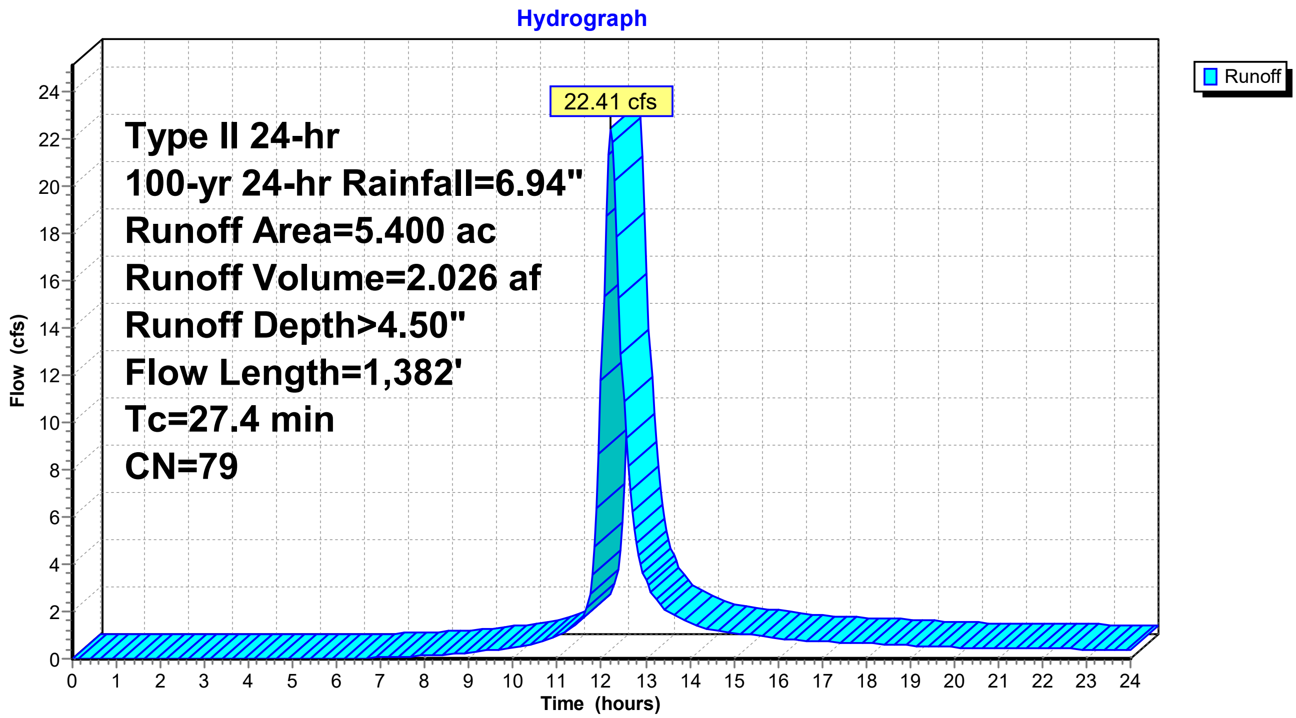
Runoff = 22.41 cfs @ 12.21 hrs, Volume= 2.026 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
5.400	79	50-75% Grass cover, Fair, HSG C
5.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.5	270	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
3.7	222	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.8	175	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.4	715	0.0180	8.48	101.76	**Trap/Vee/Rect Channel Flow, TB-6** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
27.4	1,382	Total			

Subcatchment 6S: E-2



Summary for Subcatchment 7S: E-3

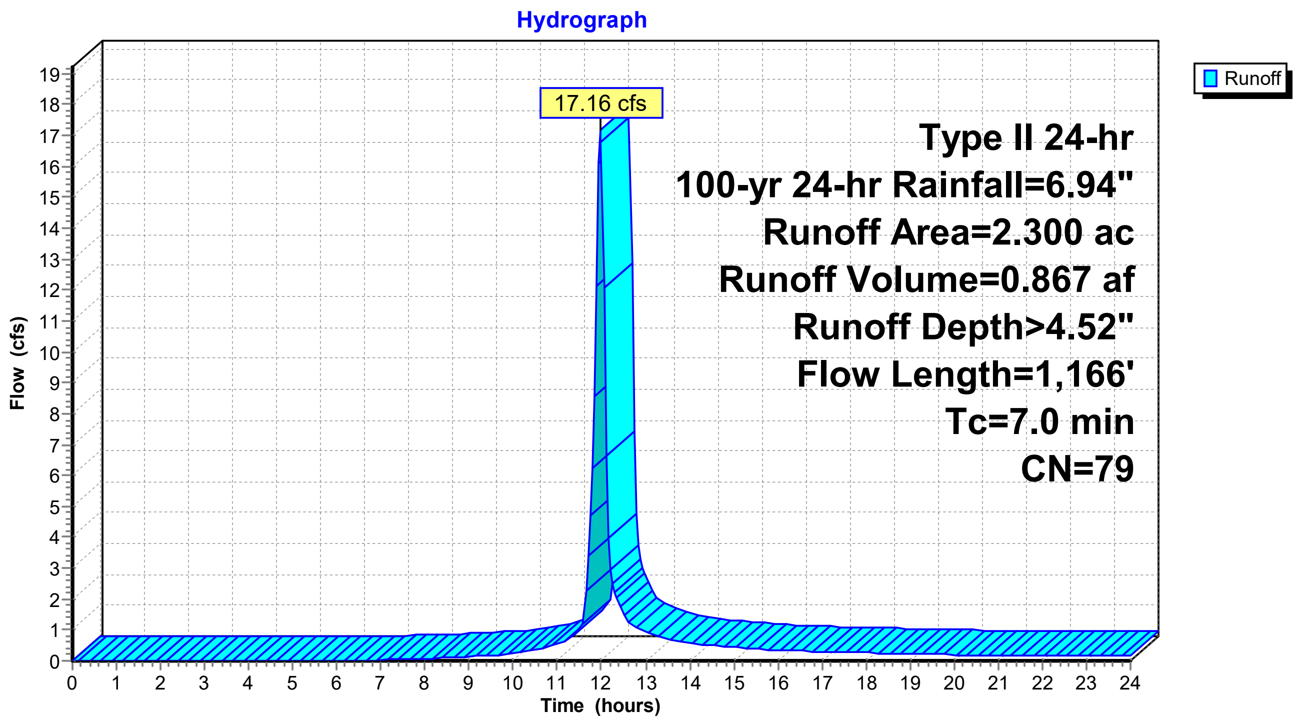
Runoff = 17.16 cfs @ 11.98 hrs, Volume= 0.867 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
2.300	79	50-75% Grass cover, Fair, HSG C
2.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.0	116	0.2500	0.49		**Sheet Flow,** Range n= 0.130 P2= 2.60"
3.0	1,050	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-8** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
7.0	1,166	Total			

Subcatchment 7S: E-3



Summary for Subcatchment 8S: E-4

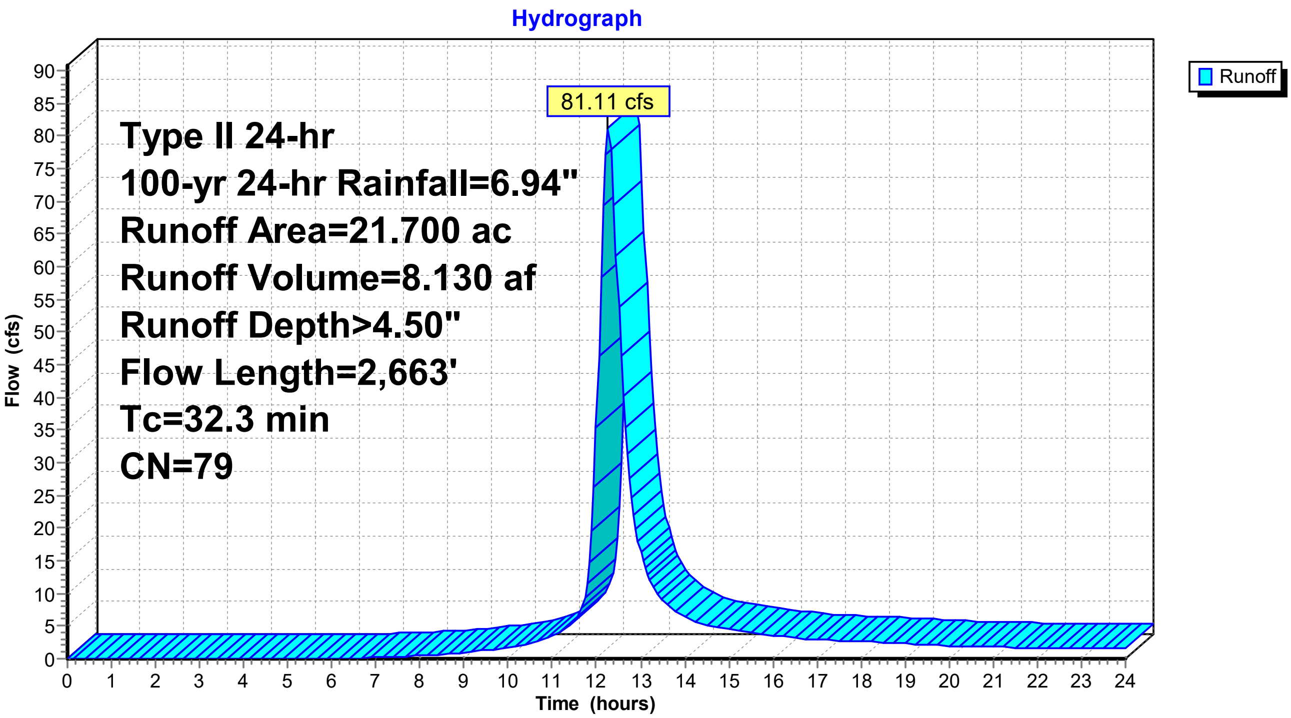
Runoff = 81.11 cfs @ 12.27 hrs, Volume= 8.130 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
21.700	79	50-75% Grass cover, Fair, HSG C
21.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	170	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	153	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
5.4	2,040	0.0100	6.32	75.84	**Trap/Vee/Rect Channel Flow, TB-9 and TB-12** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
32.3	2,663	Total			

Subcatchment 8S: E-4



Summary for Subcatchment 9S: NE-3

[49] Hint: Tc<2dt may require smaller dt

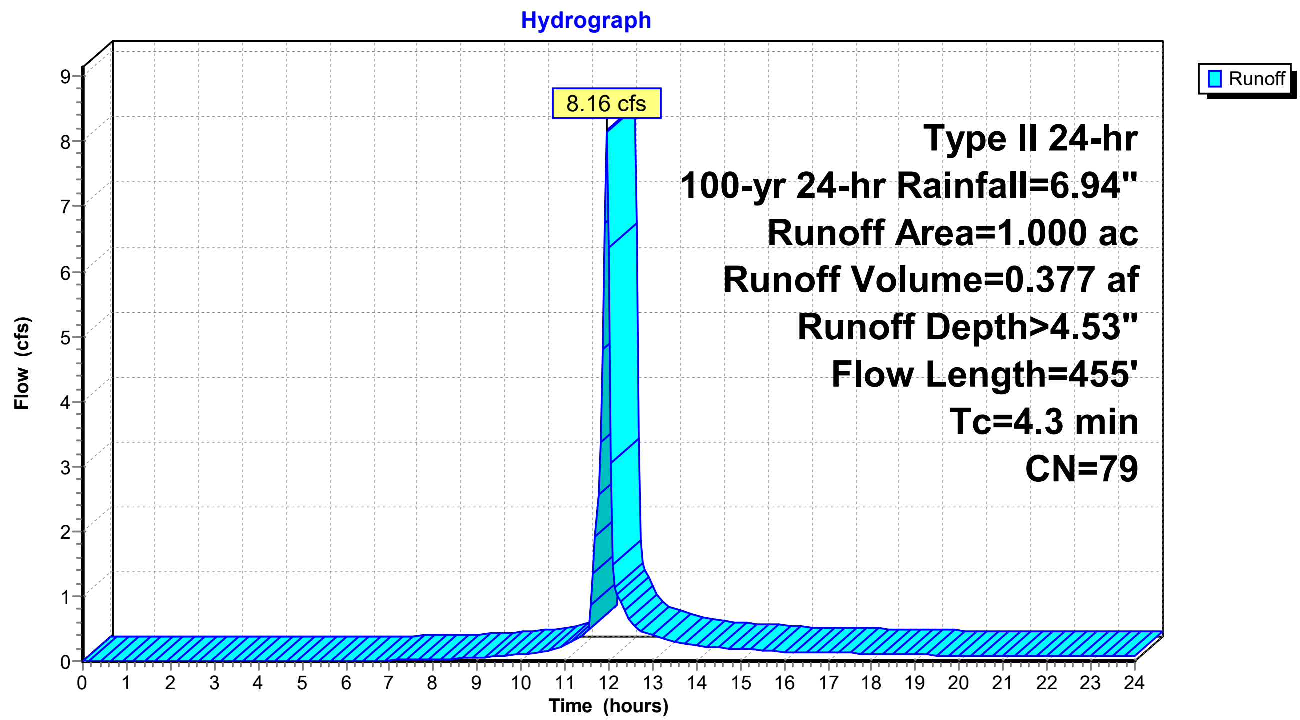
Runoff = 8.16 cfs @ 11.95 hrs, Volume= 0.377 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
1.000	79	50-75% Grass cover, Fair, HSG C
1.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.5	100	0.2500	0.47		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.8	355	0.0180	7.77	108.71	**Trap/Vee/Rect Channel Flow, TB-5** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.3	455	Total			

Subcatchment 9S: NE-3



Summary for Subcatchment 10S: SE-1

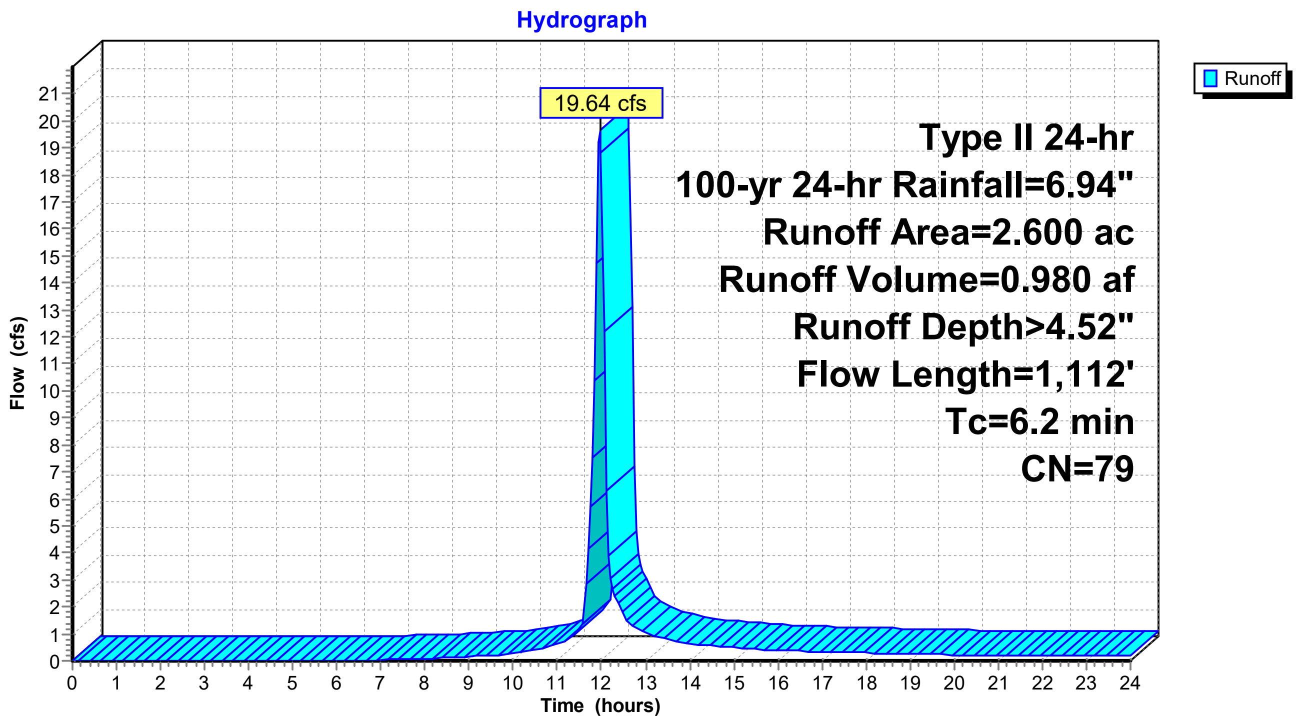
Runoff = 19.64 cfs @ 11.97 hrs, Volume= 0.980 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
2.600	79	50-75% Grass cover, Fair, HSG C
2.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	92	0.2500	0.46		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	1,020	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-11** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
6.2	1,112	Total			

Subcatchment 10S: SE-1



Summary for Subcatchment 11S: SW-1

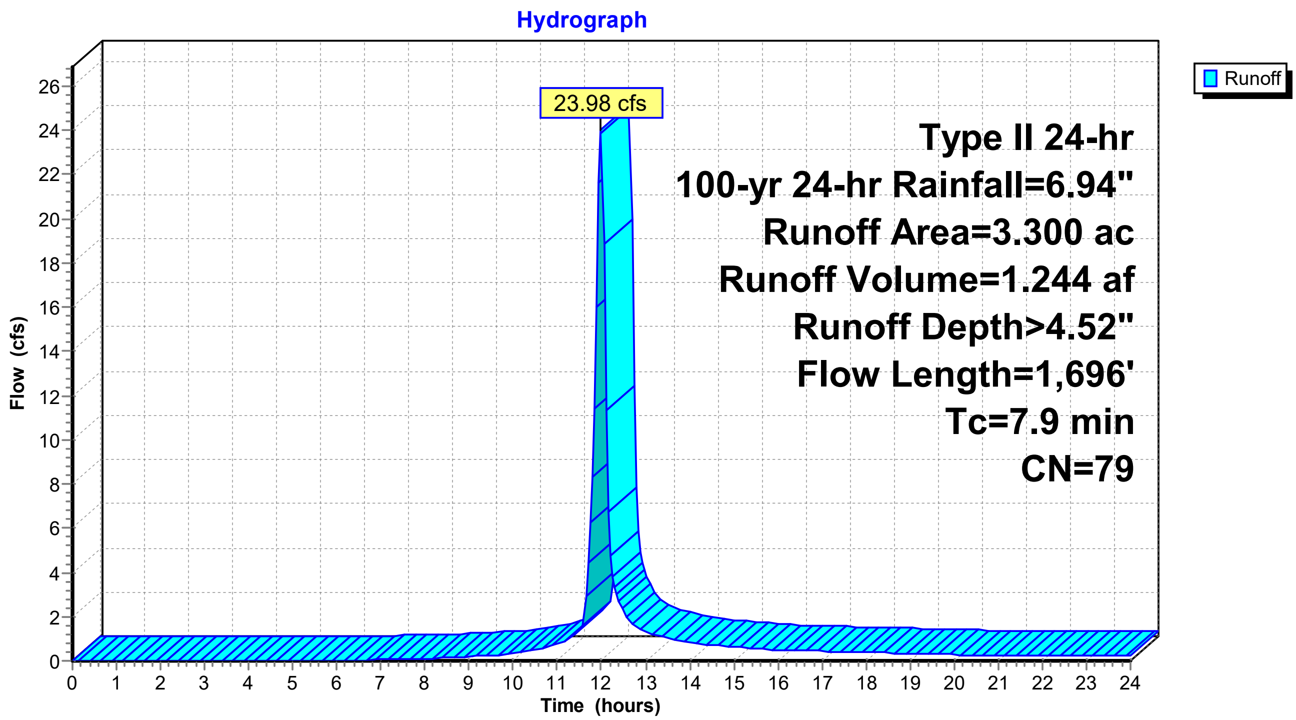
Runoff = 23.98 cfs @ 11.99 hrs, Volume= 1.244 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
3.300	79	50-75% Grass cover, Fair, HSG C
3.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.3	92	0.2500	0.46		**Sheet Flow,** Range n= 0.130 P2= 2.60"
4.6	1,604	0.0100	5.79	81.03	**Trap/Vee/Rect Channel Flow, TB-13** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
7.9	1,696	Total			

Subcatchment 11S: SW-1



Summary for Subcatchment 14S: W-3

[49] Hint: Tc<2dt may require smaller dt

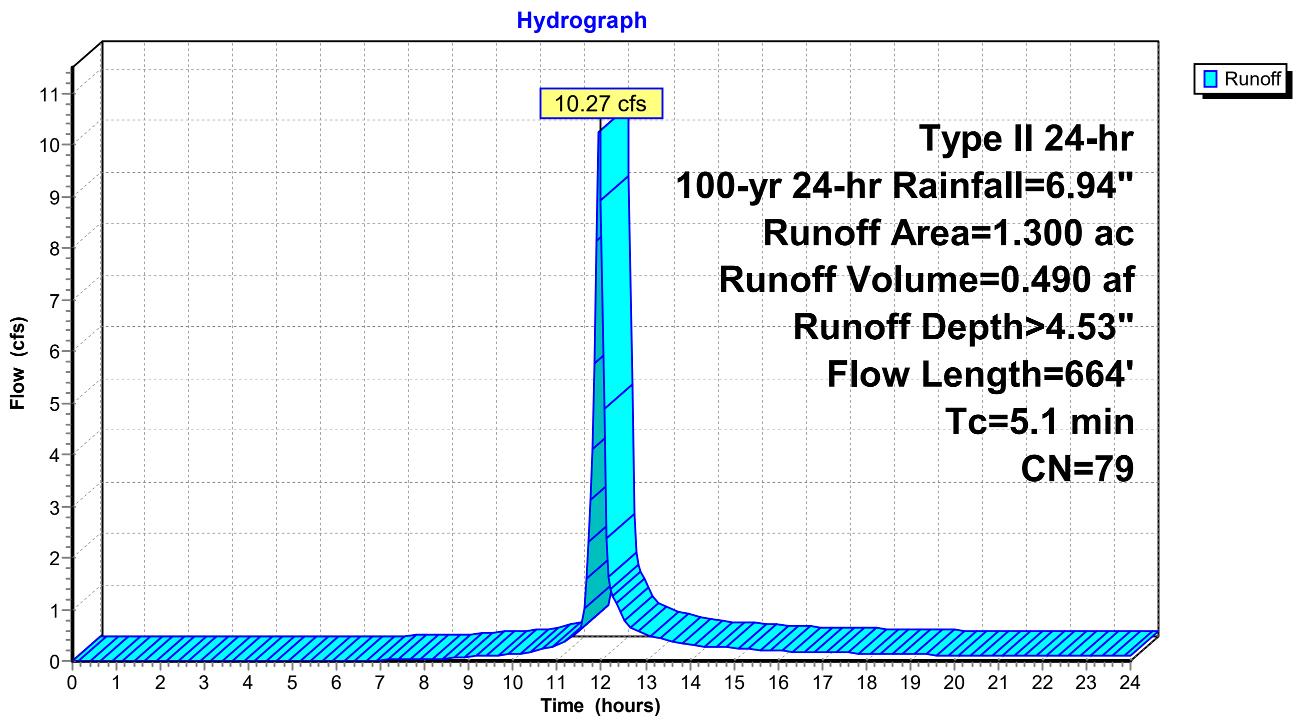
Runoff = 10.27 cfs @ 11.96 hrs, Volume= 0.490 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
1.300	79	50-75% Grass cover, Fair, HSG C
1.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	106	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
1.4	558	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-19** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
5.1	664	Total			

Subcatchment 14S: W-3



Summary for Subcatchment 15S: SW-2

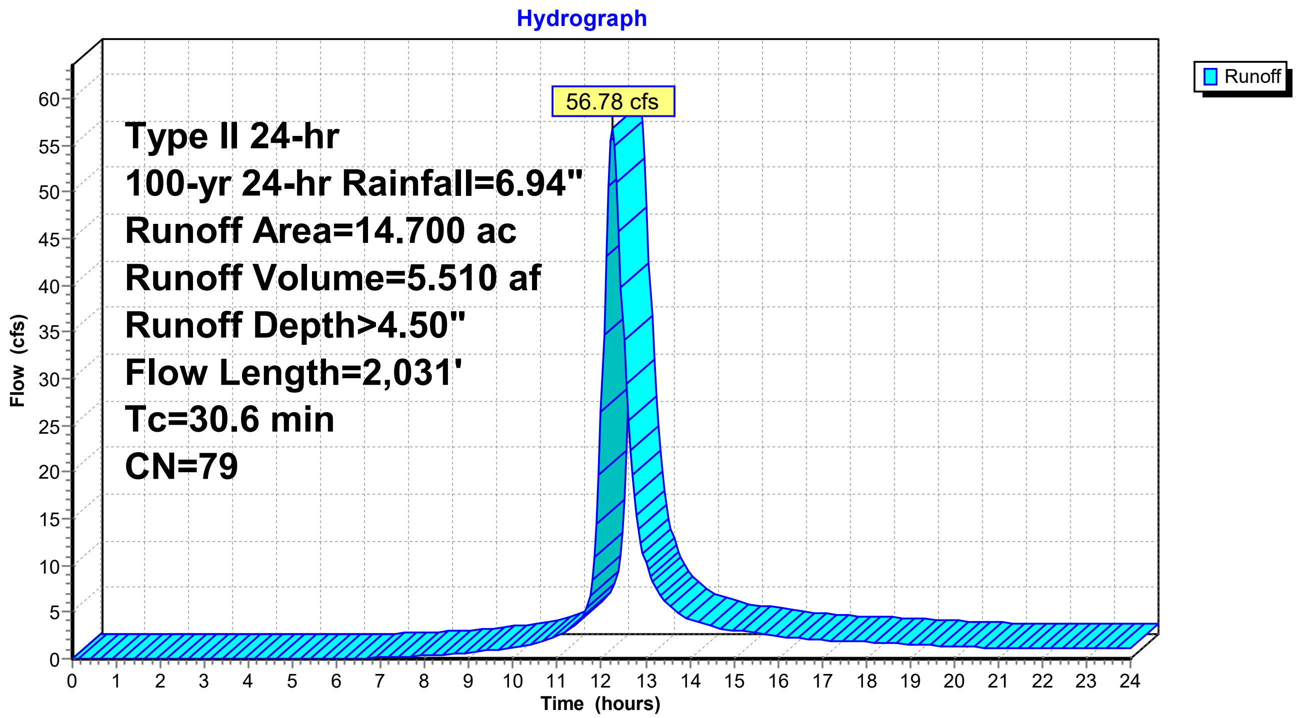
Runoff = 56.78 cfs @ 12.25 hrs, Volume= 5.510 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
14.700	79	50-75% Grass cover, Fair, HSG C
14.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.9	170	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	153	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.7	1,408	0.0100	6.32	75.84	**Trap/Vee/Rect Channel Flow, TB-14** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
30.6	2,031	Total			

Subcatchment 15S: SW-2



Summary for Subcatchment 22S: W-1

[49] Hint: Tc<2dt may require smaller dt

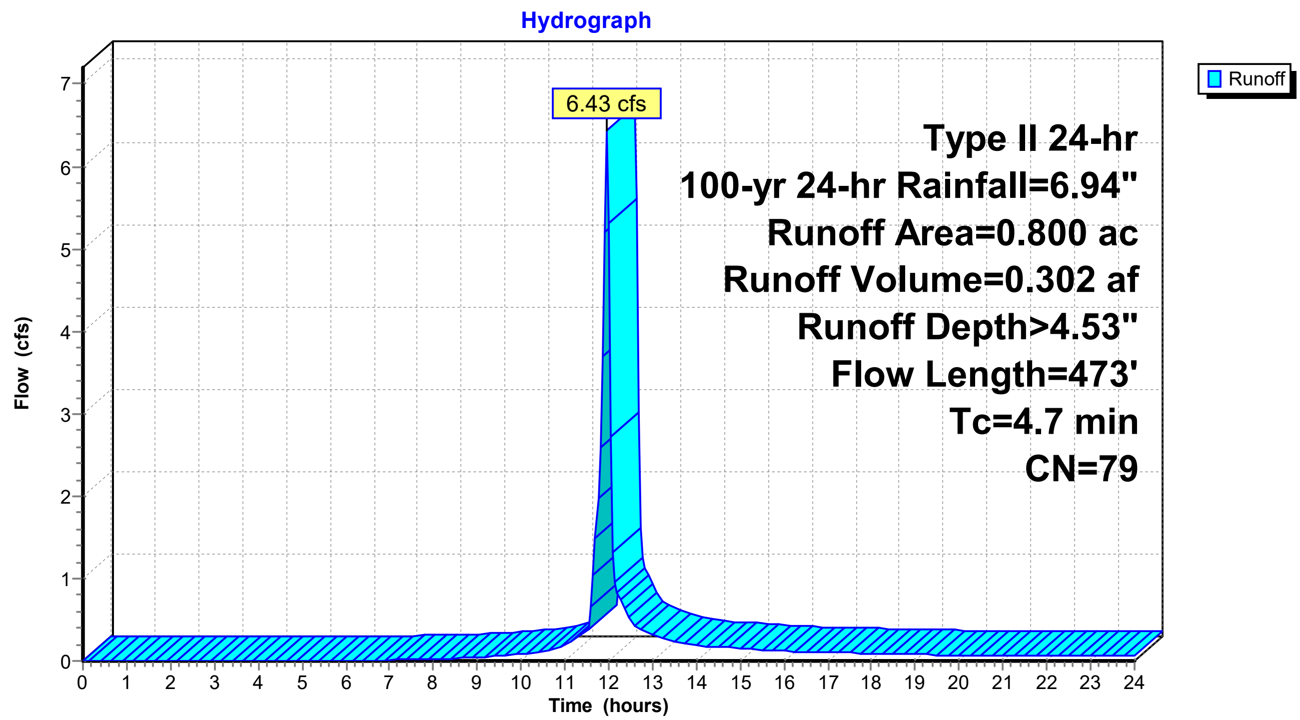
Runoff = 6.43 cfs @ 11.95 hrs, Volume= 0.302 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.800	79	50-75% Grass cover, Fair, HSG C
0.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.9	365	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-17** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.7	473	Total			

Subcatchment 22S: W-1



Summary for Subcatchment 23S: SW-3

[49] Hint: Tc<2dt may require smaller dt

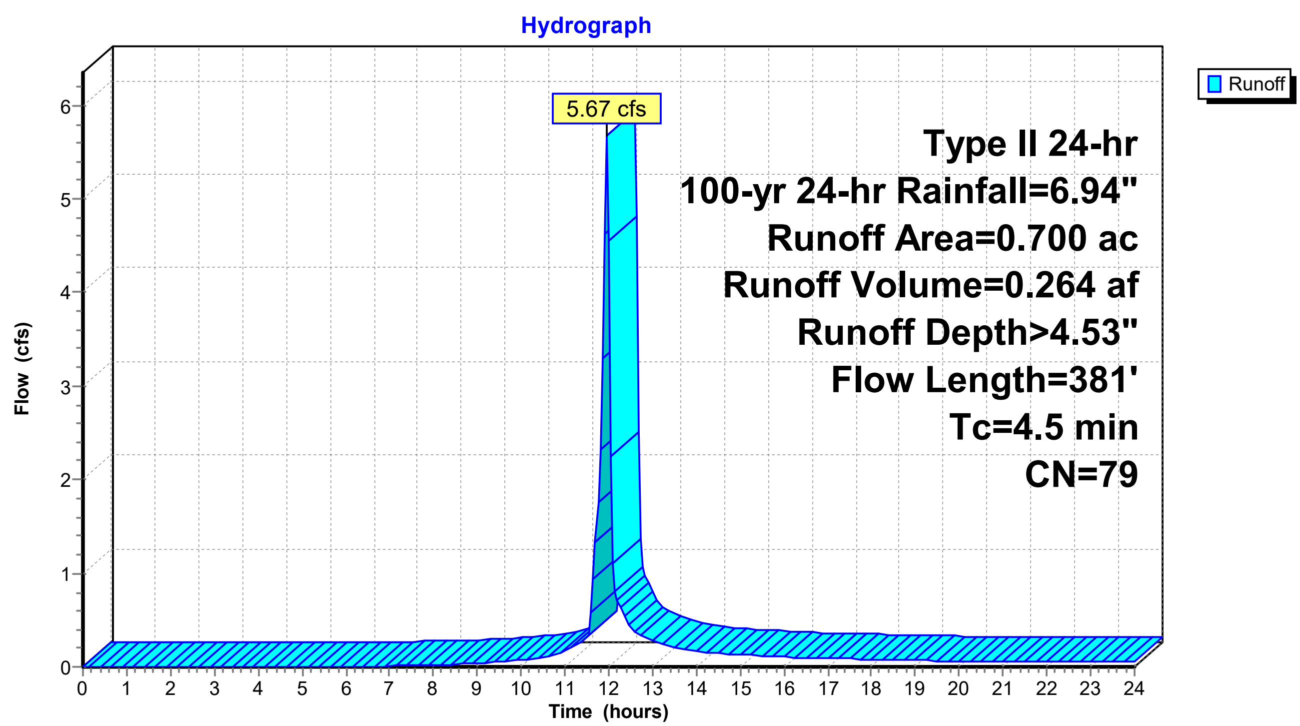
Runoff = 5.67 cfs @ 11.95 hrs, Volume= 0.264 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.700	79	50-75% Grass cover, Fair, HSG C
0.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	108	0.2500	0.48		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.7	273	0.0140	6.85	95.87	**Trap/Vee/Rect Channel Flow, TB-15** Bot.W=0.00' D=2.00' Z= 3.0 & 4.0 '/' Top.W=14.00' n= 0.025
4.5	381	Total			

Subcatchment 23S: SW-3



Summary for Subcatchment 25S: W-2

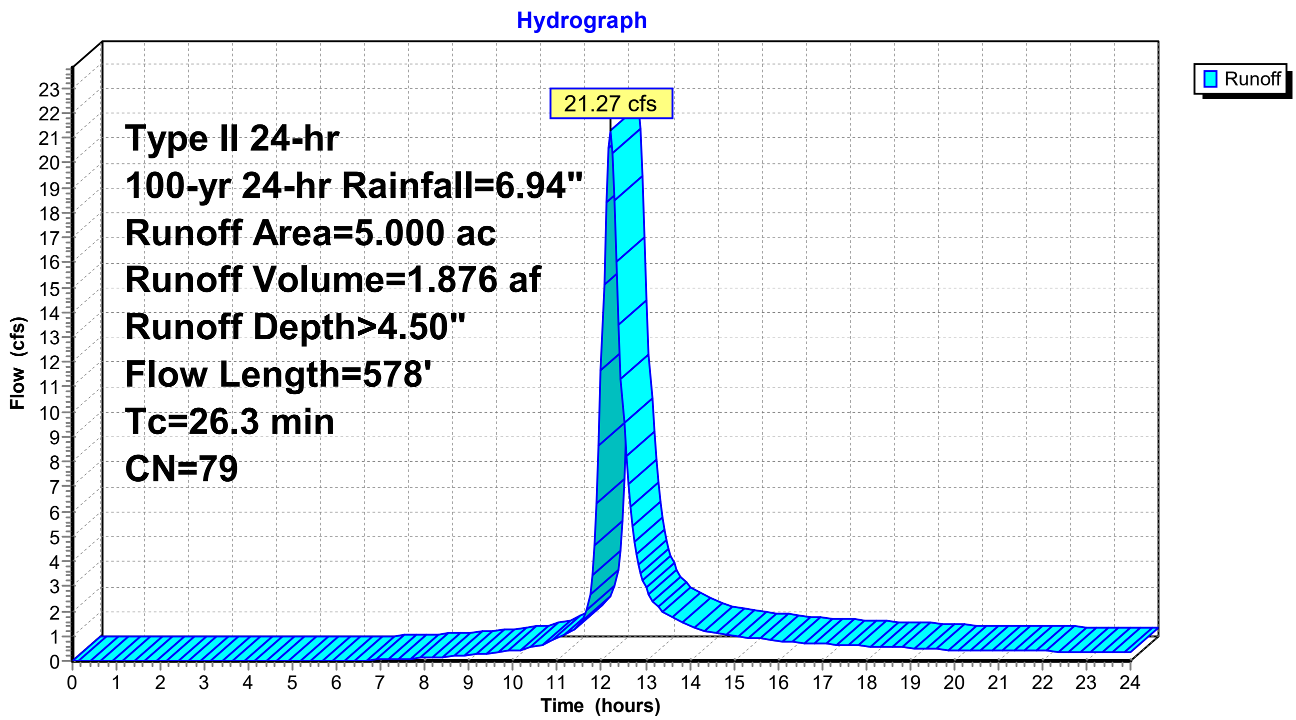
Runoff = 21.27 cfs @ 12.20 hrs, Volume= 1.876 af, Depth> 4.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
5.000	79	50-75% Grass cover, Fair, HSG C
5.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
23.3	300	0.0200	0.21		**Sheet Flow,** Range n= 0.130 P2= 2.60"
2.7	160	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.3	118	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-18** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
26.3	578	Total			

Subcatchment 25S: W-2



Summary for Subcatchment 26S: W-4

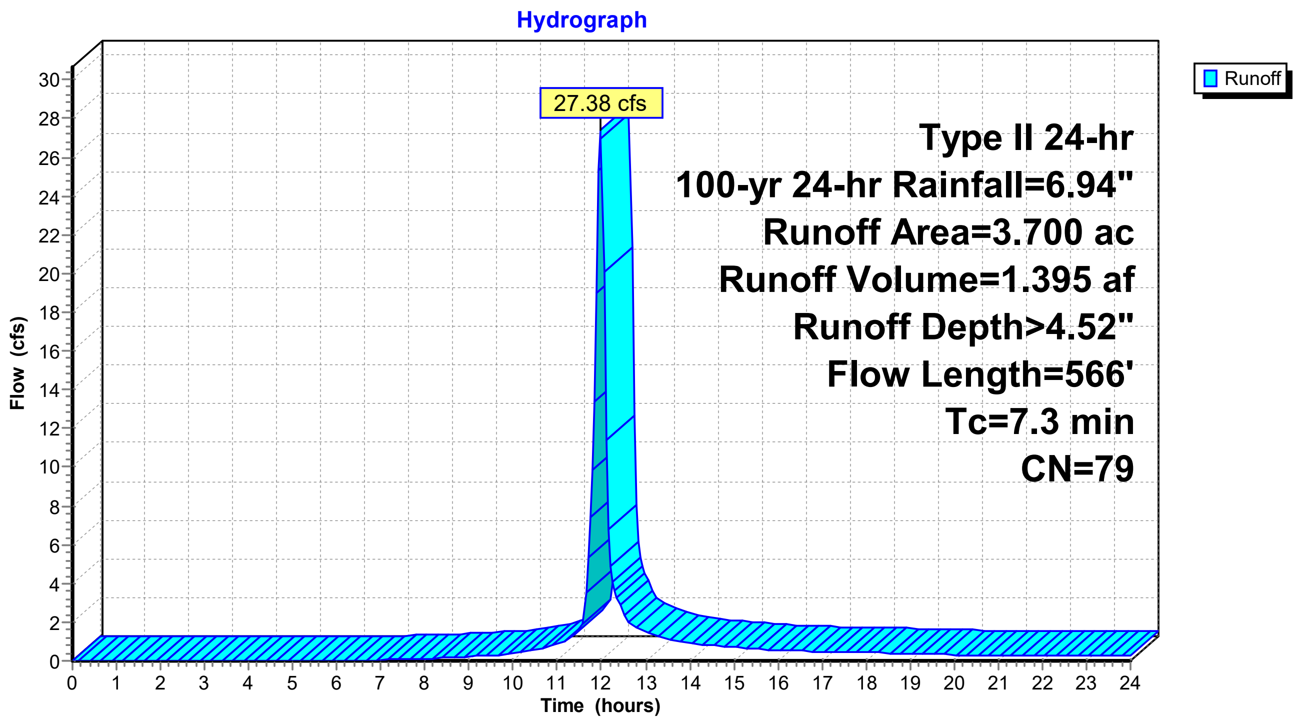
Runoff = 27.38 cfs @ 11.98 hrs, Volume= 1.395 af, Depth> 4.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
3.700	79	50-75% Grass cover, Fair, HSG C
3.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.5	214	0.2500	0.55		**Sheet Flow,** Range n= 0.130 P2= 2.60"
0.8	352	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-19** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
7.3	566	Total			

Subcatchment 26S: W-4



Summary for Subcatchment 32S: SW-4

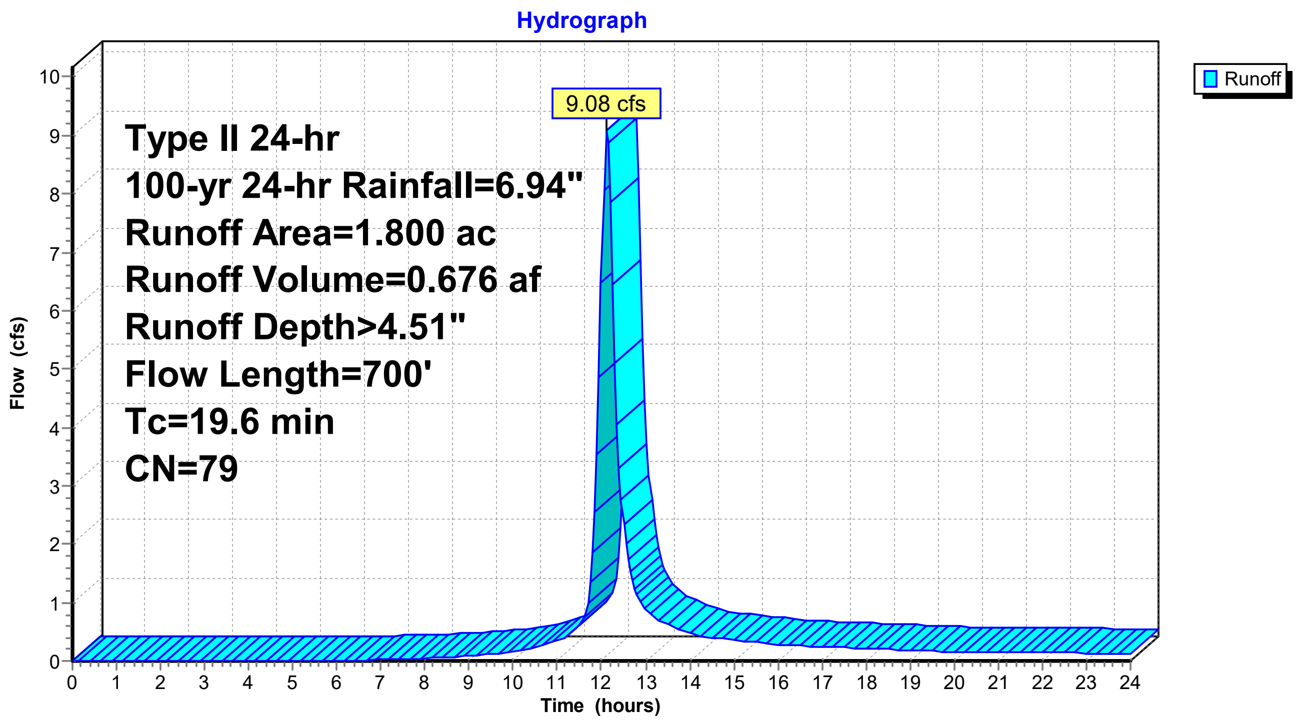
Runoff = 9.08 cfs @ 12.12 hrs, Volume= 0.676 af, Depth> 4.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
1.800	79	50-75% Grass cover, Fair, HSG C
1.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.0	216	0.0200	0.20		**Sheet Flow,** Range n= 0.130 P2= 2.60"
1.0	208	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	276	0.0140	7.48	89.74	**Trap/Vee/Rect Channel Flow, TB-16** Bot.W=2.00' D=2.00' Z= 2.0 '/' Top.W=10.00' n= 0.025
19.6	700	Total			

Subcatchment 32S: SW-4



Summary for Subcatchment 35S: Toe -1

[49] Hint: Tc<2dt may require smaller dt

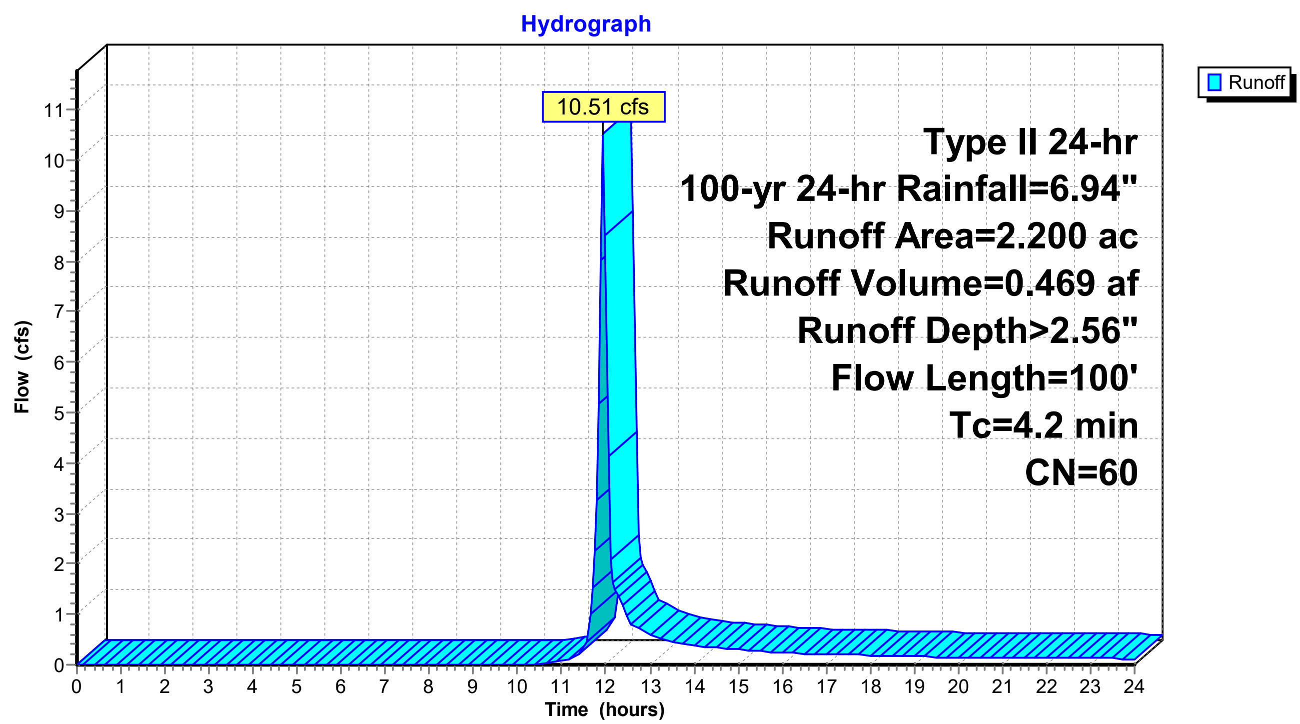
Runoff = 10.51 cfs @ 11.95 hrs, Volume= 0.469 af, Depth> 2.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.300	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
1.600	49	50-75% Grass cover, Fair, HSG A
2.200	60	Weighted Average
2.200		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	20	0.2500	0.31		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
4.2	100	Total			

Subcatchment 35S: Toe -1



Summary for Subcatchment 36S: Toe -2

[49] Hint: Tc<2dt may require smaller dt

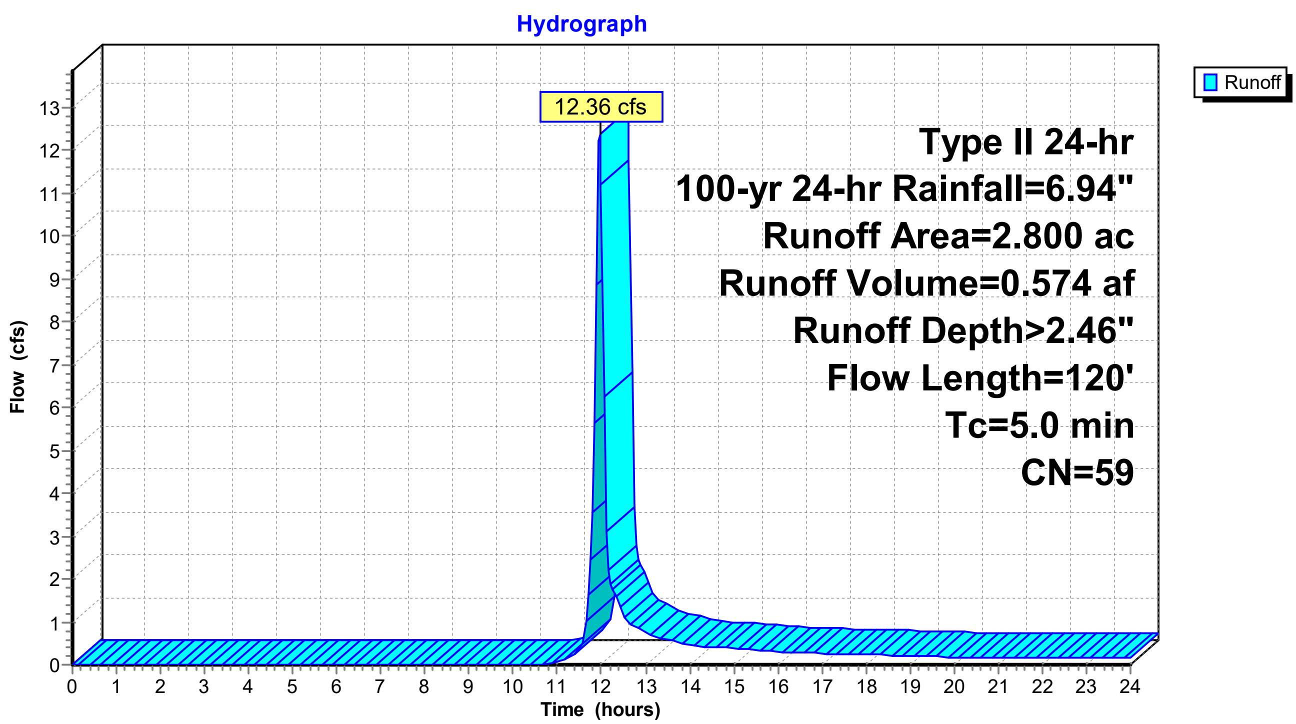
Runoff = 12.36 cfs @ 11.96 hrs, Volume= 0.574 af, Depth> 2.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.500	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
2.000	49	50-75% Grass cover, Fair, HSG A
2.800	59	Weighted Average
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			

Subcatchment 36S: Toe -2



Summary for Subcatchment 37S: Toe -3

[49] Hint: Tc<2dt may require smaller dt

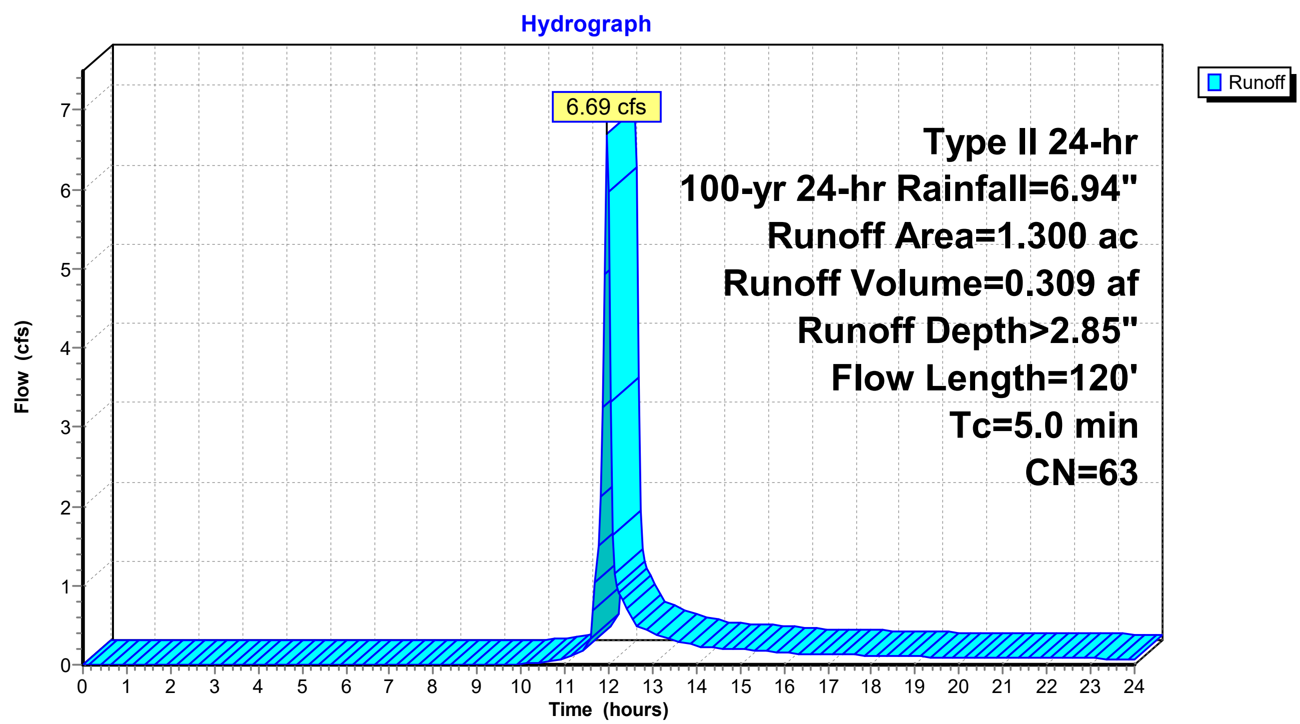
Runoff = 6.69 cfs @ 11.96 hrs, Volume= 0.309 af, Depth> 2.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.300	79	50-75% Grass cover, Fair, HSG C
0.200	96	Gravel surface, HSG A
0.800	49	50-75% Grass cover, Fair, HSG A
1.300	63	Weighted Average
1.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			

Subcatchment 37S: Toe -3



Summary for Subcatchment 38S: Toe -4

[49] Hint: Tc<2dt may require smaller dt

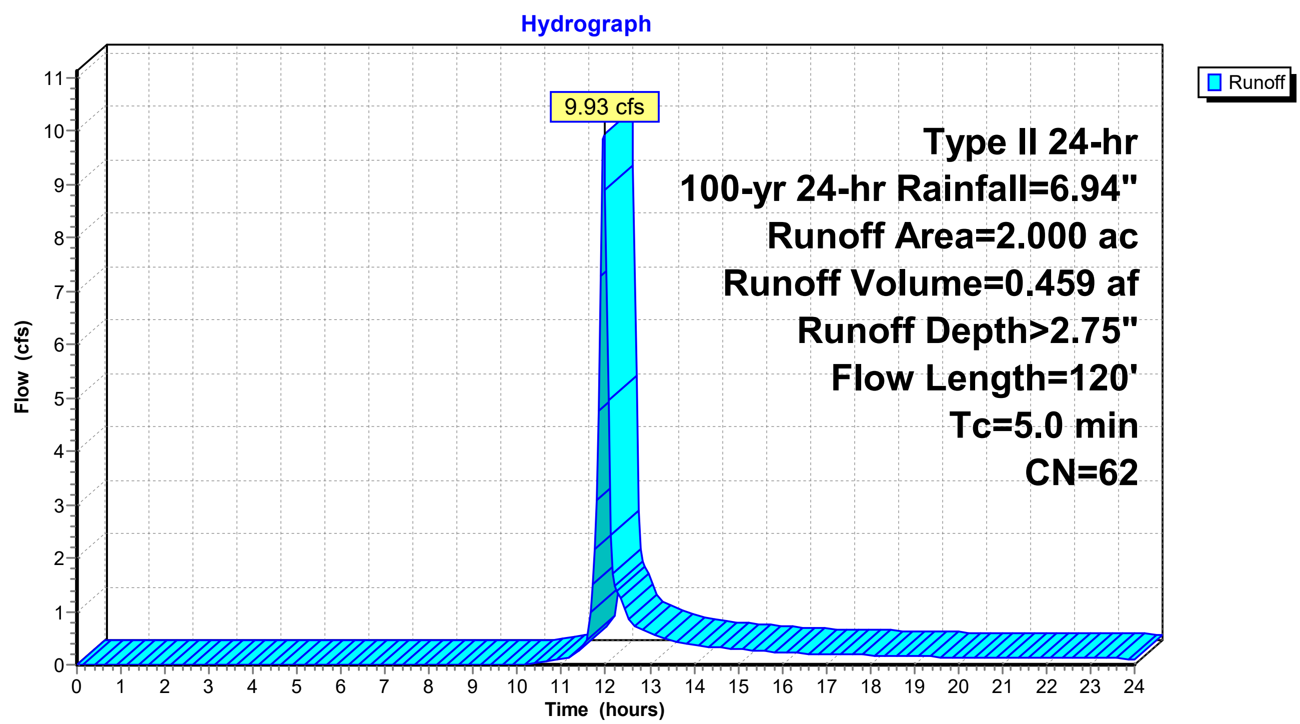
Runoff = 9.93 cfs @ 11.96 hrs, Volume= 0.459 af, Depth> 2.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.400	79	50-75% Grass cover, Fair, HSG C
0.300	96	Gravel surface, HSG A
1.300	49	50-75% Grass cover, Fair, HSG A
2.000	62	Weighted Average
2.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.9	40	0.2500	0.35		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
5.0	120	Total			

Subcatchment 38S: Toe -4



Summary for Subcatchment 39S: Toe -5

[49] Hint: Tc<2dt may require smaller dt

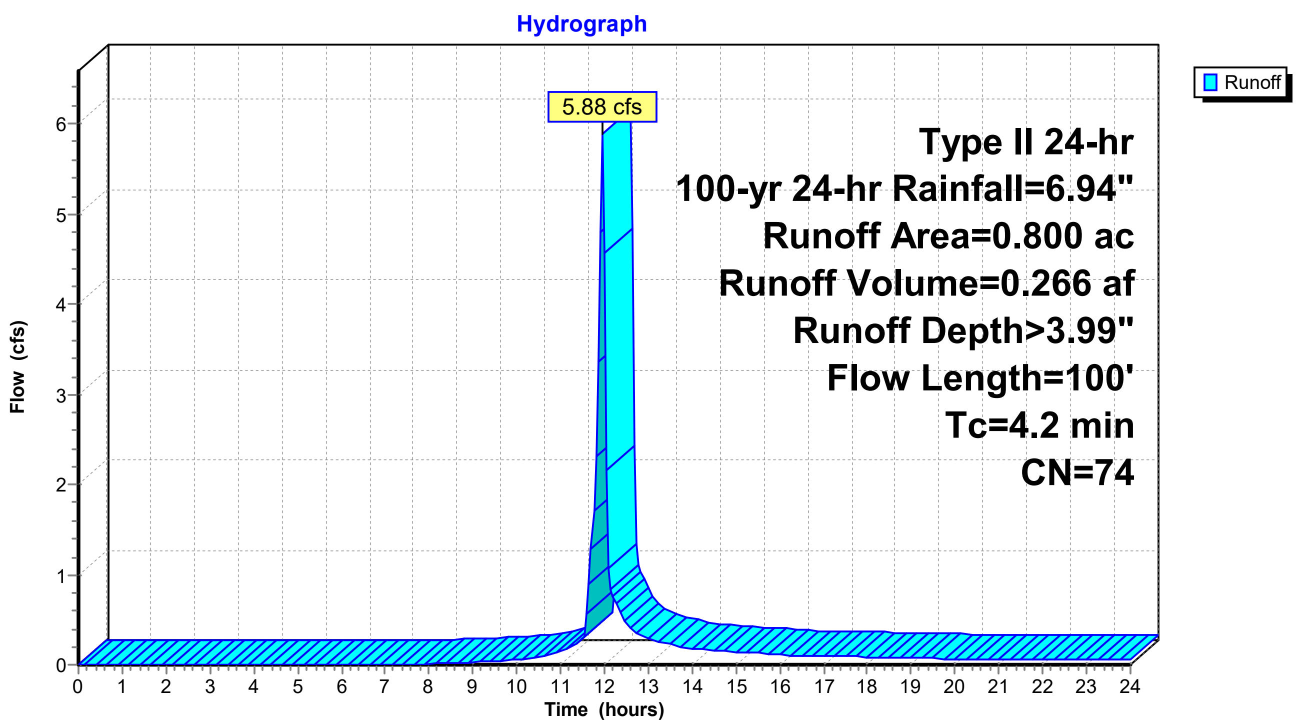
Runoff = 5.88 cfs @ 11.95 hrs, Volume= 0.266 af, Depth> 3.99"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr 24-hr Rainfall=6.94"

Area (ac)	CN	Description
0.500	79	50-75% Grass cover, Fair, HSG C
0.100	96	Gravel surface, HSG A
0.200	49	50-75% Grass cover, Fair, HSG A
0.800	74	Weighted Average
0.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.1	20	0.2500	0.31		**Sheet Flow, Landfill Toe** Grass: Short n= 0.150 P2= 2.60"
0.5	20	0.0100	0.68		**Sheet Flow, Road** Smooth surfaces n= 0.011 P2= 2.60"
2.6	60	0.2500	0.38		**Sheet Flow, Ditch Area** Grass: Short n= 0.150 P2= 2.60"
4.2	100	Total			

Subcatchment 39S: Toe -5



Summary for Reach 1R: Cell 1 DC

Inflow Area = 19.500 ac, 0.00% Impervious, Inflow Depth > 4.50" for 100-yr 24-hr event
Inflow = 65.58 cfs @ 12.23 hrs, Volume= 7.315 af
Outflow = 65.52 cfs @ 12.23 hrs, Volume= 7.314 af, Atten= 0%, Lag= 0.2 min

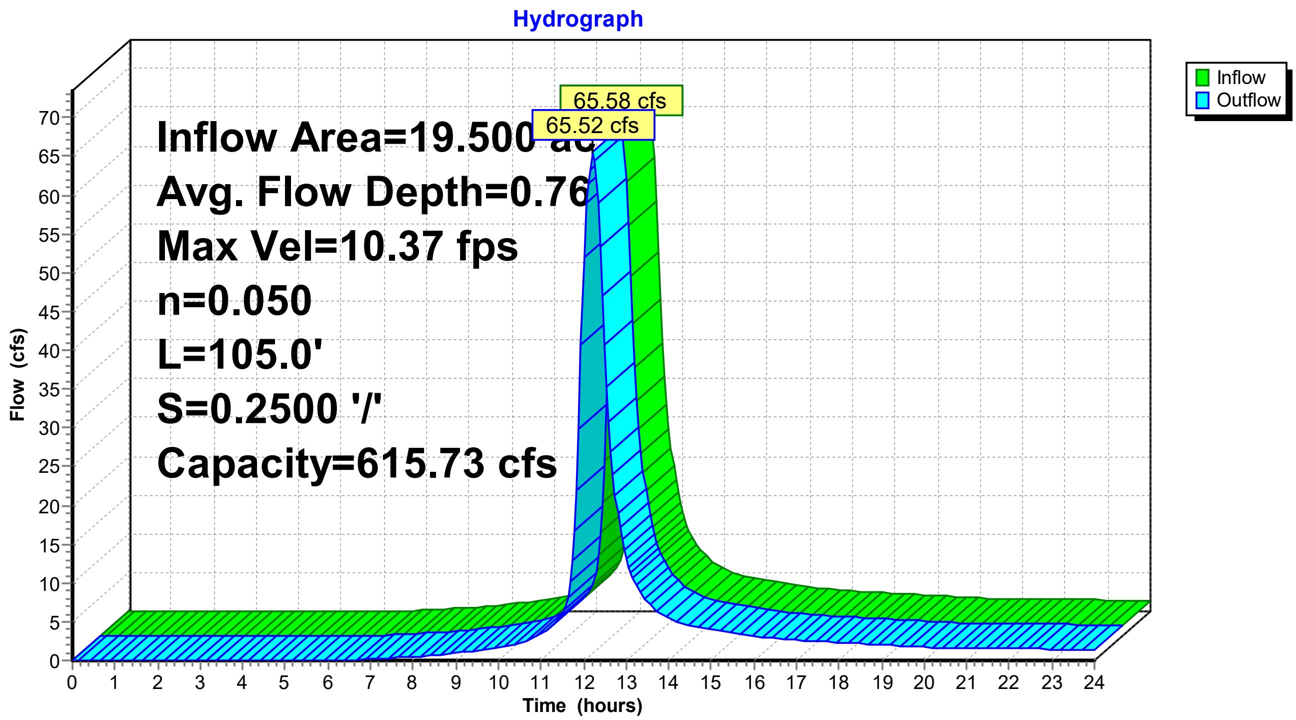
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.37 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 3.48 fps, Avg. Travel Time= 0.5 min

Peak Storage= 663 cf @ 12.23 hrs
Average Depth at Peak Storage= 0.76'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 105.0' Slope= 0.2500 '/'
Inlet Invert= 648.48', Outlet Invert= 622.23'

‡

Reach 1R: Cell 1 DC



Summary for Reach 2R: Cell 2 DC

Inflow Area = 18.200 ac, 0.00% Impervious, Inflow Depth > 4.50" for 100-yr 24-hr event
Inflow = 59.05 cfs @ 12.22 hrs, Volume= 6.831 af
Outflow = 59.02 cfs @ 12.23 hrs, Volume= 6.829 af, Atten= 0%, Lag= 0.4 min

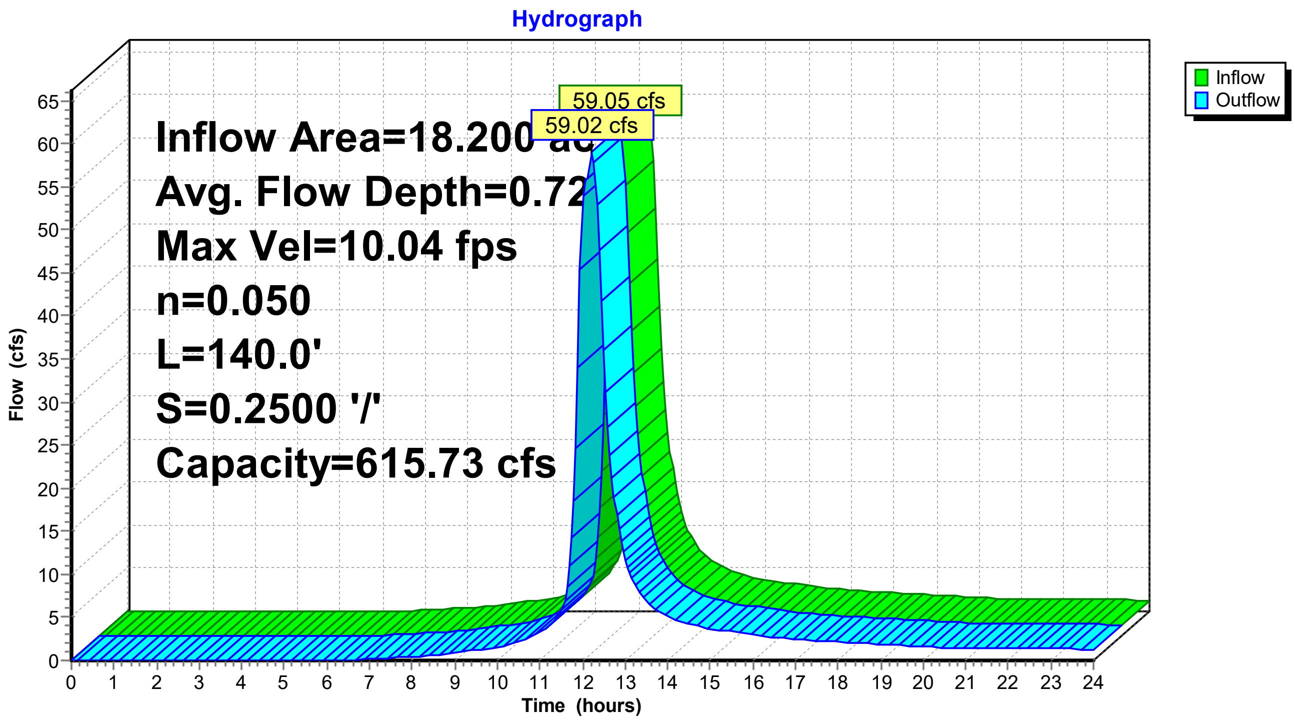
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.04 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 3.39 fps, Avg. Travel Time= 0.7 min

Peak Storage= 823 cf @ 12.23 hrs
Average Depth at Peak Storage= 0.72'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 140.0' Slope= 0.2500 '/'
Inlet Invert= 654.34', Outlet Invert= 619.34'

‡

Reach 2R: Cell 2 DC



Summary for Reach 3R: Cell 3 DC

Inflow Area = 30.300 ac, 0.00% Impervious, Inflow Depth > 4.50" for 100-yr 24-hr event
Inflow = 106.08 cfs @ 12.25 hrs, Volume= 11.362 af
Outflow = 105.98 cfs @ 12.25 hrs, Volume= 11.361 af, Atten= 0%, Lag= 0.2 min

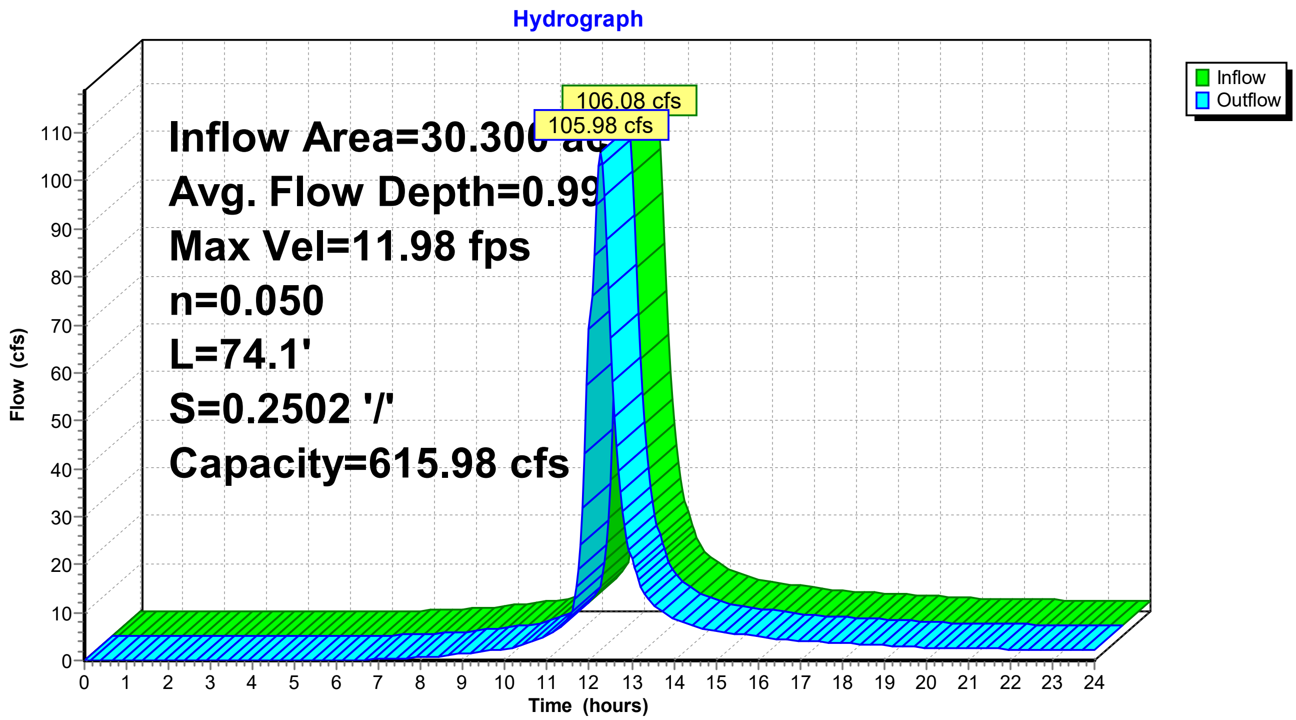
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.98 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.05 fps, Avg. Travel Time= 0.3 min

Peak Storage= 656 cf @ 12.25 hrs
Average Depth at Peak Storage= 0.99'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.98 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 74.1' Slope= 0.2502 '/'
Inlet Invert= 637.53', Outlet Invert= 618.99'

‡

Reach 3R: Cell 3 DC



Summary for Reach 16R: Cell 7 DC

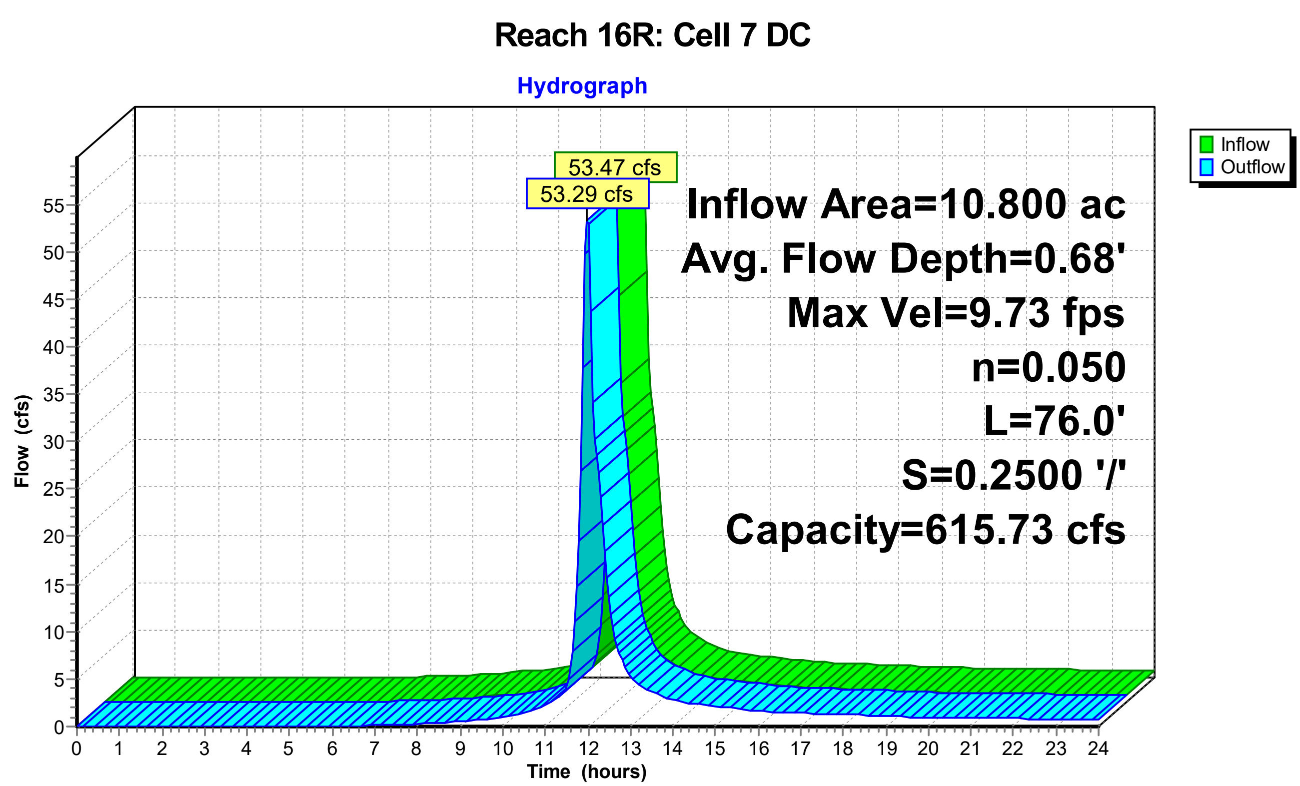
Inflow Area = 10.800 ac, 0.00% Impervious, Inflow Depth > 4.51" for 100-yr 24-hr event
Inflow = 53.47 cfs @ 11.98 hrs, Volume= 4.063 af
Outflow = 53.29 cfs @ 11.99 hrs, Volume= 4.062 af, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.73 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.81 fps, Avg. Travel Time= 0.5 min

Peak Storage= 417 cf @ 11.99 hrs
Average Depth at Peak Storage= 0.68'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 76.0' Slope= 0.2500 '/'
Inlet Invert= 640.00', Outlet Invert= 621.00'

‡



Summary for Reach 17R: SW Drainage Ditch

Inflow Area = 22.500 ac, 0.00% Impervious, Inflow Depth > 4.35" for 100-yr 24-hr event
Inflow = 70.21 cfs @ 12.21 hrs, Volume= 8.152 af
Outflow = 69.70 cfs @ 12.25 hrs, Volume= 8.136 af, Atten= 1%, Lag= 2.4 min

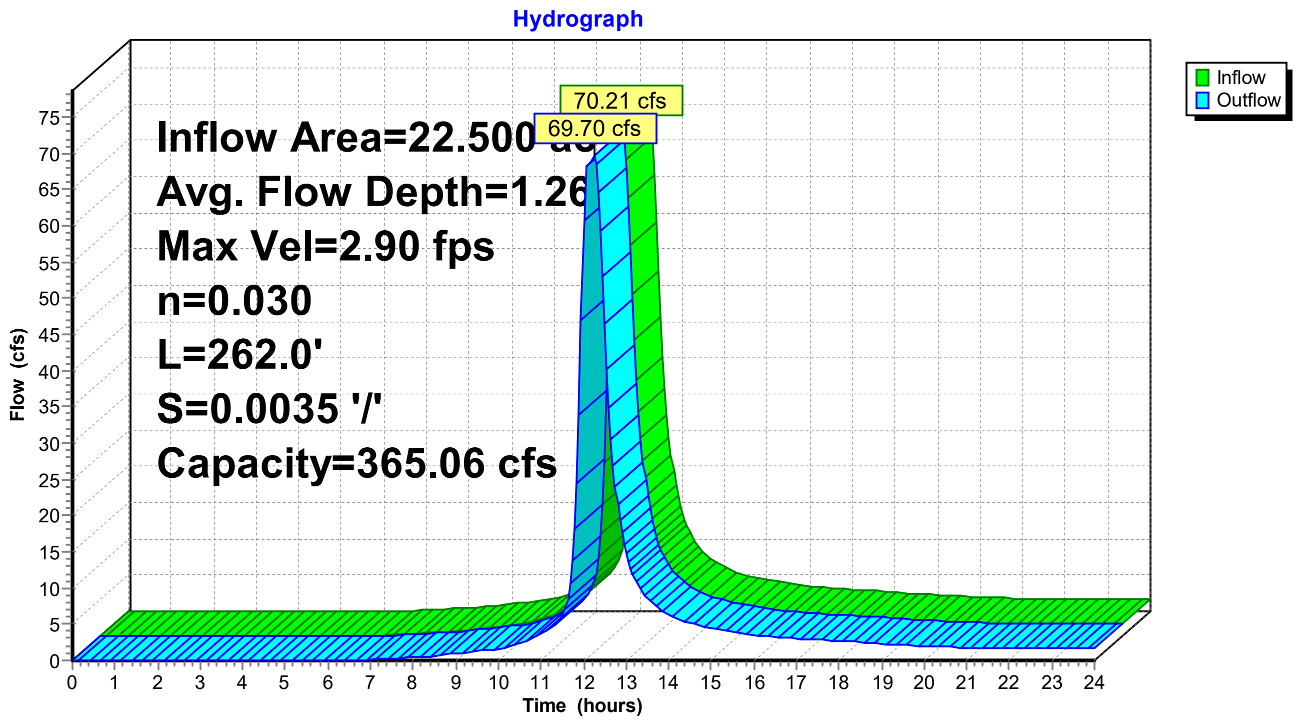
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.90 fps, Min. Travel Time= 1.5 min
Avg. Velocity = 0.97 fps, Avg. Travel Time= 4.5 min

Peak Storage= 6,310 cf @ 12.23 hrs
Average Depth at Peak Storage= 1.26'
Bank-Full Depth= 3.00' Flow Area= 78.0 sf, Capacity= 365.06 cfs

14.00' x 3.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 38.00'
Length= 262.0' Slope= 0.0035 '/'
Inlet Invert= 605.00', Outlet Invert= 604.08'

‡

Reach 17R: SW Drainage Ditch



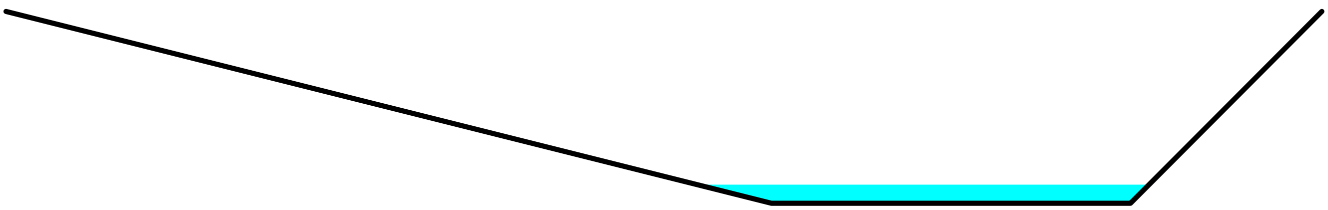
Summary for Reach 18R: South Drainage Ditch

Inflow Area = 2.600 ac, 0.00% Impervious, Inflow Depth > 4.52" for 100-yr 24-hr event
Inflow = 19.64 cfs @ 11.97 hrs, Volume= 0.980 af
Outflow = 18.47 cfs @ 12.04 hrs, Volume= 0.977 af, Atten= 6%, Lag= 4.2 min

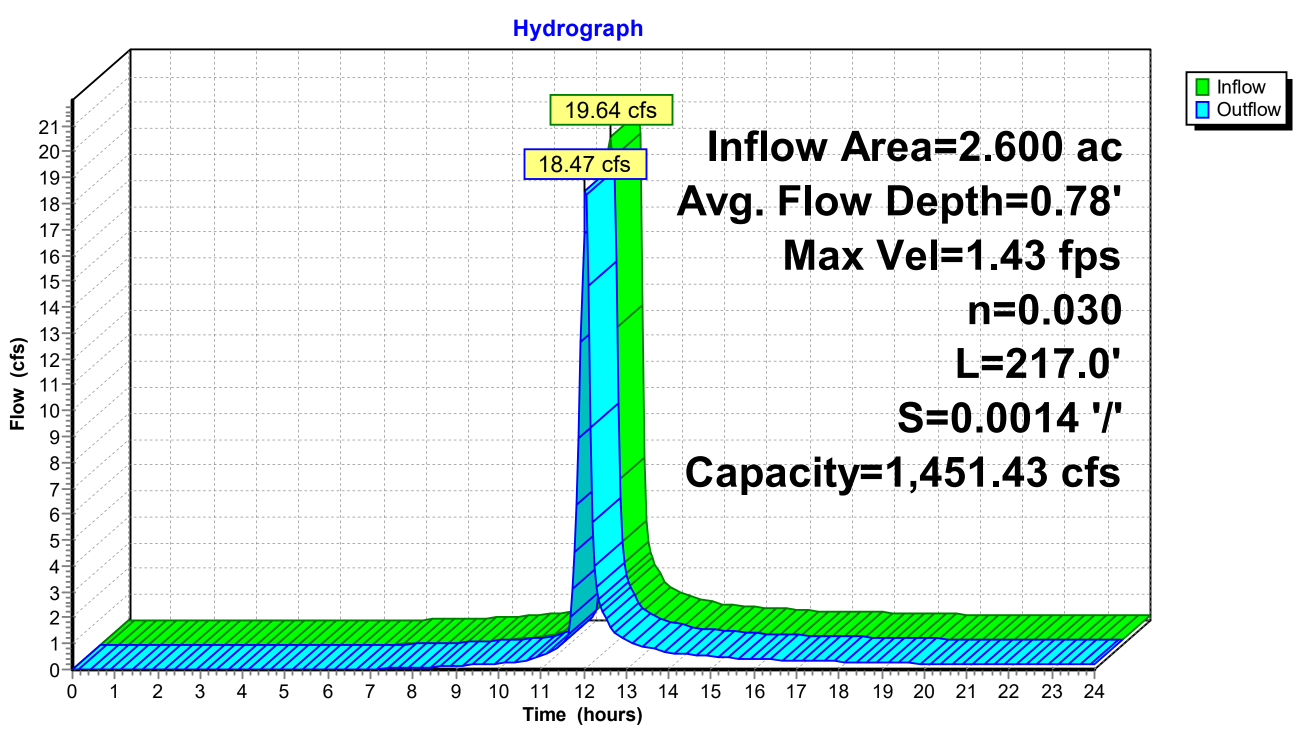
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.43 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 0.39 fps, Avg. Travel Time= 9.3 min

Peak Storage= 2,864 cf @ 12.00 hrs
Average Depth at Peak Storage= 0.78'
Bank-Full Depth= 8.00' Flow Area= 280.0 sf, Capacity= 1,451.43 cfs

15.00' x 8.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 1.0 '/' Top Width= 55.00'
Length= 217.0' Slope= 0.0014 '/'
Inlet Invert= 610.00', Outlet Invert= 609.70'



Reach 18R: South Drainage Ditch



Summary for Reach 24R: Cell 9 DC

Inflow Area = 20.500 ac, 0.00% Impervious, Inflow Depth > 4.50" for 100-yr 24-hr event
Inflow = 68.82 cfs @ 12.21 hrs, Volume= 7.694 af
Outflow = 68.76 cfs @ 12.21 hrs, Volume= 7.693 af, Atten= 0%, Lag= 0.2 min

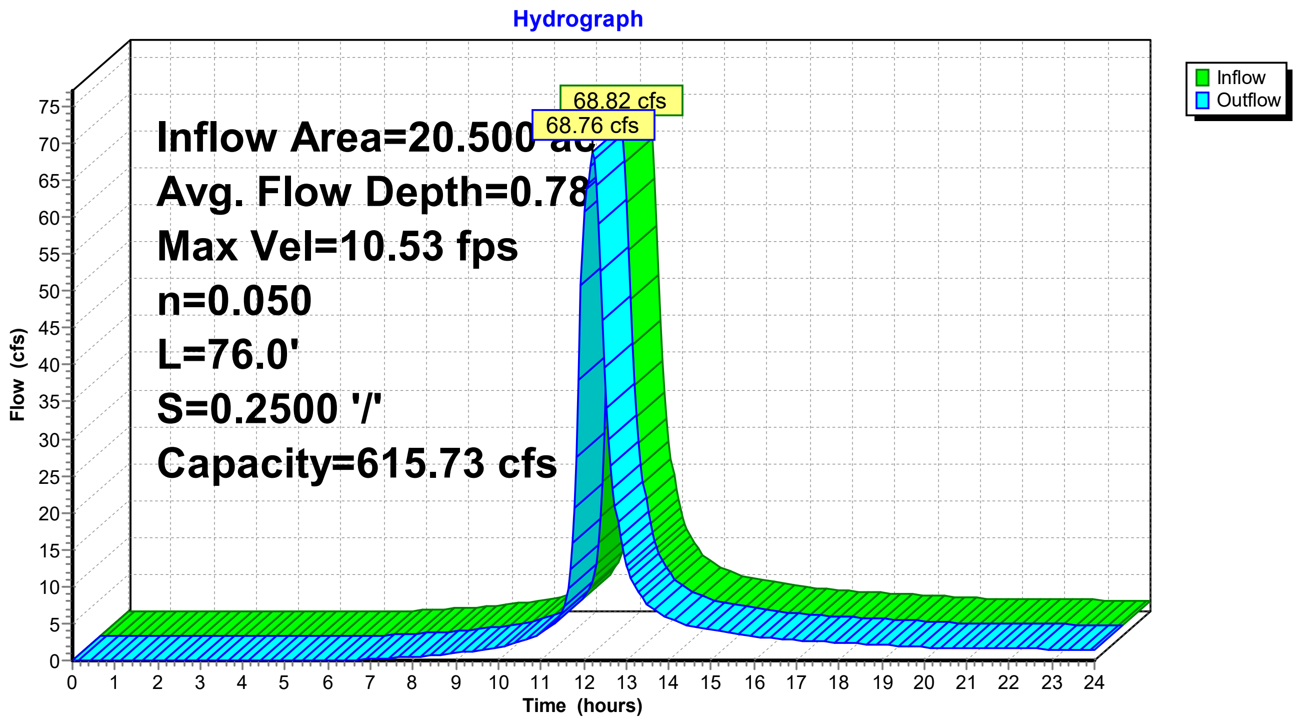
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 10.53 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.53 fps, Avg. Travel Time= 0.4 min

Peak Storage= 497 cf @ 12.21 hrs
Average Depth at Peak Storage= 0.78'
Bank-Full Depth= 2.40' Flow Area= 31.7 sf, Capacity= 615.73 cfs

6.00' x 2.40' deep channel, n= 0.050 Earth, cobble bottom, clean sides
Side Slope Z-value= 3.0 '/' Top Width= 20.40'
Length= 76.0' Slope= 0.2500 '/'
Inlet Invert= 641.00', Outlet Invert= 622.00'

‡

Reach 24R: Cell 9 DC



Summary for Reach 32R: NW Drainage Ditch

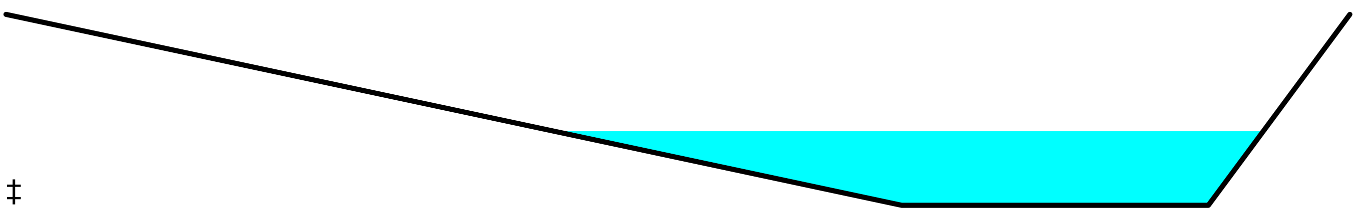
Inflow Area = 21.700 ac, 0.00% Impervious, Inflow Depth > 4.30" for 100-yr 24-hr event
Inflow = 66.95 cfs @ 12.23 hrs, Volume= 7.783 af
Outflow = 66.27 cfs @ 12.31 hrs, Volume= 7.753 af, Atten= 1%, Lag= 5.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.98 fps, Min. Travel Time= 3.3 min
Avg. Velocity = 0.71 fps, Avg. Travel Time= 9.2 min

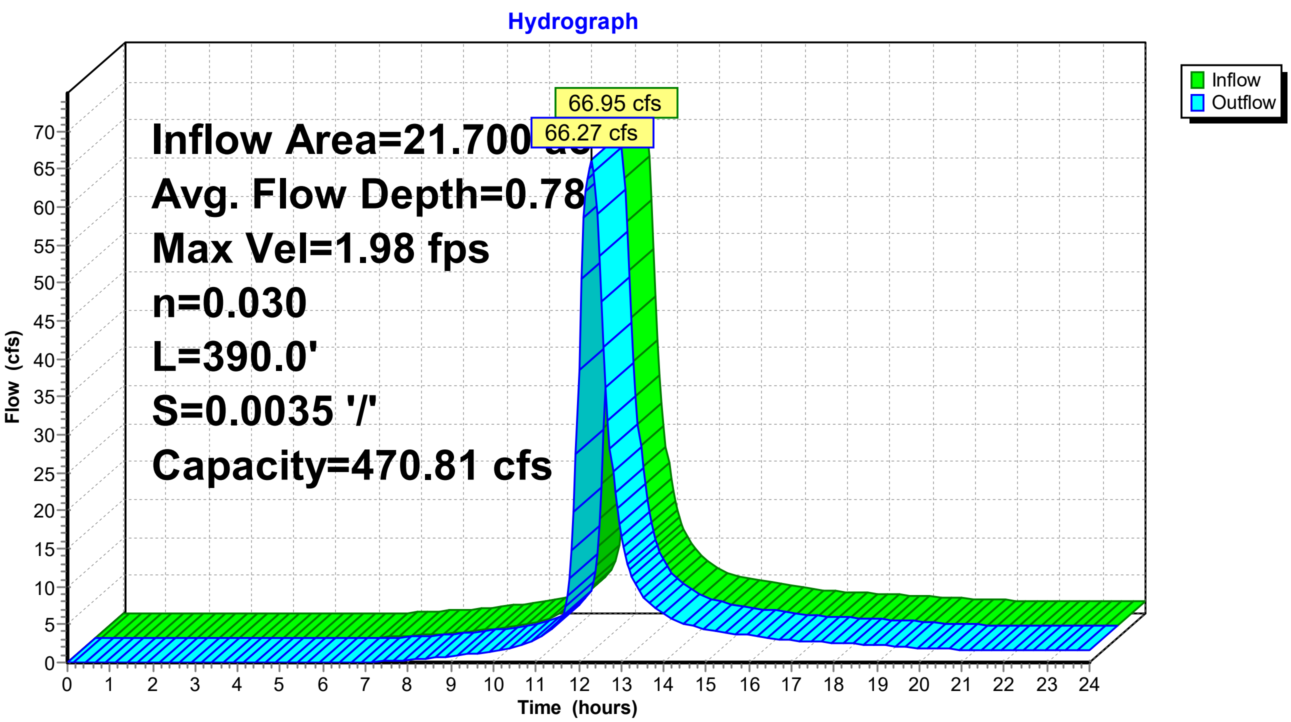
Peak Storage= 13,045 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.78'
Bank-Full Depth= 2.00' Flow Area= 140.0 sf, Capacity= 470.81 cfs

26.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 38.0 6.0 '/' Top Width= 114.00'
Length= 390.0' Slope= 0.0035 '/'
Inlet Invert= 609.00', Outlet Invert= 607.63'

‡



Reach 32R: NW Drainage Ditch



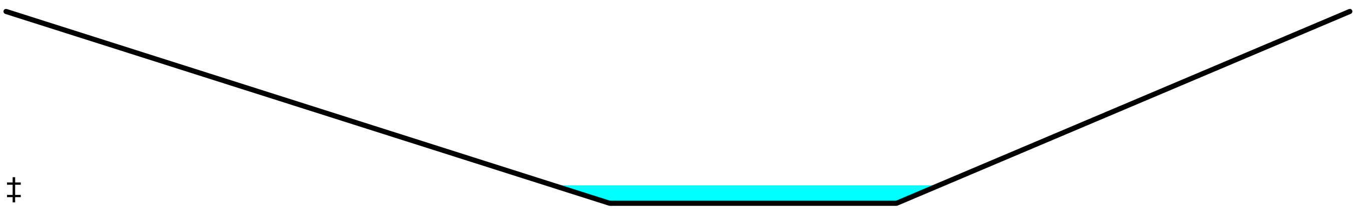
Summary for Reach 33R: NE Drainage Ditch

Inflow Area = 21.000 ac, 0.00% Impervious, Inflow Depth > 4.23" for 100-yr 24-hr event
Inflow = 65.22 cfs @ 12.01 hrs, Volume= 7.403 af
Outflow = 60.02 cfs @ 12.34 hrs, Volume= 7.353 af, Atten= 8%, Lag= 19.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.90 fps, Min. Travel Time= 5.0 min
Avg. Velocity = 1.00 fps, Avg. Travel Time= 14.6 min

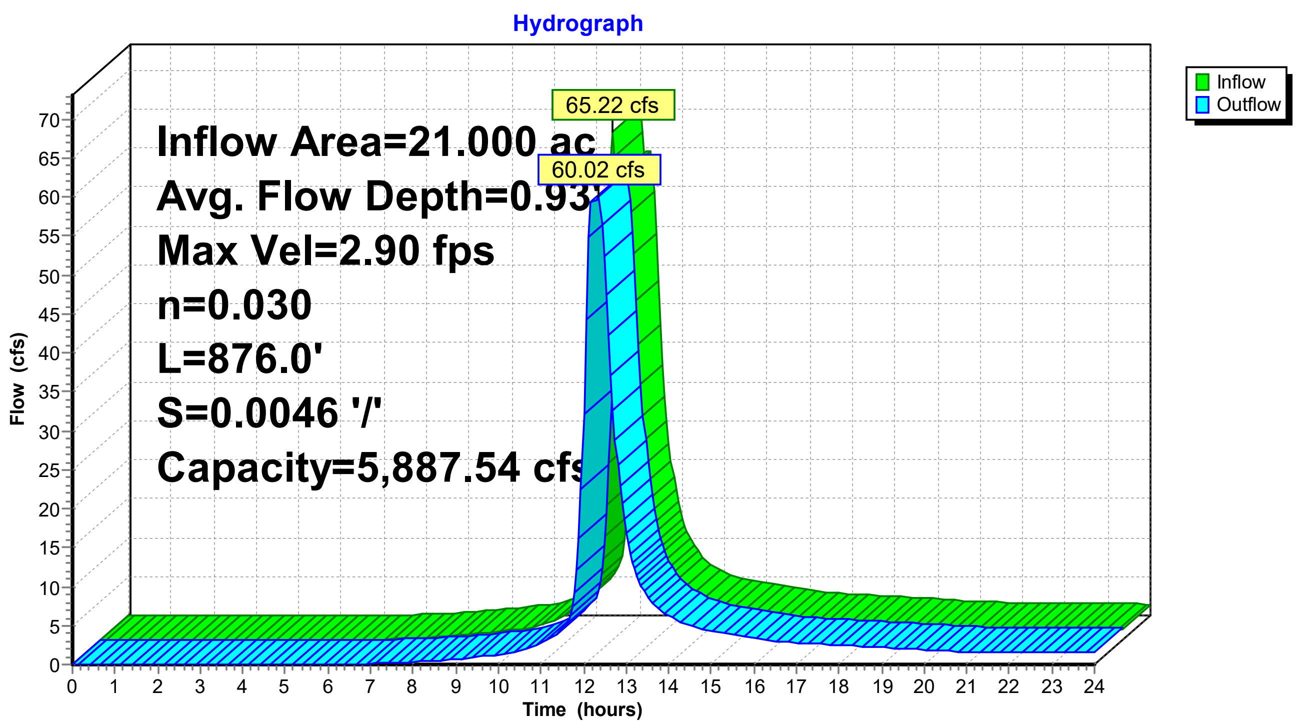
Peak Storage= 18,171 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.93'
Bank-Full Depth= 10.00' Flow Area= 540.0 sf, Capacity= 5,887.54 cfs

19.00' x 10.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 3.0 '/' Top Width= 89.00'
Length= 876.0' Slope= 0.0046 '/'
Inlet Invert= 610.00', Outlet Invert= 606.00'



‡

Reach 33R: NE Drainage Ditch



Summary for Reach 34R: SE Drainage Ditch

[79] Warning: Submerged Pond 29P Primary device # 1 OUTLET by 0.18'

Inflow Area = 31.600 ac, 0.00% Impervious, Inflow Depth > 4.43" for 100-yr 24-hr event
Inflow = 106.89 cfs @ 12.25 hrs, Volume= 11.670 af
Outflow = 105.98 cfs @ 12.29 hrs, Volume= 11.652 af, Atten= 1%, Lag= 2.2 min

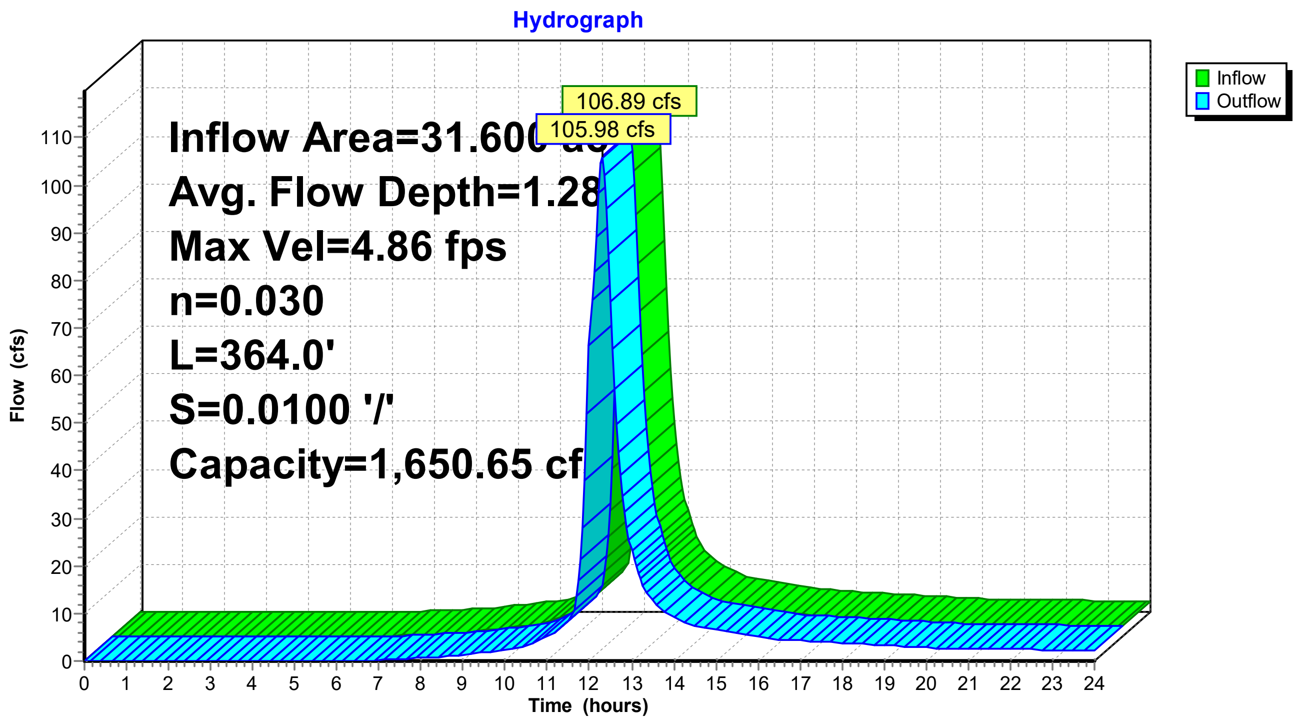
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.86 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 1.64 fps, Avg. Travel Time= 3.7 min

Peak Storage= 7,987 cf @ 12.27 hrs
Average Depth at Peak Storage= 1.28'
Bank-Full Depth= 5.00' Flow Area= 160.0 sf, Capacity= 1,650.65 cfs

12.00' x 5.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 '/' Top Width= 52.00'
Length= 364.0' Slope= 0.0100 '/'
Inlet Invert= 606.00', Outlet Invert= 602.36'

‡

Reach 34R: SE Drainage Ditch



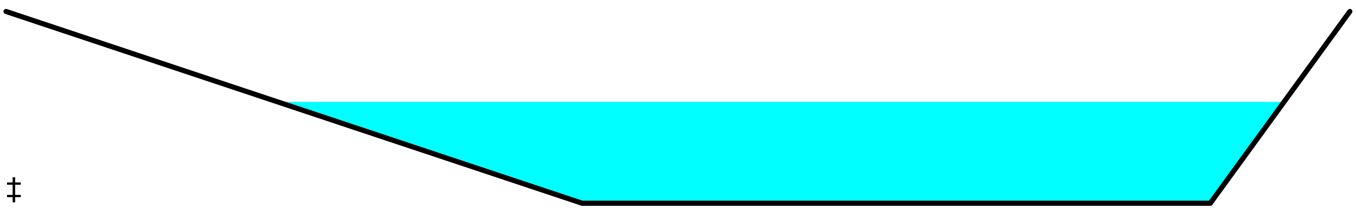
Summary for Reach 36R: W Drainage Ditch

Inflow Area = 11.600 ac, 0.00% Impervious, Inflow Depth > 4.48" for 100-yr 24-hr event
Inflow = 58.37 cfs @ 11.98 hrs, Volume= 4.328 af
Outflow = 56.35 cfs @ 12.01 hrs, Volume= 4.321 af, Atten= 3%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.35 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 0.65 fps, Avg. Travel Time= 3.7 min

Peak Storage= 3,531 cf @ 11.99 hrs
Average Depth at Peak Storage= 0.53'
Bank-Full Depth= 1.00' Flow Area= 56.5 sf, Capacity= 190.26 cfs

36.00' x 1.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 33.0 8.0 '/' Top Width= 77.00'
Length= 143.0' Slope= 0.0070 '/'
Inlet Invert= 609.00', Outlet Invert= 608.00'



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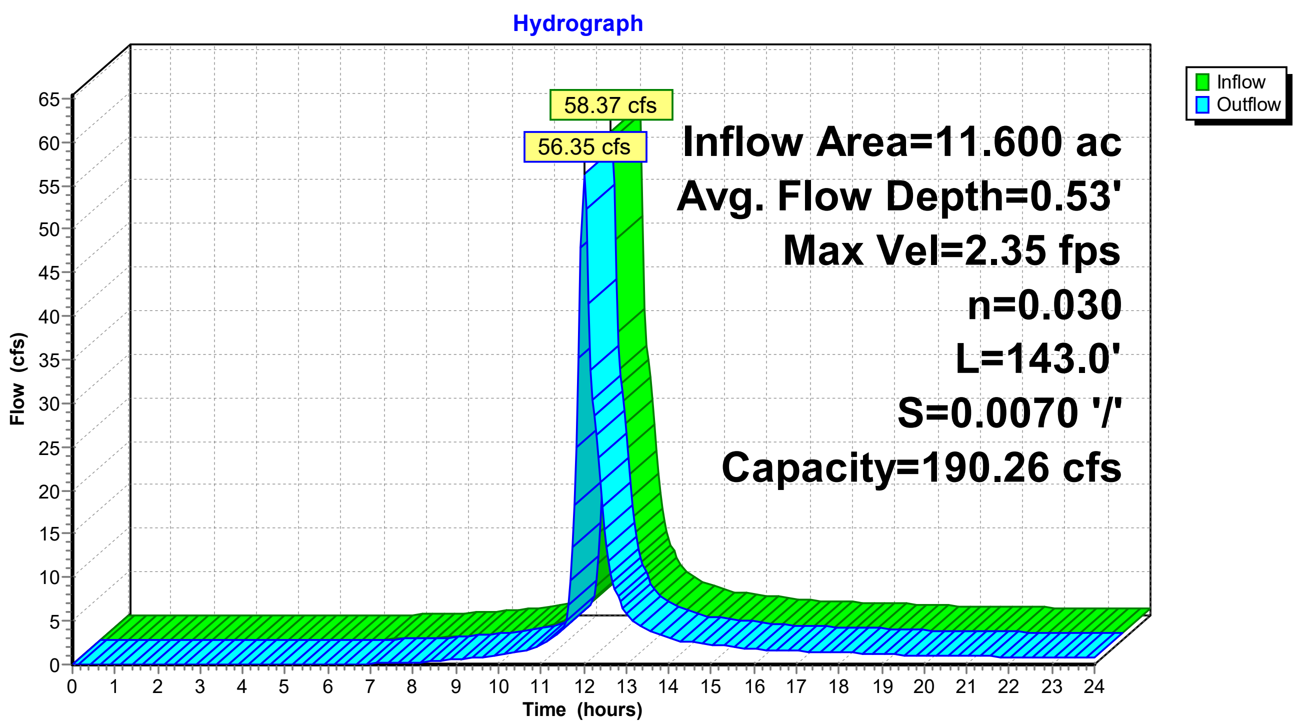
Reach 36R: W Drainage Ditch



Summary for Pond 21P: Catch Basin - C2

[57] Hint: Peaked at 617.78' (Flood elevation advised)

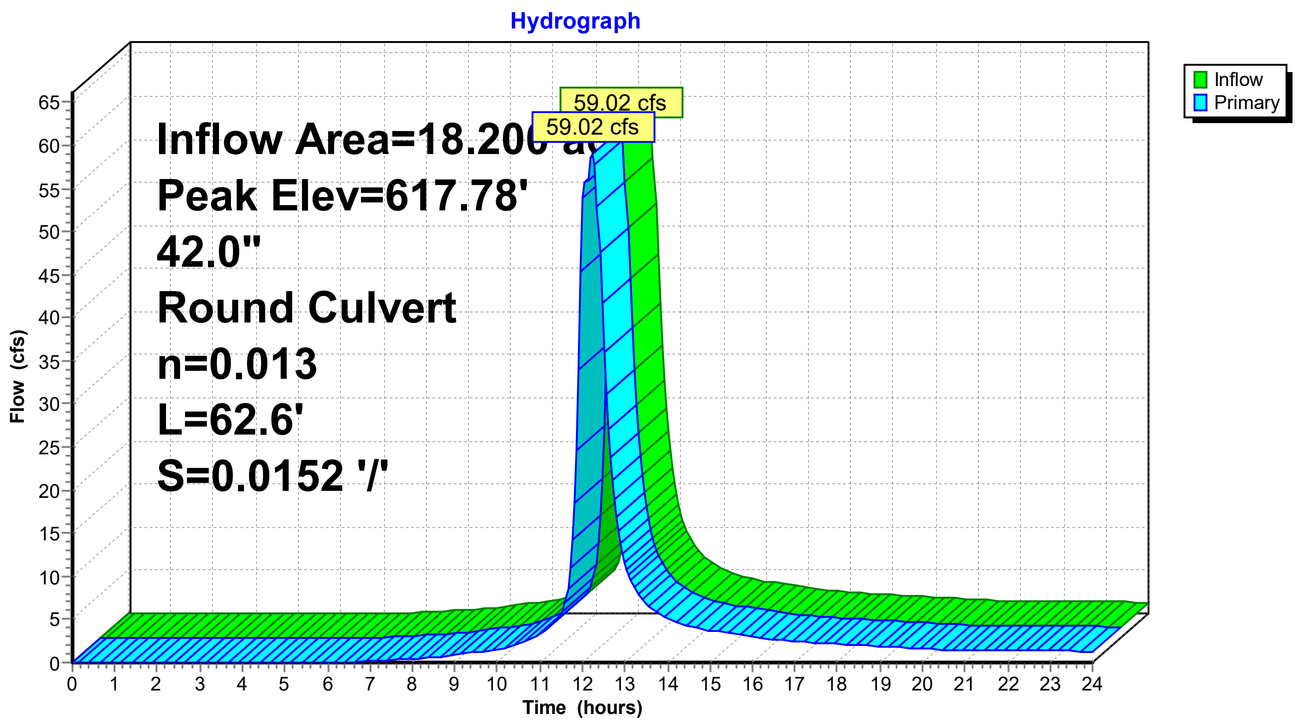
Inflow Area = 18.200 ac, 0.00% Impervious, Inflow Depth > 4.50" for 100-yr 24-hr event
Inflow = 59.02 cfs @ 12.23 hrs, Volume= 6.829 af
Outflow = 59.02 cfs @ 12.23 hrs, Volume= 6.829 af, Atten= 0%, Lag= 0.0 min
Primary = 59.02 cfs @ 12.23 hrs, Volume= 6.829 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 617.78' @ 12.23 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	613.43'	**42.0" Round Culvert** L= 62.6' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 613.43' / 612.48' S= 0.0152 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=58.74 cfs @ 12.23 hrs HW=617.76' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 58.74 cfs @ 6.11 fps)

Pond 21P: Catch Basin - C2



Summary for Pond 27P: SE Catch Basin

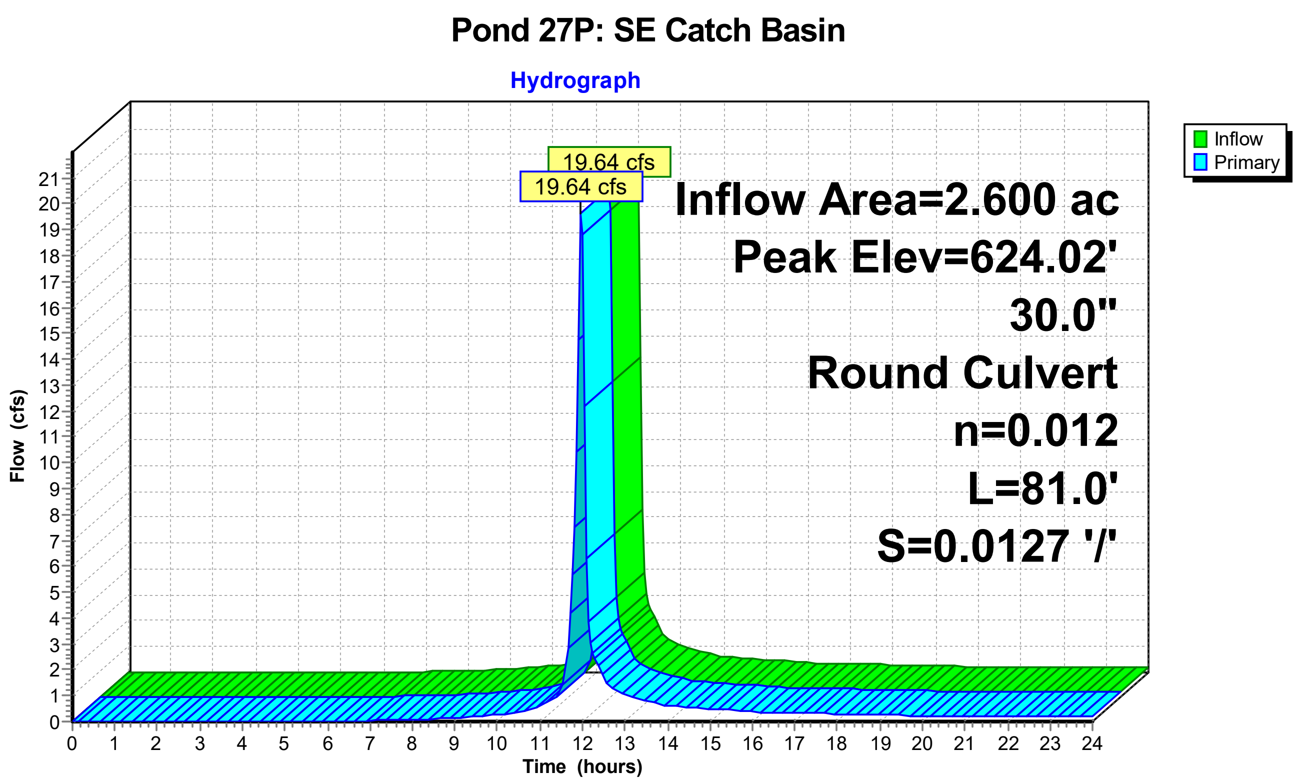
[57] Hint: Peaked at 624.02' (Flood elevation advised)

Inflow Area =	2.600 ac,	0.00% Impervious,	Inflow Depth > 4.52"	for 100-yr 24-hr event
Inflow =	19.64 cfs @	11.97 hrs, Volume=	0.980 af	
Outflow =	19.64 cfs @	11.97 hrs, Volume=	0.980 af,	Atten= 0%, Lag= 0.0 min
Primary =	19.64 cfs @	11.97 hrs, Volume=	0.980 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 624.02' @ 11.97 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	622.22'	**30.0" Round Culvert** L= 81.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 622.22' / 621.19' S= 0.0127 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 4.91 sf

Primary OutFlow Max=19.04 cfs @ 11.97 hrs HW=623.98' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 19.04 cfs @ 7.23 fps)



Summary for Pond 28P: Catch Basin - C1

[57] Hint: Peaked at 620.06' (Flood elevation advised)

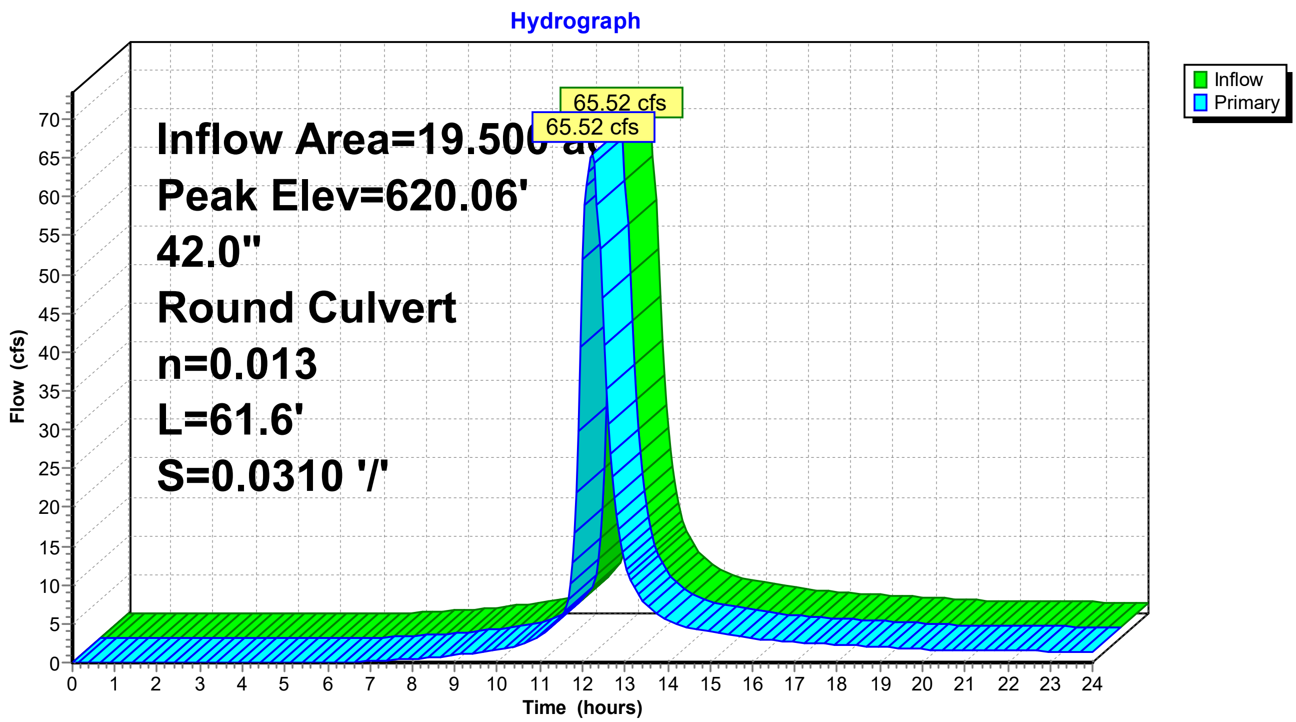
Inflow Area =	19.500 ac,	0.00% Impervious,	Inflow Depth > 4.50"	for 100-yr 24-hr event
Inflow =	65.52 cfs @	12.23 hrs, Volume=	7.314 af	
Outflow =	65.52 cfs @	12.23 hrs, Volume=	7.314 af,	Atten= 0%, Lag= 0.0 min
Primary =	65.52 cfs @	12.23 hrs, Volume=	7.314 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 620.06' @ 12.23 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.10'	**42.0" Round Culvert** L= 61.6' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.10' / 613.19' S= 0.0310 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=65.24 cfs @ 12.23 hrs HW=620.03' (Free Discharge)
↑**1=Culvert** (Inlet Controls 65.24 cfs @ 6.78 fps)

Pond 28P: Catch Basin - C1



Summary for Pond 29P: Catch Basin - C3

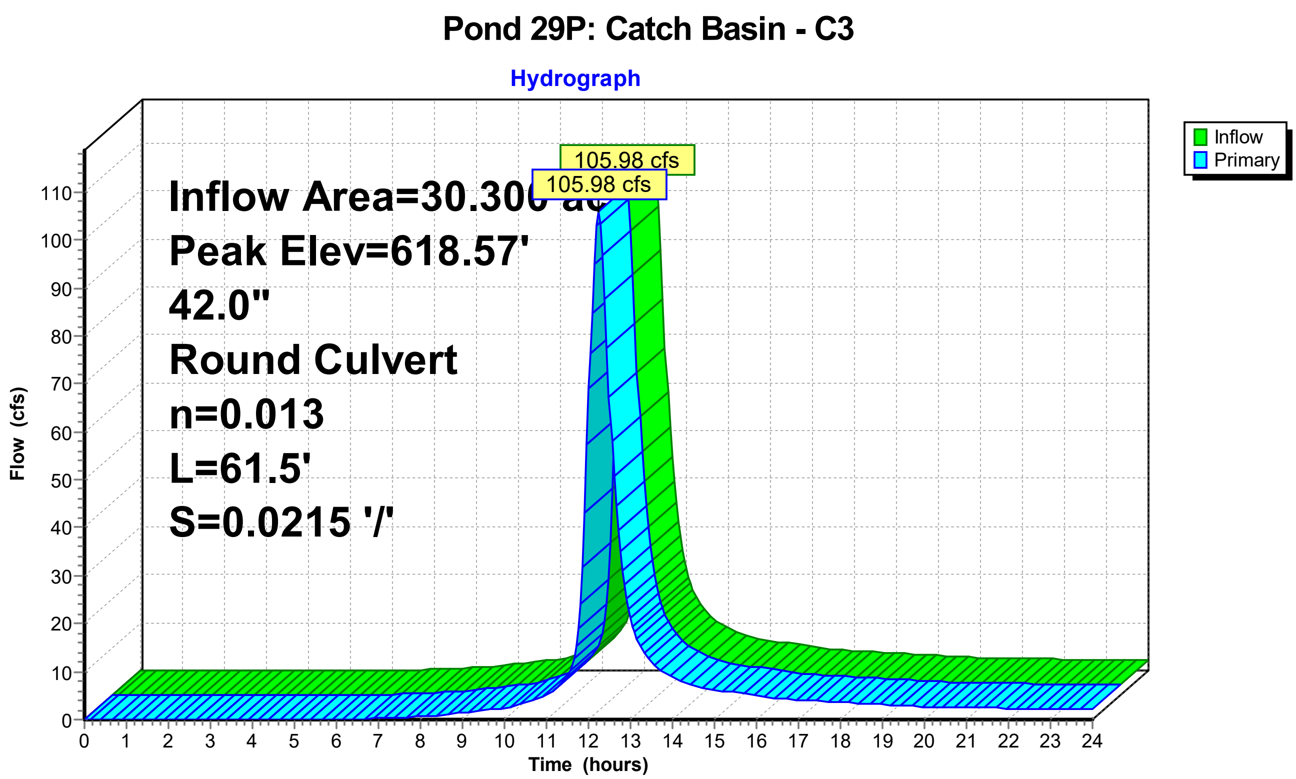
[57] Hint: Peaked at 618.57' (Flood elevation advised)

Inflow Area =	30.300 ac,	0.00% Impervious,	Inflow Depth > 4.50"	for 100-yr 24-hr event
Inflow =	105.98 cfs @	12.25 hrs, Volume=	11.361 af	
Outflow =	105.98 cfs @	12.25 hrs, Volume=	11.361 af, Atten= 0%, Lag= 0.0 min	
Primary =	105.98 cfs @	12.25 hrs, Volume=	11.361 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 618.57' @ 12.25 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	608.42'	**42.0" Round Culvert** L= 61.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 608.42' / 607.10' S= 0.0215 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=105.89 cfs @ 12.25 hrs HW=618.55' (Free Discharge)
↑**1=Culvert** (Inlet Controls 105.89 cfs @ 11.01 fps)



Summary for Pond 30P: Catch Basin C9

[57] Hint: Peaked at 620.28' (Flood elevation advised)

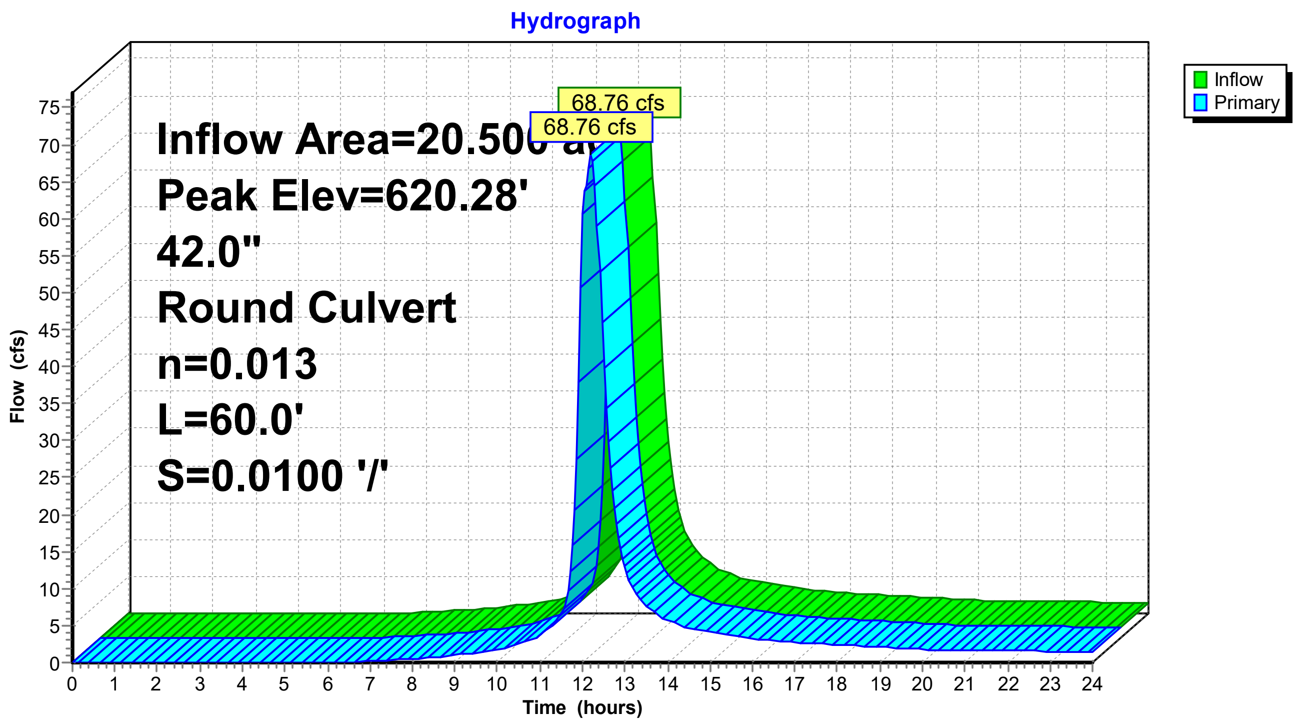
Inflow Area =	20.500 ac,	0.00% Impervious,	Inflow Depth > 4.50"	for 100-yr 24-hr event
Inflow =	68.76 cfs @	12.21 hrs, Volume=	7.693 af	
Outflow =	68.76 cfs @	12.21 hrs, Volume=	7.693 af,	Atten= 0%, Lag= 0.0 min
Primary =	68.76 cfs @	12.21 hrs, Volume=	7.693 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 620.28' @ 12.21 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.00'	**42.0" Round Culvert** L= 60.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.00' / 614.40' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=68.57 cfs @ 12.21 hrs HW=620.26' (Free Discharge)
└**1=Culvert** (Inlet Controls 68.57 cfs @ 7.13 fps)

Pond 30P: Catch Basin C9



Summary for Pond 31P: Catch Basin - C7

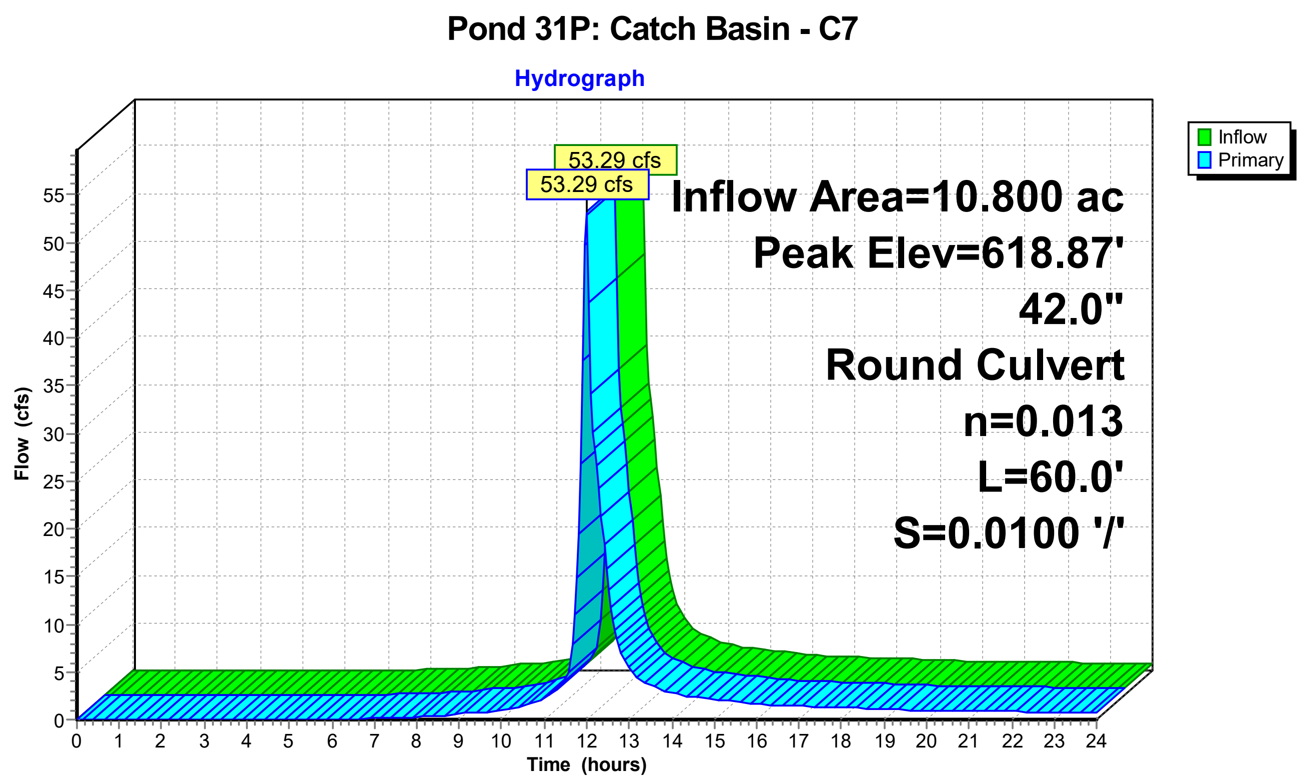
[57] Hint: Peaked at 618.87' (Flood elevation advised)

Inflow Area =	10.800 ac,	0.00% Impervious,	Inflow Depth > 4.51"	for 100-yr 24-hr event
Inflow =	53.29 cfs @	11.99 hrs, Volume=	4.062 af	
Outflow =	53.29 cfs @	11.99 hrs, Volume=	4.062 af,	Atten= 0%, Lag= 0.0 min
Primary =	53.29 cfs @	11.99 hrs, Volume=	4.062 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 618.87' @ 11.99 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	615.00'	**42.0" Round Culvert** L= 60.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 615.00' / 614.40' S= 0.0100 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 9.62 sf

Primary OutFlow Max=52.15 cfs @ 11.99 hrs HW=618.78' (Free Discharge)
└─**1=Culvert** (Inlet Controls 52.15 cfs @ 5.42 fps)



Attachment 5

Cell 7 and 9 Articulated Block Downchute Calculations

ARTICULATING CONCRETE BLOCK HYDRAULIC STABILITY CALCULATIONS FOR OPEN CHANNEL FLOW

International Erosion Control Systems, Inc.

Worksheet 1: Block Characteristics

TABLE 1: NOMINAL BLOCK DIMENSIONS AND WEIGHTS

Block Designation	Length, inches	Width, inches	Height, inches	Open area at base of system, percent	Weight in air, lb
CC 20	15.5	15.5	2.5	2	40.0
CC 35	15.5	15.5	4.5	2	70.0
CC 45	15.5	15.5	5.5	2	86.0
CC 70	15.5	15.5	8.5	2	133.0

TABLE 2: PERFORMANCE DATA FOR CRITICAL SHEAR STRESS AND VELOCITY

Block type	τ_c at horizontal, lb/ft^2	Comments
CC 20	11.3	Extrapolated value
CC 35	18.1	Tested at 2H:1V
CC 45	20.9	Extrapolated value
CC 70	28.0	Extrapolated value

		C.C. 20	C.C. 35	C.C. 45	C.C. 70
General:	Weight(lbs/sf)	23	41	50	77
	Block Height	2.5”	4.5”	5.5”	8.5”
Cable:	Longitudinal:	1/8”	5/32”	5/32”	3/16”
	Transverse:	1/8”	5/32”	5/32”	5/32”

ARTICULATING CONCRETE BLOCK HYDRAULIC STABILITY CALCULATIONS FOR OPEN CHANNEL FLOW

International Erosion Control Systems, Inc.

Worksheet 2: Hydraulic Stability Calculations - Cell 7 DC

TABLE 3: MOMENT ARMS AND CRITICAL SHEAR STRESS

Block Designation	L_1, inches	L_2, inches	L_3, inches	L_4, inches	τ_c at horizontal, lb/ft^2
CC 20	1.3	11.0	2.0	11.0	11.3
CC 35	2.3	11.0	3.6	11.0	18.1
CC 45	2.8	11.0	4.4	11.0	20.9
CC 70	4.3	11.0	6.8	11.0	28.0

TABLE 4: CHANNEL CONDITIONS

	ENTER VALUES	Degrees	Radians
Longitudinal (bed) slope θ_0, percent	25.00	14.04	0.2450
Maximum side slope θ_1, percent	33.33	18.43	0.3217
Known maximum velocity V, ft/s (from HydroCAD calcs)	9.73		
Known maximum shear stress τ_0, lb/ft^2	8.28		
Maximum block placement tolerance, inches	0.50		

Flow direction parallel to the block*: X

* Mark with X when flow conditions are parallel to the block. For other cases leave cell empty.

Unit weight of water, lb/ft^3	62.4	NOTE:	Recommended values for density of water are:
Unit weight of concrete, lb/ft^3	140		62.4 lb/ft^3 for fresh water, 64.2 lb/ft^3 for seawater

TABLE 5: SAFETY FACTOR CALCULATIONS

Block Designation	$\eta_0 = \tau_0/\tau_c$	a_θ	ratio L_2/L_1	ratio L_4/L_3	angle θ (radians)	angle B (rad)	η_1	Drag F'_d, lbs	Submerged weight (lb)	**Safety Factor**
CC 20	0.733	0.917	8.768	5.480	0.644	0.492	0.731	4.94	22.2	**0.89**
CC 35	0.458	0.917	4.871	3.044	0.644	0.398	0.453	4.94	38.8	**1.33**
CC 45	0.396	0.917	3.986	2.491	0.644	0.364	0.391	4.94	47.7	**1.47**
CC 70	0.296	0.917	2.579	1.612	0.644	0.287	0.287	4.94	73.7	**1.71**

ARTICULATING CONCRETE BLOCK HYDRAULIC STABILITY CALCULATIONS FOR OPEN CHANNEL FLOW

Internatio[...]trol Systems, Inc.

Worksheet 2: Hydraulic Stability Calculations - Cell 9 DC

TABLE 3: MOMENT ARMS AND CRITICAL SHEAR STRESS

Block Designation	L_1, inches	L_2, inches	L_3, inches	L_4, inches	τ_c at horizontal, lb/ft^2
CC 20	1.3	11.0	2.0	11.0	11.3
CC 35	2.3	11.0	3.6	11.0	18.1
CC 45	2.8	11.0	4.4	11.0	20.9
CC 70	4.3	11.0	6.8	11.0	28.0

TABLE 4: CHANNEL CONDITIONS

	ENTER VALUES	Degrees	Radians
Longitudinal (bed) slope θ_0, percent	25.00	14.04	0.2450
Maximum side slope θ_1, percent	33.33	18.43	0.3217
Known maximum velocity V, ft/s (from HydroCAD calcs)	10.53		
Known maximum shear stress τ_0, lb/ft^2	9.19		
Maximum block placement tolerance, inches	0.50		

Flow direction parallel to the block*: X

* Mark with X when flow conditions are parallel to the block. For other cases leave cell empty.

Unit weight of water, lb/ft^3	62.4	NOTE:	Recommended values for density of water are:
Unit weight of concrete, lb/ft^3	140		62.4 lb/ft^3 for fresh water, 64.2 lb/ft^3 for seawater

TABLE 5: SAFETY FACTOR CALCULATIONS

Block Designation	$\eta_0 = \tau_0/\tau_c$	a_θ	ratio L_2/L_1	ratio L_4/L_3	angle θ (radians)	angle B (rad)	η_1	Drag F'_d, lbs	Submerged weight (lb)	**Safety Factor**
CC 20	0.813	0.917	8.768	5.480	0.644	0.506	0.811	5.68	22.2	**0.80**
CC 35	0.508	0.917	4.871	3.044	0.644	0.416	0.503	5.68	38.8	**1.20**
CC 45	0.440	0.917	3.986	2.491	0.644	0.382	0.434	5.68	47.7	**1.34**
CC 70	0.328	0.917	2.579	1.612	0.644	0.305	0.319	5.68	73.7	**1.57**

NATIONAL CONCRETE MASONRY ASSOCIATION

ARTICULATING CONCRETE BLOCK HYDRAULIC STABILITY CALCULATIONS FOR OPEN CHANNEL FLOW

NATIONAL CONCRETE MASONRY ASSOCIATION
Sustainable Concrete Products for Structures and Hardscapes

ASTM Standards

C140-10 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

D6684-04 (2010) Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems

D6884-03 (2010) Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems

D7276-08 Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow

D7277-08 Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow

Manuals and Guidance Documents

Clopper, P.E., 1989, "Hydraulic Stability of Articulated Concrete Block Revetment Systems During Overtopping Flow," FHWA-RD-89-199, Office of Engineering and Highway Operations R&D, McLean, VA.

Clopper, P.E., 1992, "Protecting Embankment Dams with Concrete Block Systems," Hydro Review, Vol. X, No. 2, April.

Harris County Flood Control District, 2001, "Design Manual for Articulating Concrete Block Systems," prepared by Ayres Associates, Project No. 32-0366.00, Fort Collins, CO.

Julien, P.Y. 1995, Erosion and Sedimentation, Cambridge University Press, Cambridge, UK.

Lagasse, et al., 2007, "Countermeasures to Protect Bridge Piers from Scour," NCHRP Report 593, Transportation Research Board, National Academies of Science, Washington, D.C.

Lagasse, et al., 2009, "Bridge Scour and Stream Instability Countermeasures, Volume 2" Hydraulic Engineering Circular No. 23, 3rd Edition, Federal Highway Administration Publication Number FHWA-NHI-09-112.

National Concrete Masonry Association, 2006. "Design Manual for Articulating Concrete Block Revetment Systems," NCMA Publication Number TR220, National Concrete Masonry Association, Herndon, VA.

U.S. Army Corps of Engineers, 1991, "Hydraulic Design of Flood Control Channels," Engineering Manual EM-1110-2-1601, Department of the Army, Washington D.C.

Manning Formula Uniform Trapezoidal Channel Flow at Given Slope and Depth

Cell 7 - West Downchute

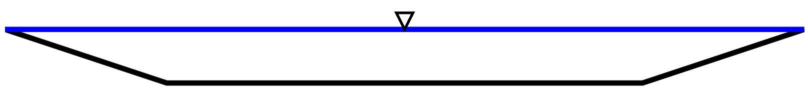
CEC JHC Landfill

Inputs

Bottom width	6	ft
Side slope 1 (horiz./vert.)	3	
Side slope 2 (horiz./vert.)	3	
Manning roughness, n ?	0.05	
Channel slope	0.25	rise/run
Flow depth	.68	ft
Bend Angle? (for riprap sizing)	0	
Stone specific gravity (2.65)	2.65	

Results

Flow area	5.4674	ft^2
Wetted perimeter	10.3007	ft
Hydraulic radius	0.5308	ft
Velocity, v	9.7407	ft/sec
Flow, Q	53.2540	cfs
Velocity head, h_v	1.4746	ft
Top width, T	10.0800	ft
Froude number, F	2.37	
Shear stress (tractive force), tau	8.2838	psf
Implied design ? riprap size based on n	4.5237	ft
Required bottom angular riprap size, D50, Maricopa County ?	0.7665	ft
Required side slope 1 angular riprap size, D50, Maricopa County ?	0.7665	ft
Required side slope 2 angular riprap size, D50, Maricopa County ?	0.7665	ft
Required angular riprap size, D50, per Maynord, Ruff, and Abt (1989)	2.0201	ft
Required angular riprap size, D50, per Searcy (1967)	0.6362	ft



Manning Formula Uniform Trapezoidal Channel Flow at Given Slope and Depth

Cell 9 - Southwest Downchute

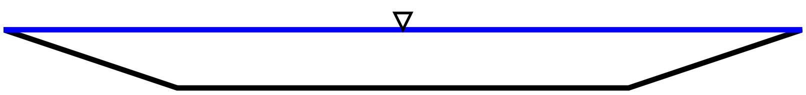
CEC JHC Landfill

Inputs

Bottom width	6	ft
Side slope 1 (horiz./vert.)	3	
Side slope 2 (horiz./vert.)	3	
Manning roughness, n ?	0.05	
Channel slope	0.25	rise/run
Flow depth	.77	ft
Bend Angle? (for riprap sizing)	0	
Stone specific gravity (2.65)	2.65	

Results

Flow area	6.3989	ft^2
Wetted perimeter	10.8699	ft
Hydraulic radius	0.5887	ft
Velocity, v	10.4369	ft/sec
Flow, Q	66.7817	cfs
Velocity head, h_v	1.6929	ft
Top width, T	10.6200	ft
Froude number, F	2.41	
Shear stress (tractive force), tau	9.1875	psf
Implied design ? riprap size based on n	4.5237	ft
Required bottom angular riprap size, D50, Maricopa County ?	0.8491	ft
Required side slope 1 angular riprap size, D50, Maricopa County ?	0.8491	ft
Required side slope 2 angular riprap size, D50, Maricopa County ?	0.8491	ft
Required angular riprap size, D50, per Maynord, Ruff, and Abt (1989)	2.3271	ft
Required angular riprap size, D50, per Searcy (1967)	0.7304	ft



APPENDIX N

Airspace and Site Life Calculations

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	24-May-21	**Made by:**	DJS
Project No.:	19132873	**Checked by:**	TDJ
Subject:	**EXPANSION AIRSPACE**	**Reviewed by:**	GJD

Project Short Title: JHC Landfill - Expansion

1.0 OBJECTIVE

Determine the amount of available remaining airspace within the J.H. Campbell Dry Ash Landfill expansion footprint using a 1 foot sand drainage layer and the traditional cap for the final cover.

2.0 ASSUMPTIONS/GIVENS

- Top of subgrade grades are taken from Engineering Drawing, Sheet 400-1.

3.0 METHODS

- Use of software with digital terrain models (AutoCAD Civil 3D, 2020 version) of the relevant surfaces (top of waste and top of subgrade) to determine the total airspace for the proposed landfill. The difference between these calculated airspaces (after subtracting the 12-inches of sand) is the airspace from the landfill.

- Values 'calculated' in this calculation are rounded to a reasonable accuracy (for example, 2.9 instead of 2.9345567). Future calculations using these values will use the un-rounded values; discrepancies may be noted.

4.0 CALCULATIONS

1) Gross airspace (before subtracting 12-inches of sand and top of final cover thickness estimated using AutoCAD Civil 3D 2020

Gross Airspace = 5,021,673 cubic yards

(includes vertical expansion airspace)

2) Leachate collection system - FLOOR

Volume = (Thickness) * (Area) = 70,235 cubic yards

3) Net Airspace available for CCR Waste

NET Airspace Remaining = 4,951,438 cubic yards

5.0 RESULTS

TABLE 1 - SUMMARY OF RESULTS

Unit	NET AIRSPACE (cy)
Dry Ash Landfill	4,951,438

APPENDIX O

Phasing Calculations

CALCULATIONS

Date:	5/24/2021	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	DJS
Subject:	**PHASING EARTHWORKS AND AIRSPACE**	**Reviewed by:**	GJD
Project Short Title:	CEC JHC ASH LANDFILL - EXPANSION CPA		

NOTE: The airspace volumes reported in this calculation for Cells 5 through 9 include total airspace available with the upgraded design of the cells and the volume included from the expansion.

1.0 OBJECTIVE

The construction, operation, and closure of the Consumers Energy Company (CEC) J.H. Campbell (JHC) Landfill will require the use of several types of soil and aggregate materials. This calculation will summarize the available soil materials on-site as well as the required volumes of these materials. The volume of imported materials (such as top soil, drainage stone, etc.) are also estimated here.

Available and required soil quantities have been estimated on a phased basis for the construction of each cell. These phased calculations have been performed using the Fill Progression Sequence drawings, Sheets 400-4 through 400-8 of the Engineering Drawings.

Calculations have been performed using the AutoCAD Civil Design 2021 software, see attached.

2.0 REQUIRED SOIL QUANTITIES

The required soil quantities and types have been estimated for the phased construction of Cells 5-9 operation, and the landfill closure. The required soil items presented in the Detailed Phasing Volume Table will be addressed below. Volumes shown in these phasing calculations are neat line quantities and do not account for expansion factors or waste.

Column	Description
(3)	**Base Liner Area**. This is the side slope and floor liner area for each phase of construction, including run-outs, excluding liner materials in the anchor trenches. These 2-dimensional areas are measured in AutoCAD and included in the attached sheets.
(4)	**Structural & General Fill.** This quantity includes fill required with respect to the existing grades to establish the perimeter berm, subgrade contours, intercell berms, etc. The total fill has been calculated by adding the earthworks required for the subgrade to a limit up to the solid waste boundary (SWB) to the perimeter berm earthworks from the SWB outside to the outside toe of the berm.
(5)	**Sand Protective Layer.** This quantity represents the construction of the sand protective layer system. **For the purposes of this calculation, the airspace will be calculated by subtracting the 1 foot (+ 20% for slopes) of protective sand over the surface area of each cell.**
(8)	**Final Cover Area (square feet (sf))**. This is the surface area where final cover materials will be required.
(9)	**Final Cover Layer.** This quantity represents soil volumes required to close the facility.

The final cover system has a total thickness of 3-feet (6 inches of grading fill plus 24 inches of soil erosion layer plus 6 inches of vegetative support layer / topsoil).

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	DJS
Subject:	**PHASING EARTHWORKS AND AIRSPACE**	**Reviewed by:**	GJD
Project Short Title:	CEC JHC ASH LANDFILL - EXPANSION CPA		

NOTE: The airspace volumes reported in this calculation for Cells 5 through 9 include total airspace available with the upgraded design of the cells and the volume included from the expansion.

3.0 AVAILABLE SOIL QUANTITIES

Utilizing the excavations shown on the Fill Progression Sequence Drawings, quantities for each type of available soil has been calculated. The available soil items presented in the detailed phasing volume tables will be addressed below by describing each column from the tables.

Column	Description
(2)	**Soil.** Available soil has been taken as all soil types excavated during the construction of the perimeter berm and Cells 5 through 9 to the lines and grades of the subgrade surface.

4.0 WASTE QUANTITIES

Utilizing the Fill Progression Sequence Drawings, the phased waste quantities for each stage of development have been estimated. The waste quantity items presented in the Detailed Phasing Volumes Tables will be addressed below by describing each column from the tables.

Column	Description
(6)	**Gross Unadjusted Airspace.** Given the intermediate fill slopes shown on the Fill Progression Sequence Drawings, the Gross Unadjusted Airspace has been calculated as the volume from the top of geosynthetics liner to the top of waste.
(7)	**Net Airspace.** The Gross Airspace has been calculated as the Gross Unadjusted Airspace minus the volume of the Leachate sand for each phase.

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	DJS
Subject:	**PHASING EARTHWORKS AND AIRSPACE**	**Reviewed by:**	GJD
Project Short Title:	CEC JHC ASH LANDFILL - EXPANSION CPA		

NOTE: The airspace volumes reported in this calculation for Cells 5 through 9 include total airspace available with the upgraded design of the cells and the volume included from the expansion.

5.0 SOIL BALANCE/EXPANSION LIFE

The Detailed Phasing Volume Tables include a phase and cumulative estimate of soil balance and expansion life. Each column will be addressed below by describing each column in the tables.

Column	Description
(10)	**Phase Soil Balance.** This term estimates the balance for soil material for each phase by examining the soil generated and required for each phase of landfill construction, operation, and closure. The **Phase Soil Balance (10) = Soil (2) - Structural & General Fill (4) - Final Cover Layer (9).**
(11)	**Cumulative Soil Balance.** This item estimates the cumulative balance of all soil material types left at the end of each phase of landfill construction, operation, and closure. This quantity is calculated by cumulative summing of the Phase soil balance quantities.
(12)	**Phase Life.** This item calculates the life gained for each phase. **Phase Life (13) = Net Airspace (8) / Yearly Waste Receipts** Where; ASH Landfill Waste rates were based on the Quarterly Survey and Airspace Calculations produced by Golder Associates for 2020. The 2020 survey provided a rate 265,200 cy/year for the first 12 years and 161,200 cy/year for the remaining 9 years.
(13)	**Cumulative Life.** This item calculates the cumulative life.
Notes:	**Daily Cover.** This quantity represents the soils which may be used for the operation of the active landfill areas. For this calculation, it assumed that no daily cover will be subtracted from the airspace. Surplus soil generated from the construction of the base grades may be used for Daily Cover.

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	DJS
Subject:	**PHASING EARTHWORKS AND AIRSPACE**	**Reviewed by:**	GJD
Project Short Title:	CEC JHC ASH LANDFILL - EXPANSION CPA		

NOTE: The airspace volumes reported in this calculation for Cells 5 through 9 include total airspace available with the upgraded design of the cells and the volume included from the expansion.

7.0 DETAILED PHASING VOLUMES

PHASE	CONSTRUCTION			
	AVAILABLE	SOIL REQUIRED		
	Total Available Excavated Soil (cy)	Base Liner Surface Area (sf)	Structural & General Fill Required (cy)	Import Leachate Collection System Layer (Assume 1 ft thick + 20% to account for extra sand on slopes) (cy)
(1)	(2)	(3)	(4)	(5)
ASH LANDFILL				
Construct Cell 5 (2018)	8,446	338,971	60,800	15,065
Construct Cell 6, Fill Cell 5	5,004	320,866	87,765	14,261
Construct Cell 7, Fill Cell 6	3,061	289,833	70,681	12,881
Construct Cell 8, Fill Cell 7	102	303,623	82,389	13,494
Construct Cell 9, Fill Cell 8	1,591	326,995	81,049	14,533
Fill Cell 9 (Close CCR Landfill)	0	0	0	0
TOTALS	**18,204**	**1,580,288**	**382,684**	**70,235**

PHASE	WASTE		CLOSURE SOIL REQUIRED		
	Gross Unadjusted Expansion Airspace (cy)	Net Expansion Airspace (cy)	Final Cover Area (Base liner + 30% slope factor) (sf)	Grading Layer and Soil Erosion Layer (total 30-inches) (cy)	Import Topsoil (6-inches) (cy)
(1)	(6)	(7)	(8)	(9)	Topsoil
ASH LANDFILL					
Construct Cell 5 (2018)	n/a	n/a	0	0	0
Construct Cell 6, Fill Cell 5	1,330,411	1,315,346	440,663	40,802	8,160
Construct Cell 7, Fill Cell 6	1,098,671	1,084,410	417,126	38,623	7,725
Construct Cell 8, Fill Cell 7	995,144	982,263	376,783	34,887	6,977
Construct Cell 9, Fill Cell 8	748,954	735,460	394,710	36,547	7,309
Fill Cell 9 (Close ASH Landfill)	848,493	833,960	425,094	39,361	7,872
Totals	**5,021,673**	**4,951,438**	**2,054,375**	**190,220**	**38,044**

GOLDER
MEMBER OF WSP

CALCULATIONS

Date:	5/24/2021	**Made by:**	TDJ
Project No.:	19132873	**Checked by:**	DJS
Subject:	**PHASING EARTHWORKS AND AIRSPACE**	**Reviewed by:**	GJD

PHASE	**Site Life SOIL BALANCE**	**Site Life SOIL BALANCE**		**LANDFILL LIFE**	**LANDFILL LIFE**
	PHASE	**CUMULATIVE**		**PHASE**	**CUMULATIVE**
	Soil Balance (cy)	**Soil Balance (cy)**		**Expansion Life (Years)**	**Expansion Life (Years)**
(1)	(10)	(11)		(12)	(13)
ASH LANDFILL					
Construct Cell 5 (2018)	-52,354	-52,354		0.0	0.0
Construct Cell 6, Fill Cell 5	-123,563	-175,917		5.0	5.0
Construct Cell 7, Fill Cell 6	-106,243	-229,806		4.1	9.0
Construct Cell 8, Fill Cell 7	-117,174	-223,417		3.7	12.8
Construct Cell 9, Fill Cell 8	-116,005	-233,180		4.6	17.3
Fill Cell 9 (Close ASH Landfill)	-39,361	-155,366		5.2	**22.5**

Burn Rate (ASH) = 265,200 cys per year for 12 years
Burn Rate (ASH) = 161,200 cys per year for 9 years
(rates are based on permitted burn rates)
****CUT/FILL VOLUMES INCLUDE PERIMETER BERM EARTHWORKS.**

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CUT-FILL CELL 6 SUBGRADE	1.000	1.000	372690.71 Sq. Ft.	5004.46 Cu. Yd.	87765.00 Cu. Yd.	82760.54 Cu. Yd.<Fill>
CUT-FILL CELL 7 SUBGRADE	1.000	1.000	302569.25 Sq. Ft.	3060.84 Cu. Yd.	70681.18 Cu. Yd.	67620.33 Cu. Yd.<Fill>
CUT-FILL CELL 8 SUBGRADE	1.000	1.000	314611.37 Sq. Ft.	101.63 Cu. Yd.	82389.04 Cu. Yd.	82287.40 Cu. Yd.<Fill>
CUT-FILL CELL 9 SUBGRADE	1.000	1.000	358012.48 Sq. Ft.	1591.47 Cu. Yd.	81049.15 Cu. Yd.	79457.68 Cu. Yd.<Fill>
Totals			1347883.81 Sq. Ft.	9758.40 Cu. Yd.	321884.36 Cu. Yd.	312125.96 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	-15	-10	
2	-10	-5	
3	-5	0	
4	0	5	
5	5	10	
6	10	15	
7	15	20	
8	20	25	
9	25	30	

NOTE(S)
1. ORIGINAL PERMITTED AND UNCONSTRUCTED CELLS WERE NAMED "CELLS 5 THROUGH 7". 2018 PERMIT UPGRADE CELLS RENAMED "CELLS 5 THROUGH 9".

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

TOP OF SUBGRADE PLAN

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 1
REV. A

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CELL 5 AIRSPACE	1.000	1.000	1024960.08 Sq. Ft.	9.28 Cu. Yd.	1330421.03 Cu. Yd.	1330411.75 Cu. Yd.<Fill>
Totals			1024960.08 Sq. Ft.	9.28 Cu. Yd.	1330421.03 Cu. Yd.	1330411.75 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	0	10	
2	10	20	
3	20	30	
4	30	40	
5	40	50	
6	50	60	
7	60	70	
8	70	80	
9	80	90	

NOTES

1. OPERATIONAL SLOPES SHOWN ON THIS FILL PROGRESSION PLAN SHEET REPRESENT ONE POSSIBLE OPTION FOR OPERATIONAL GRADING. OPERATIONAL GRADES AND TOE OF SLOPES MAY BE CHANGED AT THE OWNER'S DISCRETION BASED UPON STORMWATER MANAGEMENT NEEDS, FILLINGS RATES, OR SAFETY.
2. OPERATIONAL GRADES ON THIS SHEET REPRESENT THE MAXIMUM FILLING SLOPES FOR EACH PROPOSED CELL.
3. THE OWNER MAY CHOOSE TO IMPLEMENT ADDITIONAL LEACHATE AND STORMWATER MANAGEMENT FEATURES, SUCH AS CHIMNEY OR TOE DRAINS, BASED ON OPERATIONAL NEEDS, WITH PRIOR APPROVAL FROM EGLE.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

FILLING PROGRESSION PLAN - SHEET 1

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 2
REV. A

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CELL 6 AIRSPACE	1.000	1.000	693111.96 Sq. Ft.	465.80 Cu. Yd.	1099137.46 Cu. Yd.	1098671.66 Cu. Yd.<Fill>
Totals			693111.96 Sq. Ft.	465.80 Cu. Yd.	1099137.46 Cu. Yd.	1098671.66 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	0	10	
2	10	20	
3	20	30	
4	30	40	
5	40	50	
6	50	60	
7	60	70	
8	70	80	
9	80	90	

NOTES

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2. OPERATIONAL GRADES ON THIS SHEET REPRESENT THE MAXIMUM FILLING SLOPES FOR EACH PROPOSED CELL.
3. THE OWNER MAY CHOOSE TO IMPLEMENT ADDITIONAL LEACHATE AND STORMWATER MANAGEMENT FEATURES, SUCH AS CHIMNEY OR TOE DRAINS, BASED ON OPERATIONAL NEEDS, WITH PRIOR APPROVAL FROM EGLE.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

FILLING PROGRESSION PLAN - SHEET 2

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 3
REV. A

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CELL 7 AIRSPACE	**1.000**	**1.000**	687285.30 Sq. Ft.	228.67 Cu. Yd.	995373.47 Cu. Yd.	995144.80 Cu. Yd.<Fill>
Totals			687285.30 Sq. Ft.	228.67 Cu. Yd.	995373.47 Cu. Yd.	995144.80 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	0	10	
2	10	20	
3	20	30	
4	30	40	
5	40	50	
6	50	60	
7	60	70	
8	70	80	
9	80	90	

NOTES

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REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

FILLING PROGRESSION PLAN - SHEET 3

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 4
REV. A

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CELL 8 AIRSPACE	1.000	1.000	541292.58 Sq. Ft.	379.27 Cu. Yd.	749333.74 Cu. Yd.	748954.47 Cu. Yd.<Fill>
Totals			541292.58 Sq. Ft.	379.27 Cu. Yd.	749333.74 Cu. Yd.	748954.47 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	0	10	
2	10	20	
3	20	30	
4	30	40	
5	40	50	
6	50	60	
7	60	70	
8	70	80	
9	80	90	

NOTES

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REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

FILLING PROGRESSION PLAN - SHEET 4

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 5
REV. A

Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
CELL 9 AIRSPACE	1.000	1.000	608185.12 Sq. Ft.	322.30 Cu. Yd.	836649.33 Cu. Yd.	836327.03 Cu. Yd.<Fill>
Totals			608185.12 Sq. Ft.	322.30 Cu. Yd.	836649.33 Cu. Yd.	836327.03 Cu. Yd.<Fill>

CUT FILL TABLE

NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	0	10	
2	10	20	
3	20	30	
4	30	40	
5	40	50	
6	50	60	
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2. OPERATIONAL GRADES ON THIS SHEET REPRESENT THE MAXIMUM FILLING SLOPES FOR EACH PROPOSED CELL.
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REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
A	2021-05-10	SUBMITTED TO EGLE	DS	DS	GD	TJ	

REFERENCE DRAWINGS

SIGNATURE
NAME
MICHIGAN P.E. No.

Consumers Energy

J.H. CAMPBELL PLANT
WEST OLIVE, MI

FILLING PROGRESSION PLAN - SHEET 5

SCALE: 1" = 100'
JOB: PT-02661
DRAWING NO.
SHEET 6
REV. A

APPENDIX P

USLE Calculation

GOLDER MEMBER OF WSP	SUBJECT	**Surface Water Management - Soil Loss Van Buren South Landfill Expansion**				
	Job No.	19132873	Made By	TDJ	Date	12/30/2020
	Ref.	JHC Landfill Expansion	Checked	GJD		
			Reviewed	TDJ		

OBJECTIVE: To analyze the soil loss for the proposed surface water control berm configuration and spacing. The configuration shall be found acceptable if the annual soil loss is not more than 2 tons/acre/year, in accordance with EGLE Rule 299.4425.(8).

METHOD:

1.) This erosion check shall be performed by using the Universal Soil Loss Equation (USLE). Guidelines presented in the Michigan Department of Environment, Great Lakes and Energy (EGLE), Waste Management Division, "FINAL COVER EROSION CONTROL DESIGN GUIDANCE" (FCECDG) have been used for the selection of all parameters.

2.) A = (R) (C) (K) (LS) (P)

Where:

A	Computed Soil Loss in tons/acre/year
R	Rainfall Energy Factor (as per attached map from ref. 2)
C	Cropping Management Factor (as suggested in ref. 2, based on critical area planting guide)
K	Soil Erodibility Factor (based on soil types determined from ref. 3 and table from ref. 2)
LS	Slope Length / Topographic factor (calculated from design berm spacing and configuration in accordance w/ ref. 2)
P	Erosion Control Practice Factor (as suggested in ref. 2)

3.) These calculations are performed with an assumed topsoil organic content of greater than 2.5%.

GOLDER MEMBER OF WSP	SUBJECT	Surface Water Management - Soil Loss Van Buren South Landfill Expansion				
	Job No.	19132873	Made By	TDJ	Date	12/30/2020
	Ref.	JHC Landfill Expansion	Checked	GJD		
			Reviewed	TDJ		

ASSUMPTIONS / GIVENS:

1.) R = 100 — The rainfall energy factor has been selected from the FCECDG Attachment 1 Michigan County Map, for Ottawa County.

2.) C = 0.007 — The suggested C value is 0.007 (dimensionless) for 95% to 100% soil surface coverage, a topsoil with an organic matter content greater than or equal to 5%, and seeding, mulching, and fertilization practices following recommendations in the NRCS Critical Area Planting Guide.

3.) K = 0.02 — The surface soil in the area of the site is assumed to be mostly SAND.
Soil information was provided by the
National Resource Conservation Service
for Ottawa County, Michigan

4.) LS = 7.88 — The Topographic factor depends on the average slope length for the final cover. The final cover for the JHC Landfill is 25%, and the average slope length between diversion berms is 200 feet. The topographic factor was determined using the attached chart.

5.) P = 1 — Per ref. 2, this factor has been set equal to one.

CALCULATIONS:

1.) Calculate Soil Loss in tons/acre/year.

A = (R) (C) (K) (LS) (P)

A = 0.11 tons/acre/year

CONCLUSIONS:

The proposed final configuration has surface water control berms every 50 vertical feet on a 4(H): 1(V) slope. The berms are inclined at a minimum slope of 2% and located at approximately 200 horizontal feet apart.

The configuration for the surface water control berms has a soil loss of 0.11 tons/acre/year, which satisfies the erosion requirement of < 2 tons/acre/year, as per rule 299.4425 (8). Provide Closure Plan for topsoil to contain >5% organic material. Also, mowing should be conducted two times per year.

REFERENCES:

1.) *Nonpoint Source Pollution Load Techniques* , p. 230

2.) Michigan Waste Management Division, *Final Cover Erosion Control Design Guidance.*

3.) NRCS - Critical Planting Guide.

Critical Area Planting (Acre) 342

DEFINITION

Planting vegetation such as trees, shrubs, vines, grasses, or legumes on highly erodible or critical areas. (Does not include tree planting mainly for wood products.)

PURPOSES

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- To stabilize the soil and thereby reduce damage from sediment and runoff to downstream areas.
- Stabilize sand dunes, shifting sands, or sand areas subject to blowing.

CONDITIONS WHERE PRACTICE APPLIES

On highly erodible or critically eroded areas. These areas usually cannot be stabilized by ordinary conservation treatment and management. If left untreated, can cause severe erosion or sediment damage.

Examples of applicable areas are: dams, dikes, mine spoil, cuts, fills, surface-mined area, sand blown areas and denuded gullied areas, grass waterways, or heavy use areas where vegetation is difficult to establish with usual seeding or planting methods.

This also applies to small concentrated flow areas where the drainage area is five (5) acres or less; and where adequate capacity exists without earth moving.

CRITERIA

General Criteria Applicable To All Purposes

Use grasses or grass-legume mixtures on all earth fill and actively eroding areas (see Table 1 and Table 2). Woody vegetation may be used on less erosive sites where canopy and leaf litter will provide adequate erosion control (see Table 3). Temporary vegetative cover may be used only until long-term protection can be established (see Table 4).

Seed

Seed will be clean and at an acceptable level of weed seed and other contaminants. Bags will be labeled with a germination and purity test completed within the past nine months. Certified seed is preferred. Seed that has become wet, moldy, or otherwise damaged in transit or storage is not acceptable.

Inoculation

Inoculate all legume seed in accordance with the manufacturer's recommendations. The inoculate for treating legume seeds shall be a pure culture of nitrogen-fixing bacteria specifically for the species and shall not be used later than the date indicated on the container or as otherwise specified. A mixing medium, as recommended by the manufacturer, shall be used to bond the inoculate to the seed. All legumes not preinoculated will be inoculated within 12 hours of seeding with inoculate specific to the species being seeded. If seed was preinoculated more than 60 days prior to seeding, reinoculate. When the area is seeded with a hydroseeder or a site where a new legume is seeded for the first time ever, use 5 times the recommended rate of inoculate.

Fertilizer

Lime and fertilizer is needed for the proper establishment and maintenance of critical area seeding. Fertilize according to the soil test results; soil test is recommended, but not necessary. If no soil test see Table 5.

At time of establishment, work lime and fertilizer into the soil either before or during final seedbed preparation. When a hydroseeder is used, the fertilizer may be applied at the time of seeding.

Seedbed Preparation

Seed may be sown by hand, cyclone seeder, mechanical seeders, drills, cultipacker-seeders, hydroseeder, or other suitable equipment.

Plant in a moist, firm seedbed unless the area will be mulched. Place seed from 1/4 inch to not more than 1/2 inch deep. Use a cultipacker to make a firm seedbed. On slopes too steep for farm equipment, tracking type equipment may be used to firm the seedbed.

Where practical, grade to permit use of conventional equipment for seedbed preparation, seeding, mulch application, anchoring, and maintenance.

The seedbed, immediately before seeding, shall be firm but not so compact as to prohibit covering seed or securing adequate germination or root penetration. Tillage implements shall be used as necessary to provide at least a 3 inch depth of firm but friable soil, free of large clods and stones. On slopes steeper than 3:1, the 3 inch minimum depth of seedbed preparation is not required, but the soil shall be worked enough to ensure sufficient loose soil to provide an adequate seed cover.

Where broadcast seeding, the seed will be covered by use of hand rake or by dragging harrows, chains, or other suitable equipment over the surface or mulch to cover the seed.

Mulching

Mulch is extremely important on new seedings on slopes, droughty sands, clayey soils, on areas without topsoil, and areas subject to erosion.

Anchor mulch with one of the following methods: strawy manure, emulsified asphalt, mulch netting, excelsior blanket, and other similar approved products (see Mulching Standard, 484). Anchoring may also be completed by track equipment. This practice is commonly known as cleating.

Planting Dates

To improve chances for success of seeding, follow the prescribed planting dates (see Table 6).

Sodding

Where applicable, sod may be used. Before sodding, control excessive water runoff, grade to a stable slope, prepare site, and apply lime and fertilizer. Fill areas must be compacted to resist uneven settling. Cut areas must be loosened to permit grass root penetration. The surface shall be free from large clods, stones, or other debris. Lime and fertilizer should be uniformly applied and incorporated into the soil surface. Immediately before placing sod, the soil surface shall be loosened to a depth of 1 inch and thoroughly dampened if not already moist. The staking of sod is needed in areas of concentrated flow.

Tree and Shrub Planting

For planting instructions, refer to Tree/Shrub Establishment Standard, 612. See Table 3 for trees and shrubs to plant on critical areas.

Other Ground Covers

Where applicable, other ground covers may be used (see Table 8) on erosive sites where low growing plants are desirable. These plants are typically planted in an urban setting. Most of these plants are not considered to be native to Michigan.

Additional Criteria To Stabilize The Soil And Reduce Damage From Sediment And Runoff To Downstream Areas

Sheet and Rill Erosion Sites

The soil loss must be computed by using RUSLE or the latest soil loss prediction method. The criteria for an eroded site is met when the soil loss tolerance "T" for the soil or map unit listed in the FOTG, Section II, is not exceeded.

Sites Requiring Approved Designs

The following sites must be stabilized using approved designs and specifications:

- Ephemeral and Classic Gully Sites
- Streambank and Shoreline Sites
- Roadbank and Construction Sites
- Heavy Use Areas
- Mine Sites
- Ditch Sites

See the applicable standard in the FOTG, Section IV, for more details.

Small concentrated flow areas may not require approved design.

Critical area planting may be used for small concentrated flow areas when all the following are met:

- The watershed area is five (5) acres or less.
- The watercourse requires no shaping beyond that which can be done by normal tillage equipment for seedbed preparation.
- The planner is assured there is an adequate cross-section for conducting runoff.
- An area of at least 10 feet wide will be seeded.
- See Table 2 for seeding rate.
- Seed only during May 15 to June 15; or August 1 to September 15.

Soil loss computations must be completed using the Gully Erosion Equation or the Channel Erosion Equation.

<u>Additional Criteria To Stabilize Sand Dunes, Shifting Sands, Or Sand Areas Subject To Blowing</u>

The soil loss must be computed by using the Wind Erosion Equation. The criteria for an eroded site is met when the soil loss tolerance "T" for the soil or map unit listed in the FOTG, Section II, is not exceeded.

For planting American Beachgrass: Where wind velocities are high, space clumps 12" x 12" or about 43,000 clumps or 86,000-130,000 culms (culms are a single stem with roots attached, clumps are 2-3 culms) per acre.

Where areas are not exposed to strong winds, space clumps 24" x 24" or about 11,000 clumps or 22,000 to 33,000 culms per acre.

Where trees and other grasses are to be planted in beachgrass after it has controlled sand movement but before the grass becomes too dense (about two years), space trees 6' x 6' to 8' x 8' (see Table 7). For planting instructions, refer to Tree/Shrub Establishment Standard, 612.

Where trees are to be planted in open blow areas without beachgrass, apply a brush mulch. Space trees 6' x 6' to 8' x 8'. Lay brush mulch after trees are planted with the butts to the wind and the tops over the butts.

Blowing areas may also be controlled by planting two or more rows of trees each year, beginning on the windward side and progressing across the area as it is stabilized. Space trees at 4' x 6', staggered in rows.

CONSIDERATIONS

Critical areas of grassed waterways (see Grass Waterway Standard, 412), such as an increase in channel grade, a change to a more erosive soil type, or other erosion problems, will require special attention. The use of jute netting, excelsior blanket, mulchnet, or sod (staked down) should be considered (see Mulching Standard, 484).

Where slopes must be steeper than 2 horizontal to 1 vertical or on slopes with soil slippage problems, vegetation alone cannot be expected to fully stabilize the slope. Consider mechanical retaining walls or rock riprap rather than vegetative cover.

Where slopes are flatter than 2:1, consider a combination of structural practices and soil bio-engineering. When considering soil bio-engineering techniques for protecting critical areas, refer to Engineering Field Handbook, Chapter 18.

Where internal water movement may cause seeps or soil slippage or poor drainage, consider installing subsurface drainage (see Subsurface Drain Standard, 606) before establishing vegetation.

Divert runoff water away from the area being stabilized whenever possible. Control excessive water runoff by grassed waterways, diversions, terraces, street and storm sewers, closed outlets, or other mechanical means.

Provide the best possible soil conditions for seeding. Wherever possible, stock-pile and replace topsoil after grading. Desirable soil textures are sandy loam, loam, or silt loam. Where sands or claycy soils are encountered, consider modifying them with additions of hauled-in materials, add 2-4 inches of topsoil, then apply the fertilizer and prepare a 5 inch deep seedbed.

When considering seeding and fertilization rates, be aware that severely eroded or disturbed sites may have low fertility and few, if any, resident seeds. Higher seeding and fertilizer rates may be needed to ensure adequate vegetative cover.

When the fertilized area is immediately above a water body, the phosphorus maybe reduced to avoid nutrient loading.
Consider permanent exclusion of people, ORV, domestic livestock, and other avoidable disturbances.

This practices is not to be used for general cover plantings such as the Conservation Reserve Program (see Conservation Cover Standard, 327).

If the primary purpose for the activity is for wildlife, refer to Wildlife Upland Habitat Management Standard, 645 and Wildlife Wetland Habitat Management Standard, 644.

PLANS AND SPECIFICATIONS

Plans and specifications are to be prepared for each treatment area and include planting area preparation, species to be planted, methods and rates of planting, planting depth, time of planting, fertilizer requirements, and management or/and establishment requirements.

OPERATION AND MAINTENANCE

An O&M plan for this practice includes:

- Periodic inspection and evaluation of vegetation to determine maintenance needs.
- Replanting due to drought, insects, or other events which prevented adequate stand establishment should be addressed within 1-3 years of planting. Recommendations may vary from complete re-establishment to overseeding or spot planting.
- Maintain all necessary fencing (see Fence Standard, 382), if applicable. Protect the area from grazing by livestock or other uses until the vegetative cover is established.

If possible, as a temporary measure on grassed waterways, divert water out of the channel by a temporary diversion above the waterway and by spoil ridges along the sides of the waterway until the seeding is established.

<u>Maintenance of Planting</u>

Fertilize annually according to the soil test or use Table 5. Fertilization in the fall will aid in controlling annual grasses.

Weeds should be controlled by mowing or herbicides. When spraying, use herbicides according to Michigan State University recommendations and the label. Mow broadleaved weeds or woody growth between August 1 to August 20, where necessary, to maintain grasses and legumes, but late enough to allow wildlife to use the area for nesting. Mowing of the cover will help create a dense sod.

Vehicular traffic must be controlled so as not to leave depressions or deposits of soil which can result in concentrations of water and formation of gullies. Overgrazing by livestock or grazing when wet should not be permitted. If washouts occur, repair by sodding or reseeding.

REFERENCES

USDA-NRCS Technical Note 4b.

USDA-NRCS Plants Projects Internet Sites: http://plants.usda.gov.

Michigan State University Extension Bulletin E-2107.

Table 1 - Agronomic Adaptation and Characteristics of Perennial Vegetation - Michigan

Perennial Species [4] (seeds/lbs in 1000)	Minimum Adequate Drainage[1]	Tolerance to pH < 6.0	Minimum Adequate Fertility	Drought Tolerance	Persistence	Seedling Aggres-siveness	Growth Habit
LEGUMES							
Alfalfa (200)	WD	Low	High to Med	High	High	High	Bunch
Red Clover (272)	SPD	Medium	Medium	Medium	Low	High	Bunch
Birdsfoot Trefoil (375)	SPD	High	Medium	Medium	Medium	Low	Bunch
White Dutch Clover (802)	PD	Medium	Medium	Low	High	Low	Spreading
Ladino Clover (871)	PD	Medium	High to Med	Low	High	Low	Spreading
Sweetclover (260)	MWD	High	Medium	High	Medium	High	Bunch
Alsike Clover (680)	PD	High	Medium	Low	Low	Low	Spreading
Lancer' Perennial Pea (8)	MWD	Low	High to Med	Low	High	Low	Spreading
Lathco' Flatpea (8)	MWD	High	Low	High	High	Low	Spreading
Crownvetch (140)	MWD	Medium	Medium	Medium	High	Medium	Spreading
COOL SEASON GRASSES							
Kentucky Bluegrass (2,177)	SPD	Medium	Medium	Low	High	Low	Dense Sod
Orchardgrass (550)	SPD	Medium	Medium	Medium	Medium	High	Bunch
Perennial Ryegrass (227)	SPD	Medium	Med to High	Low	Low	Very High	Bunch
Reed Canarygrass (533)	VPD	High	Med to High	High	High	Low	Open Sod
Redtop (4,990)	VPD	High	High	Medium	Medium	High	Bunch
Smooth Brome (136)	MWD	Medium	High	High	High	Medium	Open Sod
Tall Fescue (227)	SPD	High	Medium	Medium	High	High	Variable[2]
Timothy (1,230)	MWD	Medium	Medium	Low	High	Low	Bunch
Creeping Red Fescue (615)	MWD	Medium	Medium	High	High	Medium	Dense Sod
American Beachgrass[3]	MWD	High	Medium	High	High	Medium	Spreading
WARM SEASON GRASSES							
Switchgrass (275)	SPD	High	Low to Med	Excellent	High	Very Low	Bunch
Big Bluestem (130)	MWD	High	Low to Med	Excellent	High	Very Low	Bunch
Indiangrass (170)	MWD	High	Low to Med	Excellent	High	Very Low	Bunch
Tioga' Deertongue (400)	MWD	Very High	Very High	High	High	Medium	Bunch
Prairie Sand Reed (274)	MWD	Medium	Low	High	Medium	Medium	Bunch

1. Minimum drainage required for acceptable growth: WD=Well Drained; MWD=Moderately Well Drained; SPD=Somewhat Poorly Drained; PD=Poorly Drained; and VPD=Very Poorly Drained.
2. If not cut often, tall fescue has a bunch growth; under frequent cutting or grazing, it forms a sod.
3. Beachgrass is planted vegetatively.
4. These plant materials are considered to be invasive: Crownvetch, Reed Canarygrass, Smooth Brome, and Birdsfoot trefoil.

Table 2 - Permanent Critical Area Seedings (Waterway-Type Areas, Critical Areas, and Construction Areas)

Seeding Mixture 1,3,4	lbs/acre (/1000 ft^2)	Suitable Uses	Wildlife Value	Drainage	Remarks
Creeping Red Fescue	40 (1.0)	WW,CA,HU,CO	LOW	MWD	
Creeping Red Fescue Kentucky Bluegrass	20 (.5) 20 (.5)	CA, HU, CO	LOW	MWD	For waterways, if management as a lawn.
Creeping Red Fescue Tall Fescue Kentucky Bluegrass Perennial Ryegrass	25 (.6) 20 (.6) 5 (.2) 5 (.2)	CA, HU, CO, FR, WW	LOW	SPD	On soils which have a higher clay content, increase Tall Fescue and reduce Creeping Red Fescue.
Creeping Red Fescue Kentucky Bluegrass Redtop Smooth Bromegrass Timothy Birdsfoot Trefoil	20 (.5) 5 (.2) 1 (.03) 20 (.5) 2 (.05) 10 (.3)	CA, HU, CO	LOW	SPD	
Creeping Red Fescue Redtop Smooth Bromegrass Perennial Ryegrass	20 (.5) 1 (.03) 20 (.3) 5 (.2)	CA, HU, CO	LOW	PD	
Tall Fescue Smooth Bromegrass	15 (.4) 15 (.4)	WW, CA, HU, CO	LOW	SPD	Add 6# of Birdsfoot Trefoil if desired.
Tall Fescue Redtop Perennial Ryegrass	30 (.7) 2 (.05) 5 (.2)	WW, CA	LOW	SPD,MK	For close mowing and for waterways with < 2.0 ft/sec velocity. Add 6# of Birdsfoot Trefoil if desired.
Smooth Bromegrass Birdsfoot Trefoil	15 (.4) 10 (.3)	CA	LOW	SPD	
Tall Fescue Smooth Bromegrass	20 (.5) 20 (.5)	WW	LOW	SPD	
Tall Fescue Crownvetch	10 (.3) 15 (.4)	CA, HU, CO	LOW	MWD	
Reed Canarygrass	10 (.3)	CA, HU, CO	LOW	VPD, MK	
Reed Canarygrass Timothy Redtop	10 (.3) 4 (.1) 1 (.03)	CA, HU, CO	MED	MK	
Smooth Bromegrass	30 (.7)	WW, CA	LOW	MWD	Add 6# of Birdsfoot Trefoil if desired.
Smooth Bromegrass Red Top Perennial Ryegrass	25 (.6) 2 (.05) 5 (.2)	WW	LOW	SPD	Add 6# of Birdsfoot Trefoil if desired.
Timothy Birdsfoot Trefoil	3 (.1) 10 (.3)	CA, HU, CO	MED	MWD	

1. One (1) bushel/acre of rye or wheat or oats; or 5 lbs/acre of annual or perennial rye is highly recommended for adding to the mix for quicker green-up or stabilization. See Table 4 for further details.
2. WW=Waterway Type Areas; CA=Critical Areas; HU=Heavy Use Areas; CO=Construction Areas; and FR=Harvest Trails and Landing Sites.
3. See Table 6 for seeding dates.
4. Use the higher seeding rates for steeper slopes, reclamation areas, or poorer site conditions.
5. Minimum drainage or better required for acceptable growth: WD=Well Drained; MWD=Moderately Well Drained; SPD=Somewhat Poorly Drained; PD=Poorly Drained; and MK=Muck Soils.
6. All warm-season grass seeding rates are listed as pure live seed (PLS).

Table 2 - Permanent Critical Area Seedings (Waterway-Type Areas, Critical Areas, and Construction Areas)

Seeding Mixture 1,3,4	lbs/acre (/1000 ft^2)	Suitable Uses	Wildlife Value	Drainage	Remarks
Big bluestem Prairie Sandreed Little Bluestem	5 (.2) 5 (.2) 5 (.2)	Sand Dune area	HIGH	MWD	Plant after sand is stabilized with beach grass (2 yrs).
American Beachgrass	Planted Vegeta-tively	Sandy areas subject to blowing	MED	WD	To stabilize sand areas subject to blowing refer to Additional Criteria on page 3 for planting information.
Red Top Perennial Ryegrass Orchard Grass Birdsfoot Trefoil	2 (.05) 5 (.2) 1 (.03) 3 (.1)	CA, CU	HIGH	SPD	
Switch Grass Perennial Ryegrass Ladino Clover Orchard Grass	2 (.05) 5 (.2) 3 (.1) 1 (.03)	CA, HU, CO	HIGH	SPD	
Big Bluestem Little Bluestem Switchgrass	2 (.05) 2 (.05) 2 (.05)	CA, CO	HIGH	MWD	
Orchard Grass Ladino Clover Red Top	8 (.25) 2 (.05) 3 (.1)	FR	HIGH	MWD	
Creeping Red Fescue Perennial Ryegrass Red Clover	20 (.5) 6 (.2) 3 (.1)	CO, CA, FR	LOW	MWD	
Lathco' Flatpea Perennial Ryegrass	30 (.7) 20 (.5)	FR	MED	MWD	For shaded Woodland.
Lathco' Flatpea Tall Fescue	20 (.5) 20 (.5)	FR	LOW	MWD	For shaded Woodland.
Crownvetch Tall Fescue Redtop	15 (.4) 20 (.5) 2 (.05)	FR	LOW	MWD	For shaded Woodland.
Birdsfoot Trefoil Timothy	8 (.3) 4 (.1)	FR	HIGH	MWD	For Wooded Edges and Openings.
White Clover Kentucky Bluegrass Timothy	1 (.03) 6 (.2) 2 (.05)	FR	MED	MWD	For Wooded Edges and Openings.
Orchardgrass Ladino Clover Redtop	10 (.3) 2 (.05) 3 (.1)	FR	HIGH	MWD	For Wooded Edges and Openings.
Tioga' Deertongue Birdsfoot Trefoil	8 (.3) 6 (.2)	FR	MED	MWD	For Wooded Edges and Openings.

1. One (1) bushel/acre of rye or wheat or oats; or 5 lbs/acre of annual or perennial rye may be added to the mix for quicker green-up or stabilization.
2. WW=Waterway Type Areas; CA=Critical Areas; HU=Heavy Use Areas; CO=Construction Areas; and FR=Forest Roads and Landing Sites
3. See Table 6 for seeding dates.
4. Use the higher seeding rates for steeper slopes, reclamation areas, or poorer site conditions.
5. Minimum drainage or better required for acceptable growth: WD=Well Drained; MWD=Moderately Well Drained; SPD=Somewhat Poorly Drained; PD=Poorly Drained; and MK=Muck Soils.
6. All warm-season grass seeding rates are listed as pure live seed (PLS).

Table 3 - Trees and Shrubs for Critical Areas (for areas less subject to erosion)

Plant trees in areas less subject to erosion and where the plant canopy and leaf litter will provide adequate erosion control. Space trees 6' x 6' and shrubs 3' x 3'. Stagger seedlings in adjacent rows.

Soil Conditions	Trees	Shrubs
Well and moderately well drained sand and loamy sand (coarse textured soils)	Jack Pine$_1$, Red Pine, White Pine$_1$, Black Locust$_2$, Imperial Carolina Poplar	Hawthorn$_1$, Crabapple$_1$, Serviceberry$_1$, Arnot' Bristly Locust$_2$, Autumn Olive$_{1,2}$
Well and moderately well drained, moderately coarse to moderately fine textured soils (sandy loam, loam silt loam, and clay loam textured soils)	Jack Pine$_1$, Red Pine, White Pine$_1$, Norway Spruce$_1$, White Spruce$_1$, Black Locust$_2$	Gray Dogwood$_1$, Crabapple$_1$, Nannyberry$_1$, Autumn Olive$_{1,2}$
Well and moderately well drained clay and silty clay (fine textured soils)	White Pine$_1$, Norway Spruce$_1$, Black Locust$_2$, White Spruce$_1$	Silky Dogwood$_1$, Crabapple$_1$ Nannyberry$_1$, American Cranberrybush$_1$

1. Indicates species best suited for wildlife food or cover.
2. Indicates species that may be invasive in some areas.

Table 4 - "Temporary Seedings" for Fields or Critical Areas

Seed Mixture	lbs/acre or lbs/1000 ft^2	Planting Zone 1_1	Planting Zone 2_1	Planting Zone 3_1
Oats	96 or 2	4/1 to 9/15	4/15 to 8/1	5/1 to 8/1
Perennial Ryegrass	20 or .5	8/1 to 10/15	6/1 to 8/1	8/1 - 10/1
Sudangrass	40 or 1	6/1 to 7/15	6/1 to 7/15	Not Rec.
Wheat	120 or 3	9/20 to 10/15	9/10 to 10/1	9/10 to 10/1
Cereal Rye	120 or 3	8/1 to 10/15	8/1 to 10/10	8/1 to 11/1
Buckwheat	75 or 2	6/1 to 7/15	6/1 to 7/15	6/15 to 7/15

1. Planting Zones: 1 - Lower Peninsula, South of US 10
   2 - Lower Peninsula North of US 10
   3 - Upper Peninsula

Table 5 - Fertility for Critical Area Type Seedings[1]

Lime	Nitrogen[2]	Phosphorous (P2O5)	Potash (K2O)
As needed per site condition[3]	50- 60 Lbs/Acre 1.25 Lbs/1000 ft sq	50- 60 Lbs/Acre 1.25 Lbs/1000 ft sq	50- 60 Lbs/Acre 1.25 Lbs/1000 ft sq

1. Fertilize according to the soil test results; soil test is recommended, but not necessary. If no soil test, use this Table.
2. For Warm Season Mixes, do not apply Nitrogen.
3. For seedings containing legumes, soils should be limed, if needed, to a pH of 6.5 to 7.0. For seedings without legumes, a pH of 5.5 is adequate.

Table 6 - Seeding Dates for Long-Term Vegetative Cover

Zones	With Irrigation and/or Mulch[1]	Without Irrigation or Mulch	Dormant Seeding with Mulch[2]
Lower Peninsula, South of US 10 MLRA 97, 98, 99, and 111	4/1 to 8/1	4/1 to 5/20 or 8/10 to 10/1	11/1 to freeze-up
Lower Peninsula, North of US 10 MLRA 94-S, 95, and 96	5/1 to 9/20	5/1 to 6/10 or 8/1 to 9/20	10/25 to freeze-up
Upper Peninsula MLRA 92, 93, and 94-N	5/1 to 9/10	5/1 to 6/15 or 8/1 to 9/20	10/25 to freeze-up

1. Grassed waterways shall be seeded and mulched by September 15.
2. A dormant seeding may be made in late fall to germinate in spring. Dormant seedings must be mulched. Do not seed when ground is frozen or snow covered. Do not use a dormant seeding on grassed waterways.

Table 7 - Trees, Shrubs, and Grasses to Plant on Wind Blown Areas[1]

Site Condition	Vegetation to Plant
Grasses to plant on sand dunes, once sand is stable	Prairie Sand Reed[2] at 5 lbs per acre Big Bluestem[2] at 5 lbs per acre Little Bluestem[2] at 5 lbs per acre
Trees to stabilize blowing loamy sands	Red Pine, White Pine[2], Jack Pine[2]
Trees to stabilize blowing sands	Jack Pine[2], Red Pine, "Imperial Carolina" poplar
Trees and shrubs to plant on wet spots of shifting sands	Cottonwood, Shrub Willow[2], American Cranberrybush[2], Nannyberry[2], Red Osier Dogwoods[2]
Trees to plant on sand dunes adjacent to large lakes	White Pine[2], "Imperial Carolina" Poplar, Red Pine, Jack Pine[2]

1. Where trees and other grasses are to be planted in beachgrass after it has controlled sand movement, but before the grass becomes too dense (about two years), space trees 6' x 6' to 8' x 8'. For planting instructions, refer to Tree/Shrub Establishment Standard, 612.
2. Indicates species best suited for wildlife food or cover.

Table 8 - Urban Ground Covers and Shrubs for Critical Areas

Small plants such as bugleweed should be set 4 to 6 inches apart; set larger plants like junipers about 3 to 4 feet apart. Spring is the best planting time. This list of plants is not all inclusive, there are other plants, both native and ornamental that can be considered.

Plant	Height (inch)	Sun	Partial Shade	Shade	Soil	Remarks
Bugleweed (carpet bugle) (Ajuga reptans)	4 to 8	X	X	X	most soils	One of the best perennials; spreads rapidly. Parent plant has deep green foliage, blue flowers. Gaiety and Metallica Crispa varieties have bronze-purple leaves. Silver Beauty's foliage is cream and light green.
Virgina Creeper (Parthenocissus quinquefolia)	Climbs to 20 ft	X	X		sand to loamy clay	Flowers inconspicuous, yellow-green to white. Leaves turn a beautiful scarlet in fall. Berries eaten by game birds and small mammals.
Japanese Spurge (Pachysandra terminalis)	up to 6		X	X	fertile, moist	Universally popular evergreen herb. Some plants have small, spiked white flowers sometimes followed by white berries in the fall. Improved forms: Green Carpet, Silver Edge.
Juniper * (Juniperus horizontalis)	12 to 18	X	X		dry areas	Creeping, soft-textured plant; light green to steel blue needles frequently turn purple in winter.
Juniper * (J. sabina tamariscifolia)	up to 24	X	X		dry areas	Sometimes called Tamarrix Savin juniper. Needlelike silver-green leaves. A good spreader for slopes; use as foreground for deciduous trees or complete ground cover.
Lily-of-the-Valley (Convallaria majalis)	6 to 10	X	X		rich moist	Fragrant white bell-like flowers; Rosea variety has purplish-pink flowers.
Periwinkle (myrtle) (Vinca minor)	up to 6	X	X		moist, well drained	Almost universally used, dislikes humid conditions. Good on slopes, level land, or as a backdrop for bulbs. "Bowles", a superior variety, has glossier leaves, larger blue flowers; Golden Bowles has gold and yellow foliage with white flowers. Invasive plant in the natural forest.
Stonecrop, Goldmoss (Sedum aere)	up to 4	X	X		stoney, sandy, dry	Mats of tiny foliage, good between stepping stones and in crevices. Spreads rapidly and can become a weed in grass. The sedum variety, Dragon's Blood, is known for its reddish-brown inch high foliage and carmine flowers.
Sedum album	up to 4	X	X		sandy, well drained	Forms mats of attractive dark-green to red foliage on creeping stems. Not as likely to invade grass areas as Stonecrop.

* Indicates species best suited for wildlife food or cover.

CRITICAL AREA PLANTING GUIDE ATTACHED

Waste Management Division
Final Cover Erosion Control Design Guidance

The Part 115 rules of Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended require the final cover on Type II landfills be designed to control erosion. Rule 425 states that the slopes of the final cover shall not exceed those necessary to prevent erosion and maintain slope stability. Rule 425(8) further states that the final slope shall not be more than 1 vertical to 4 horizontal at any location and if the final slope is more than 15%, the slope shall include either of the following:

(a) A horizontal terrace which is not less than 15 feet wide on the slope and which is spaced and designed as necessary to control erosion and allow vehicle access to the top of the final cover. The gradient of the terrace shall not be more than 6%.

(b) Other controls that the applicant demonstrates are sufficient to maintain slope stability, prevent erosion, and allow access. The controls shall be sufficient to limit erosion to not more than 2 tons per acre per year based on the Universal Soil Loss Equation (USLE) or other method approved by the director.

U.S. Environmental Protection Agency guidance on landfill final cover design recommends breaking the slope every 20 vertical feet and collecting the accumulated stormwater for erosion-proof transport down the remaining slope in order to meet the performance criteria of not more than 2 tons/acre-year of soil erosion as predicted by the USLE. The Waste Management Division (WMD) will accept using horizontal terraces spaced every 20 vertical feet as meeting the soil loss requirement without demonstration provided that appropriate shallow rooted vegetation is selected, established and maintained. An agronomist/soil scientist should be consulted for the selection, establishment, and care of appropriate shallow rooted vegetation. The drainage swales can be horizontal terraces or stormwater diversion berms that have a backslope of greater than 25%. In order to establish appropriate shallow rooted vegetation, the backslope should not be too steep to mow and otherwise maintain. The WMD has agreed to accept stormwater diversion/control berms as providing equivalent protection to horizontal terraces. The stormwater diversion berms shall be sized so that the flow channel has the capacity to handle the stormwater that is expected to be generated by the area it drains.

If a facility elects a design other than horizontal terraces or stormwater diversion berms spaced on a maximum vertical spacing of 20 feet, the facility must demonstrate, using the USLE, that the performance criteria of not more than than 2 tons/acre-year of soil erosion is met. If the design meets the soil loss criteria of not more than 2 tons/acre-year of soil erosion the alternate design may be approved pursuant to Rule 425(8)(b). Guidance on using the USLE and some recommendations on the design variables are included below.

Regardless of which option the facility elects, Rule 921(2)(d) requires that observations and tests of the other layers of the final cover to ensure that the design specifications are met shall accompany the construction records and an engineer's certification of a unit, or portion of a unit that has received final cover. Further, these activities shall include inspection of the completed cover slope, vegetation, and drainage conduits to ensure that they are in compliance with the specified design. All of the components of the final cover, except the vegetation, can be verified during or immediately after installation of the final cover. Since the vegetation may take a period of time to become established to the level that was assumed in the design, it will be necessary for the owner to conduct periodic inspections during the post-closure period. If the assumed vegetative cover is not achieved after three full growing seasons, the owner shall institute additional measures to establish the intended vegetative cover. The final closure certification may be submitted prior to establishment of the vegetative cover. The post-closure period shall begin as specified in Rule 448(7).

The Michigan Department of Environmental Quality (DEQ) feels that the most effective ways to establish effective vegetative cover are ensuring that the slopes have the most ideal growing conditions possible and providing extra care for the vegetation until it thrives. This will minimize future maintenance activities and provide the best long-term erosion control for the final cover. The proper establishment of landfill cover vegetation is impacted by site preparation, material selection, planting techniques, and maintenance. Proper seedbed preparation is critical to establishing healthy vigorous vegetation. The growing medium most be high quality with an adequate supply of nutrients and good water holding capacity. The seeds that are sown must be appropriate for the anticipated site conditions. The application rate should be large enough so that the seedlings can become adequately established. Mulch should be used to protect the seedbed from erosion before the vegetation is established. The mulch should be applied at a high enough rate to protect the soil surface from rain splash. The mulch should be anchored in place with crimping, mulch tackifiers, or erosion control netting. Proper nutrient balance is essential to establish vegetation as quickly as possible. Fertilization and soil amendments are two excellent ways to provide essential nutrients to landfill cap vegetation. Mowing is vitally important in establishing grass cover systems. Mowing will reduce the amount of volunteer and woody vegetation in a landfill cap. Mowing will help to self sow seeds of the vegetation that is thriving on a landfill cap. Mowing encourages lateral growth of sod forming grasses that propagate by rhizomes. To prevent stressing the vegetation, care should be taken so that mowing will remove no more than 1/3 of the grass height each time that it is mowed. A higher frequency of mowing in the first few growing seasons is usually very effective in establishing the maximum amount of ground cover in the shortest possible time.

There is a Revised Universal Soil Loss Equation (RUSLE) that the Natural Resources Conservation Service (NRCS) has started working with. It still remains to be demonstrated that this revision will prove more applicable to landfill design than the USLE. The RUSLE uses subfactors to calculate many of the different factors described below. The RUSLE has the same basic limitations as the USLE and predicting erosion potential for long steep slopes begins to stretch the method beyond its usefulness. Pursuant to Rule 425(8)(b) the RUSLE method must be approved by the director before use. This approval has not been made. Until the effectiveness of the USLE vs. RUSLE can be gauged, the factors for the USLE that are described below appear to be the best tool that we have to judge the effectiveness of a final cover system with regard to soil erosion.

Using the USLE to Demonstrate Soil Erosion Control

The USLE, as follows, expresses soil loss rate per unit area :

$$A = (R)\ (C)\ (LS)\ (K)\ (P)$$

Where:

A	=	Computed Soil Loss in tons/acre-year	
R	=	Rainfall Energy factor	[Picked by Michigan County]
C	=	Cropping Management factor	[Picked from Table]
LS	=	Slope-Length factor	[Calculated with RUSLE or Equations]
K	=	Soil Erodibility factor	[Picked from Table or Nomograph]
P	=	Erosion Control Practice factor	[Value of 1.0 is used]

The Rainfall Energy factor (R) has been calculated for all of the Michigan counties by the NRCS. A map of these factors calculated by county has been included in attachment 1. The **R** factors are based on recent rainfall data.

The DEQ suggests that a sound approach to estimating the **C** factor would be to use a value corresponding to 80%, 90%, or 95% - 100% soil surface coverage (depending on seeding rates, mulching rates, fertilization, mowing and topsoil organic content) with an adjustment for the weed component. The corresponding **C** factor would range from 0.007, at a minimum, to a possible higher number based upon local conditions and vegetative care plans. The table below summarizes recommended care and preparation steps to achieve each **C** factor and the maximum swale separation to be used for design purposes. The care and preparation steps summarized with each **C** factor are efforts that the DEQ believes will achieve the corresponding ground cover estimates. There are so many different permutations of site preparation, materials utilized and vegetative care that it is not practical to enumerate all of them. Different combinations may be approved as long as the facility is able to demonstrate equivalent erosion protection and that the design assumptions made are achieved.

DEQ Design Recommendations

Ground Cover Estimate		Suggested C value	Maximum Separation
95% - 100%			
Topsoil :	organic matter ≥ 2.5%		
Seeding :	NRCS Critical Area Planting Guide		
Mulching :	NRCS Critical Area Planting Guide	0.007	60' vertical if $A \leq 2.0$
Fertilization :	NRCS Critical Area Planting Guide		
Mowing :	Minimum of two annually		
90%			
Topsoil :	1.25% ≤ organic matter < 2.5%		
Seeding :	NRCS Critical Area Planting Guide		
Mulching :	NRCS Critical Area Planting Guide	0.014	60' vertical if $A \leq 2.0$
Fertilization :	None Prescribed		
Mowing :	Minimum of one annually		
80% or Less			
Topsoil :	organic matter < 1.25%		
Seeding :	NRCS Critical Area Planting Guide	0.028 or higher depending on local conditions	
Mulching :	NRCS Critical Area Planting Guide		60' vertical if $A \leq 2.0$
Fertilization :	None Prescribed		
Mowing :	None Prescribed		

The actual level of coverage of the vegetation will need to be measured on the final cover to ensure that the design assumptions are being met. It may be advisable to include a provision for repairing the final cover vegetation if the level of growth does not correspond with the design assumptions after a reasonable time period. If the level of coverage is not being achieved, extra care for the vegetation should be considered before the final cover is repaired. The facility should consult with an agronomist/soil scientist to pursue the most appropriate measures to remedy inadequate growth.

The Length/Slope factor (**LS**) is a rough measure of the available potential energy for runoff. The previous method for calculating the **LS** factor has been found through experimental data to over predict erosion on control plots. The new method for calculating the **LS** factor is based on research by D. K. McCool et al. **LS** can be read from the table in attachment 2 for simple slopes. **LS** can also be calculated using the following equations :

LF	$= (0.0138\,\lambda)^m$ or $(\lambda / 72.6)^m$ for uniform slopes	(1)
m	$= (2(11.16 \sin\theta / 3(\sin\theta)^{0.8} + 0.56)) / (1 + (2(11.16 \sin\theta / 3(\sin\theta)^{0.8} + 0.56)))$	(2)
SF	$= 16.8 \sin\theta - 0.5$ for slopes $> 15'$ or $3(\sin\theta)0.8 + 0.56$ for slopes $< 15'$	(3)
LS	$= (LF)(SF)$ for uniform slopes	(4)
LS_i	$= \dfrac{SF_i(\lambda_i^{m+1} - \lambda_{i-1}^{m+1})}{(\lambda_i - \lambda_{i-1})(72.6)^m}$	(5)
LS	$= \dfrac{\sum[LS_i(\lambda_i - \lambda_{i-1})]}{\lambda_{total}}$	(6)

Where :

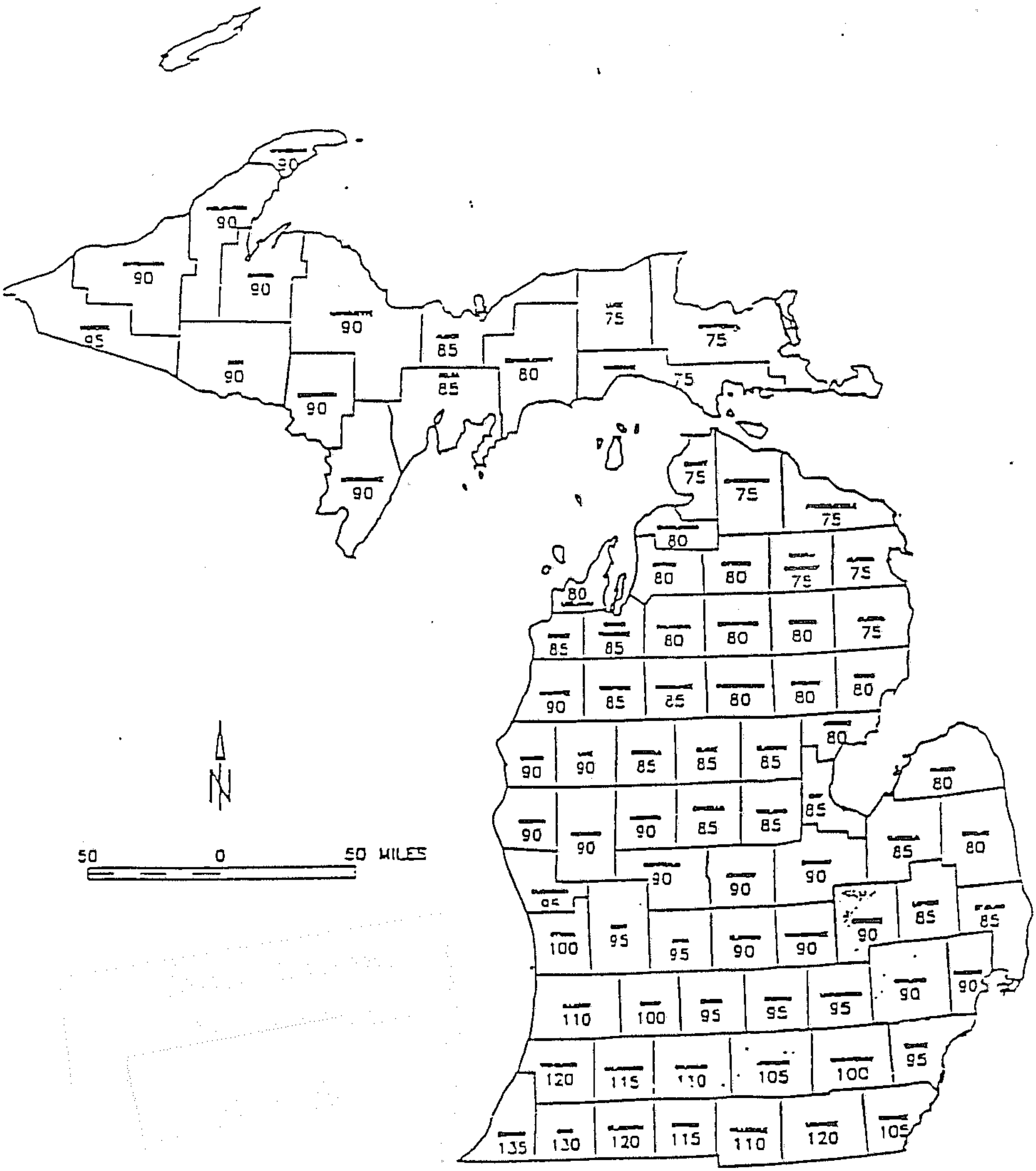
λ	=	Horizontal length of slope in feet (e.g. Slope Length·cos (atan (Slope %)))
θ	=	Slope Angle (e.g. atan (Slope %))
LF	=	Length factor
SF	=	Slope factor
λ_{total}	=	Total horizontal length of complex slope
LS_i	=	Effective LS factor for each slope segment
λ_i	=	Horizontal length from the top of the slope to the bottom of the segment
λ_{i-1}	=	Horizontal length from the top of the slope to the top of the segment

Note 1: *Equation 1 is valid for slopes greater than 9%. Values for slopes greater than 18% and/or 300 feet in length are extrapolations from experimental data.*
Note 2: *These equations make for easier calculation since precise LS factors can be calculated from design slopes and lengths easily with a spreadsheet or calculator.*
Note 3: *The LS factor for complex slopes can be calculated from design slopes and lengths using equations 2, 3, 5, & 6*
Note 4: *At slope lengths longer than approx. 200 - 300' the primary erosional process is gully erosion due to channelized flow. The USLE does not account for gully erosion. It is recommended that design slope lengths should be less than 200' - 300' long.*

The Soil Erodibility factor (K) is dependent on the soil's properties, both physical and chemical. This factor can be estimated based on the U.S. Department of Agriculture (USDA) Textural Classification or it can be estimated from a soil erodibility nomograph. The K factor that is most appropriate for the on-site soils should be obtained from either the approximation of K values based on the USDA Textural Classification and the organic content or the K factor nomograph. Both of these methods are included in attachment 3. Adequate topsoil testing should be provided to ensure that the **K** value is appropriate for the site.

The Erosion Control Practice factor (*P*) is based on surface preparation on the slopes. This factor is primarily applied to tilling practices on a farm field. *P* would be more applicable if the USLE were calculated for a facility using a **C** factor = 1.0 (e.g. no vegetative cover). *P* = 1.0 should be used for landfill design.

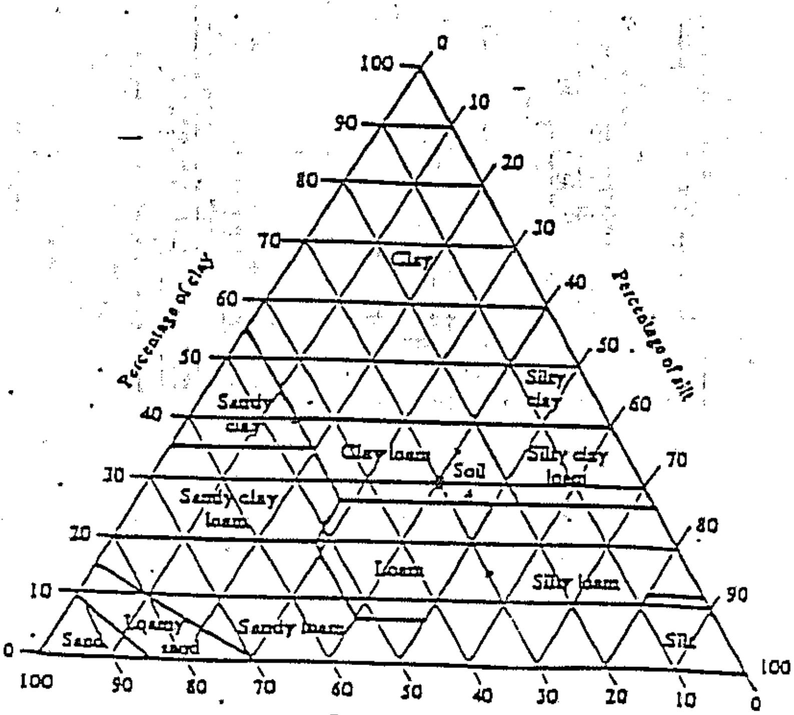
Waste Management Division
Final Cover Erosion Control Design Guidance
Attachment 1



APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES

Texture class	Organic matter content <0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13–0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.



U.S. Department of Agriculture textural classification

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Ottawa County, Michigan

JH Campbell

April 22, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


86° 11' 23" W
86° 10' 55" W
42° 54' 57" N
42° 54' 44" N
566130
566200
566270
566340
566410
566480
566550
566620
566690
566760
4751780
4751710
4751640
4751570
4751500
4751430
PlfabB
PlfabD
CovabB
PlfabB
PlfacF
PlfabB
Polk St
CovabB
PlfabB
Soil Map may not be valid at this scale.
Map Scale: 1:2,970 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 40 80 160 240
Feet
0 100 200 400 600
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Ottawa County, Michigan
Survey Area Data: Version 14, Sep 16, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Oct 20, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CovabB	Covert-Pipestone sands, 0 to 6 percent slopes	4.7	10.3%
PlfabB	Plainfield sand, lake plain, 0 to 6 percent slopes	26.9	59.2%
PlfabD	Plainfield sand, lake plain, 6 to 18 percent slopes	1.3	2.9%
PlfacF	Plainfield sand, dunes, 18 to 60 percent slopes	12.5	27.6%
Totals for Area of Interest		**45.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Ottawa County, Michigan

CovabB—Covert-Pipestone sands, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2rfgw
Elevation: 580 to 830 feet
Mean annual precipitation: 33 to 37 inches
Mean annual air temperature: 46 to 48 degrees F
Frost-free period: 129 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Covert and similar soils: 69 percent
Pipestone and similar soils: 19 percent
Minor components: 12 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Covert

Setting

Landform: Outwash plains, nearshore zones (relict)
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Talf, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciolacustrine deposits

Typical profile

A - 0 to 8 inches: sand
E - 8 to 13 inches: sand
Bs1 - 13 to 18 inches: fine sand
Bs2 - 18 to 29 inches: sand
BC - 29 to 47 inches: fine sand
C - 47 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 59.98 in/hr)
Depth to water table: About 18 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A/D
Ecological site: Acidic Sandy Flatwoods (F097XA006MI), Acidic Sandy Depression (F096XB021MI)

Hydric soil rating: No

Description of Pipestone

Setting

Landform: Nearshore zones (relict), outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciolacustrine deposits

Typical profile

A - 0 to 2 inches: sand
E - 2 to 4 inches: sand
Bs1 - 4 to 13 inches: sand
Bs2 - 13 to 19 inches: sand
BC - 19 to 28 inches: fine sand
C - 28 to 80 inches: sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 59.98 in/hr)
Depth to water table: About 6 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A/D
Ecological site: Acidic Sandy Flatwoods (F097XA006MI), Acidic Sandy Depression (F096XB021MI)
Hydric soil rating: No

Minor Components

Plainfield, high ecological site

Percent of map unit: 7 percent
Landform: Outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Kingsville

Percent of map unit: 2 percent
Landform: Nearshore zones (relict), outwash plains
Landform position (three-dimensional): Dip, rise
Down-slope shape: Linear
Across-slope shape: Linear

Hydric soil rating: Yes

Kaleva

Percent of map unit: 1 percent
Landform: Outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Saugatuck

Percent of map unit: 1 percent
Landform: Outwash plains, nearshore zones (relict)
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Acidic Sandy Flatwoods (F097XA006MI)
Hydric soil rating: No

Covert, stratified substratum

Percent of map unit: 1 percent
Landform: Nearshore zones (relict)
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

PlfabB—Plainfield sand, lake plain, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2w4kc
Elevation: 580 to 750 feet
Mean annual precipitation: 30 to 41 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Plainfield, lake plain, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plainfield, Lake Plain

Setting

Landform: Nearshore zones (relict)
Landform position (two-dimensional): Shoulder, summit

Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear
Parent material: Sandy glaciolacustrine deposits

Typical profile

A - 0 to 8 inches: sand
Bw - 8 to 27 inches: sand
BC - 27 to 35 inches: sand
C - 35 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 0.1 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Minor Components

Brems

Percent of map unit: 8 percent
Landform: Nearshore zones (relict)
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Kaleva

Percent of map unit: 4 percent
Landform: Nearshore zones (relict)
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Brethren

Percent of map unit: 2 percent

Landform: Nearshore zones (relict)
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Spinks

Percent of map unit: 1 percent
Landform: Nearshore zones (relict)
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear
Hydric soil rating: No

PlfabD—Plainfield sand, lake plain, 6 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2w5ll
Elevation: 580 to 760 feet
Mean annual precipitation: 30 to 41 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Plainfield, lake plain, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plainfield, Lake Plain

Setting

Landform: Dunes, beach ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Head slope, nose slope, side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear, concave
Parent material: Eolian sands

Typical profile

A - 0 to 6 inches: sand
Bw - 6 to 25 inches: sand
BC - 25 to 33 inches: sand
C - 33 to 80 inches: sand

Properties and qualities

Slope: 6 to 18 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 0.1 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Minor Components

Brems

Percent of map unit: 5 percent
Landform: Dunes, beach ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave, convex
Hydric soil rating: No

Kaleva

Percent of map unit: 3 percent
Landform: Dunes, beach ridges
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Head slope, nose slope, side slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, concave, convex
Ecological site: Sandy Lake Plain (F097XA004MI)
Hydric soil rating: No

Thompsonville

Percent of map unit: 2 percent
Landform: Dunes, beach ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave, convex
Hydric soil rating: No

PlfacF—Plainfield sand, dunes, 18 to 60 percent slopes

Map Unit Setting

National map unit symbol: 2ptc2
Elevation: 580 to 810 feet
Mean annual precipitation: 30 to 36 inches
Mean annual air temperature: 46 to 48 degrees F
Frost-free period: 140 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Plainfield, dune, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Plainfield, Dune

Setting

Landform: Dunes on lake plains
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, crest, nose slope, head slope
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Eolian sands

Typical profile

AE - 0 to 2 inches: sand
E - 2 to 4 inches: sand
Bs1 - 4 to 8 inches: sand
Bs2 - 8 to 18 inches: sand
BC - 18 to 24 inches: sand
C - 24 to 80 inches: sand

Properties and qualities

Slope: 18 to 60 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Ecological site: Sand Hills (F097XA010MI)
Hydric soil rating: No

Minor Components

Plainfield, dune

Percent of map unit: 14 percent
Landform: Dunes on lake plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope, rise
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Platteriver

Percent of map unit: 5 percent
Landform: Dunes on lake plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Dune land

Percent of map unit: 1 percent
Landform: Dunes
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Side slope, base slope, head slope, nose slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: Unranked

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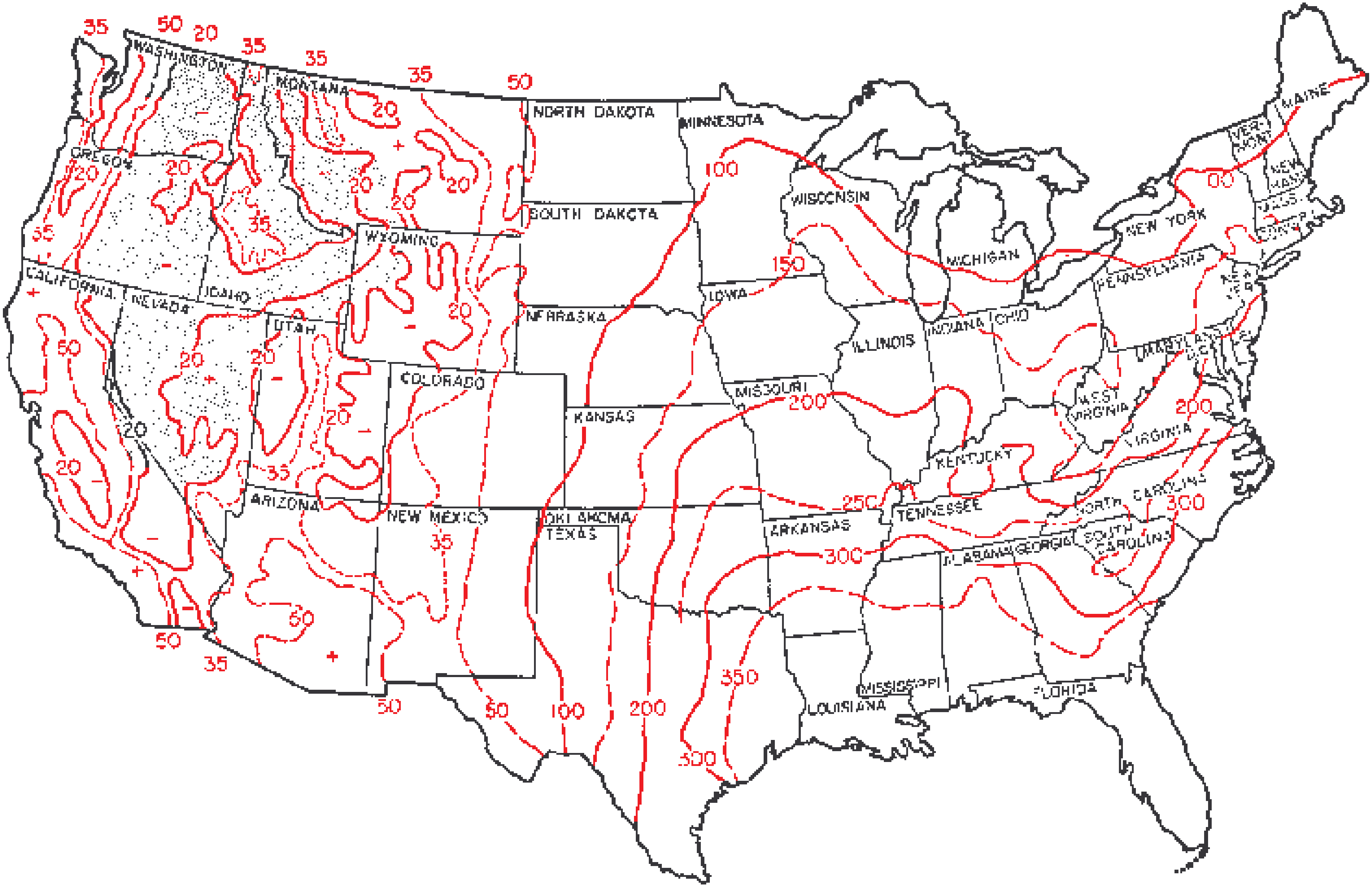
Universal Soil Loss Equation:

(Wischmeier and Smith)

A = RKLSCP

A	**=**	**Computed soil loss per unit area (tons per acre)**
R	**=**	**Rainfall factor**
		# of erosion index units in a normal year's rain. Erosion index is a measure of the erosive force of a specific rainfall
K	**=**	**Soil erodability factor**
		erosion rate/unit of erosion index for a specific soil in cultivated continuous fallow on a 9% slope 72.6 feet long
L	**=**	**Slope length factor**
		ratio of soil loss from the filed slope length to that from a 72.6-foot length on the same soil type and gradient
S	**=**	**Slope gradient factor**
		ratio of soil loss from the field gradient to that from a 9% slope
C	**=**	**Cropping management factor**
		ratio of soil loss from a field with specified cropping and management to that from the fallow condition on which the factor K is evaluated
P	**=**	**Erosion control management factor**
		ratio of soil loss with contouring, strip cropping or terracing to that with straight-row farming, up and down slope


WASHINGTON
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NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
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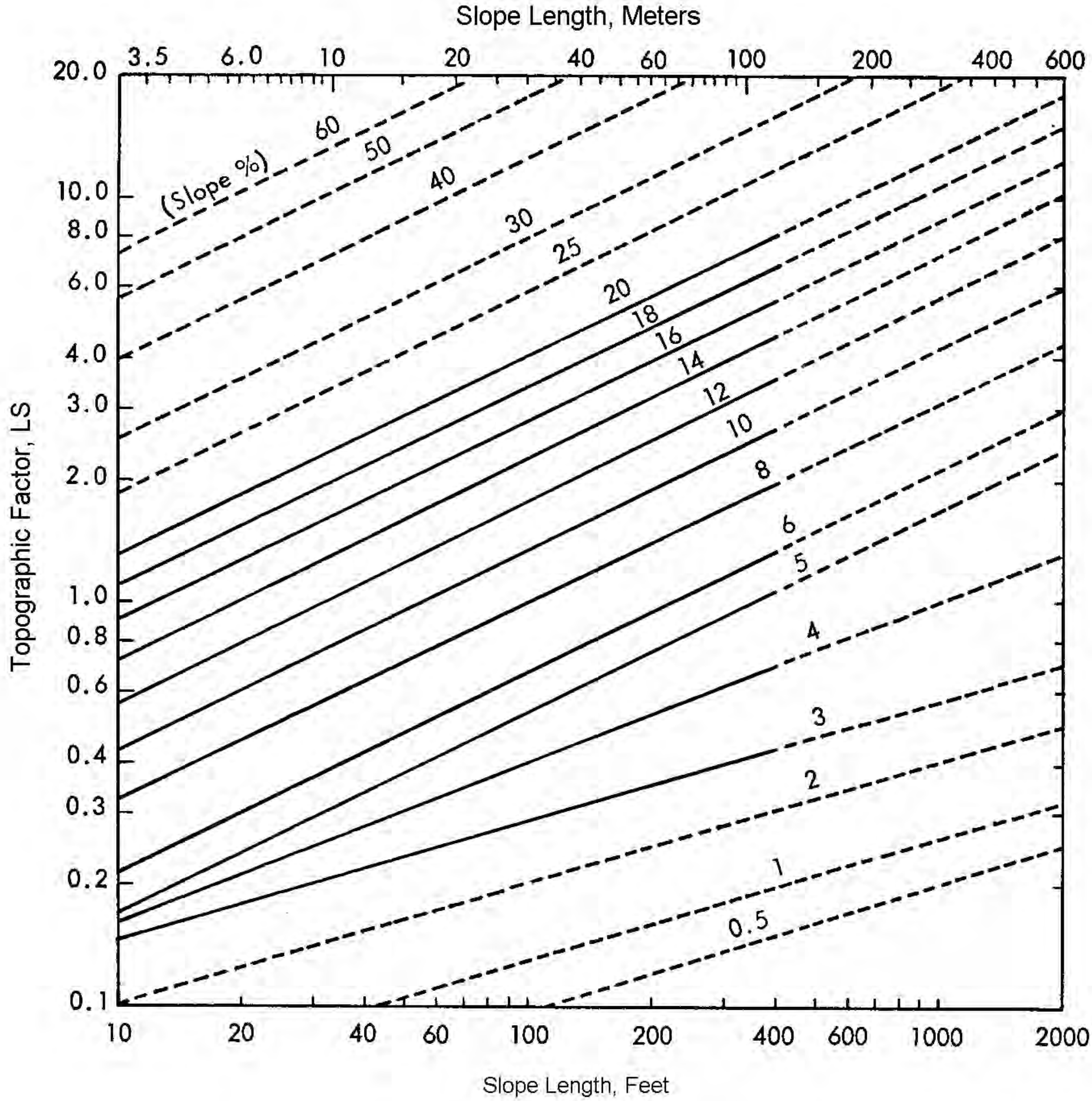
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
MARYLAND
PENNSYLVANIA
NEW YORK
MAINE

Computed K Values for Soils on Erosion-Research Stations

Soil	Source of Data	Computed K
Dunkirk silt loam	Geneva, N.Y.	0.69[a]
Keene silt loam	Zanesville, Ohio	0.48
Shelby loam	Bethany, Mo.	0.41
Lodi loam	Blacksburg, Va.	0.39
Fayette silt loam	LaCrosse, Wis.	0.38[a]
Cecil sandy clay loam	Watkinsville, Ga.	0.36
Marshall silt loam	Clarinda, Iowa	0.33
Ida silt loam	Castana, Iowa	0.33
Mansic clay loam	Hays,Kans.	0.32
Hagerstown silty clay loam	State College, Pa.	0.31[a]
Austin clay	Temple, Tex.	0.29
Mexico silt loam	McCredie, Mo.	0.28
Honeoye silt loam	Marcellus, N.Y.	0.28[a]
Cecil sandy loam	Clemson, S.C.	0.28[a]
Ontario loam	Geneva, N.Y.	0.27[a]
Cecil clay loam	Watkinsville, Ga.	0.26
Boswell fine sandy loam	Tyler, Tex.	0.25
Cecil sandy loam	Watkinsville, Ga.	0.23
Zaneis fine sandy loam	Guthrie, Okla.	0.22
Tifton loamy sand	Tifton, Ga.	0.10
Bath flaggy silt loam with surface stones 2 inches removed	Arnot, N.Y.	0.08,
Albia gravelly loam	Beemerville, N.J.	0.03

From Wischmeier and Smith, 1965.

[a] Evaluated from continuous fallow. All others were computed from row crop data.



Dashed lines represent estimates for slope dimensions beyond the range of lengths and steepnesses for which data are available

RELATIVE PROTECTION OF GROUND COVER AGAINST EROSION
(in order of increasing C factor)

Land-use groups	Examples	Range of "C" values
Permanent vegetation	Protected woodland Prairie Permanent pasture Sodded orchard Permanent meadow	0.0001 -- 0.45
Established meadows	Alfalfa Clover Fescue	0.004 -- 0.3
Small grains	Rye Wheat Barley Oats	0.07 -- 0.5
Large-seeded legumes	Soybeans Cowpeas Peanuts Field peas	0.1 -- 0.65
Row crops	Cotton Potatoes Tobacco Vegetables Corn Sorghum	0.1 -- 0.7
Fallow	Summer fallow Period between plowing and growth of crop	1.0

Practice factor values for contouring

Land slope, %	P value
1.1 to 2	0.60
2.1 to7	0.50
7.1 to 12	0.60
12.1 to 18	0.80
18.1 to 24	0.90

APPENDIX Q

Closure Plan

REPORT

Appendix Q - Closure Plan

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion Facility ID 395496

Submitted to:

Consumers Energy Company
J.H. Campbell Generating Facility
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50, Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

Table of Contents

TABLES

1.0 INTRODUCTION

In accordance with Act 451, Part 115 requirements, a closure plan has been prepared for the facility that describes the steps necessary to close the landfill unit at any point during the active life. These closure activities include placement of final cover, installation of stormwater management facilities, and notification procedures. The objective of the closure plan is to describe the methods and procedures necessary for partial and final closure. Partial closure may commence when a sufficient area reaches final grade but will typically be delayed allowing settlement and potential placement of additional waste fill. The final closure configuration is shown on Sheet 400-3 of the Engineering Drawings.

This Closure Plan is to be used in conjunction with the approved engineering design plans and engineering report. All design criteria and specifications for the final cover are included within those documents. Once the closure plan is approved, any modification to the plan will be subject to approval by the director of the Michigan Department of Environment, Great Lakes and Energy (EGLE) pursuant to Part 115 Rule 299.4446 (2).

Additionally, on April 17, 2015, the United States Environmental Protection Agency (EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule") to regulate the beneficial use and disposal of CCR materials generated at coal-fired electrical power generating complexes. In accordance with the CCR RCRA Rule, any CCR surface impoundment or CCR landfill that was actively receiving CCRs on the effective date of the CCR RCRA Rule (October 19, 2015) was deemed to be an "Existing CCR Unit" on that date and subject to self-implementing compliance standards and schedules. Consumers Energy Company (CEC) currently operates the Dry Ash Landfill CCR unit (Dry Ash Landfill) at the J.H. Campbell Generating Facility (JHC). JHC is located in West Olive, Michigan as presented in this Construction Permit Application (CPA) Engineering Drawings Sheet 200-1.

The Dry Ash Landfill was permitted as a Type III landfill by the Michigan Department of Natural Resources (MDNR) in 1993 and is licensed under State of Michigan Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 115). Construction began in 1997 and, to date, five cells (Cells 1 through 5) have been constructed. CCR is currently being placed in Cells 4 and 5. Cells 6 through 9 will be constructed in the future. Cells 1, 2, 3 and areas of Cell 4 have been closed in six closure phases occurring from 2006 through 2019 as summarized in Table 1 – Summary of Previous Closure Phases. The final closure plan is provided in the CPA Engineering Drawings Sheet 400-3.

Table 1: Summary of Previous Closure Phases

Phase	Year Completed	Areas Closed
Closure Phase I	2006	Northern area of Cells 1 and 2
Closure Phase II	2007	Southeast area of Cell 2 and northeast area of Cell 3
Closure Phase III	2009	East and southeast area of Cell 3
Closure Phase IV	2012	Southeast area of Cell 2 and central northeast area of Cell 3
Closure Phase V	2014	Southern area of Cell 2
Closure Phase VI	2019	Remainder of Cell 3 and West area of Cell 4

This written closure plan is being generated pursuant to 40 CFR 257.102(a) and describes the steps necessary to close the JHC Dry Ash Landfill consistent with recognized and generally accepted good engineering practices. This closure plan is being prepared with the assumption that the Dry Ash Landfill will not receive waste beyond December 31, 2040 when JHC is estimated to be closed and decommissioned. Once the closure plan is approved, any modification to the plan will be subject to approval by the director of the Michigan Department of Environment, Great Lakes and Energy (EGLE) pursuant to Part 115 Rule 299.4446 (2).

2.0 NARRATIVE DESCRIPTION [40 CFR 257.102(B)(1)(I,III-V)]

The JHC Landfill will be closed with CCR in place and capped with a final cover system. Design grades will be reached with construction of a 2.5-foot-thick final cover system designed with a minimum two percent top slope and 25-percent side slopes to meet performance standard requirements per 40 CFR 257.102(d)(3)(ii). Details of the closure construction are provided in the following sections.

2.1 Dry Ash Landfill CCR Quantity [40 CFR 257.102(b)(1)(iv)]

CEC is submitting a Solid Waste Disposal Area CPA for proposed expansion of the facility to provide additional Type III solid waste capacity. The expansion is to include an estimated additional 532,000 cubic yards of disposal volume to be placed within the southwest quadrant of the existing landfill. As such, the lateral extent of the landfill solid waste boundary will remain unchanged. As part of the construction permit modification that was approved by EGLE in 2018, airspace was lost from the re-design of the floor grades in Cells 5 through 9 within the currently permitted footprint. An expansion within the currently permitted solid waste boundary is proposed to regain the lost airspace and to provide sufficient capacity for the remaining life of the generating facility. The proposed expansion will result in a total disposal volume of approximately 10,032,000 cubic yards (9,500,000 cubic yards + 532,000 cubic yards) when combined with the existing disposal area. The proposed increase in airspace will provide an estimated additional 2 years of site life with a total remaining site life of approximately 22.5 years.

2.2 Dry Ash Landfill Final Cover Area [40 CFR 257.102(b)(1)(v)]

For closure planning purposes as described in Section 3.2, the largest area of the CCR unit ever requiring a final cover would be approximately 20.5 acres.

2.3 Closure Construction Sequence [40 CFR 257.102(b)(1)(i,iii) and 40 CFR 257.102(d)(1)]

The remaining active areas of the Dry Ash Landfill will continue to be closed in phases. Once an area has reached planned final grade, it will be closed with CCR in place and capped with a final cover system. Design and construction of the final cover system are discussed in the following sections.

2.3.1 Final Cover System Design and Performance [40 CFR 257.102(b)(1)(iii) and 40 CFR 257.102(d)(3)]

The final cover system will be 2.5-feet-thick and consist of a 40-mil linear low-density polyethylene (LLDPE) textured geomembrane (infiltration layer) overlain with a two-foot-thick layer of fine to medium grained, well sorted sand (erosion layer). To protect the geomembrane from damage, low ground pressure equipment will be utilized to spread the erosion layer, if required. The erosion layer material will generally be placed in a single lift. The erosion layer will be overlain with a six-inch-thick vegetative layer. The vegetative layer consists of topsoil, seed, fertilizer, and mulch in accordance with Michigan Department of Transportation (MDOT) Standard Specification

816 – Turf Establishment. Typical details of the final cover system are provided on CPA Engineering Drawings Sheet 500-8.

Together, the final cover system is designed to:

- Control runoff
- Minimize the need for maintenance
- Control, minimize, or eliminate post-closure infiltration of liquids
- Minimize releases of CCR and leachate into ground and surface waters or the atmosphere
- Prevent the sloughing or movement of the liner

The system is designed with a minimum two percent slope on the top deck and 4H:1V side slopes with diversion berms to:

- Prevent/limit the future impoundment of water, sediment, and slurry
- Minimize erosion
- Prevent/control the release of waste
- Limit the effects of settlement/subsidence

2.3.2 Final Cover Construction [40 CFR 257.102(b)(1)(i)]

The Dry Ash Landfill will be filled to permitted grade with CCR. Once CCR has been placed to design grades, the final cover system described in Section 2.3.1 will be constructed and tested to confirm it meets the requirements of the designed final cover. The final cover system is presented on CPA Engineering Drawings Sheet 400-3. Waste grades will be checked by field survey to ensure that the elevation does not deviate by more than 1 foot above the design grade per Rule 299.4921(4)(d).

2.3.3 Surface Water Management

A surface water management system shown on Sheet 700-1 of the CPA Engineering Drawings will be installed as soon as practical after the final cover is in place to collect and route surface water runoff from the facility. The system includes diversion berms linked to downchutes which will convey surface water runoff through manholes and culverts to the landfill perimeter ditches.

3.0 SCHEDULE [40 CFR 257.102(B)(1)(IV)]

This Closure Plan was prepared assuming the Dry Ash Landfill at JHC will continue to receive CCR through 2040 when the generating facility has been closed and decommissioned. In order to close the Dry Ash Landfill during a typical summer construction season and within the six-month timeframe required by 40 CFR 257.102(f)(1)(i), it is assumed for the purpose of this closure plan, that the Dry Ash Landfill will receive its final receipt of waste on April 1, 2040 and initiate closure of remaining unclosed areas by May 1, 2040.

Additionally, it is assumed that active areas of the Dry Ash Landfill will continue to be closed sequentially as they reach permitted grades and that a maximum area of 20.5 acres will remain to be covered at final closure. Part 115 Rule 299.4448(4) requires final closure to begin within 30 days after the date on which the unit receives the known final amount of waste. In accordance with 40 CFR 257.102(f)(1)(i) and Part 115 R 299.4317, the closure activities are expected to be completed within six months of the notification for intent to initiate closure.

3.1 Closure Construction Schedule

The closure construction schedule is developed assuming that the last active portion of the Dry Ash Landfill will not be in excess of 20.5 acres. The CPA Engineering Drawings Sheet 400-4 through 400-8 show the JHC Landfill fill progression plan. As cells are developed, the amount of waste placed and life of each cell depends on a variety of factors such as incoming volume, compaction factor, and vertical height obtainable. As a landfill begins operations, the initial cells can only be partially filled until additional floor space is open and the maximum vertical height can be achieved.

As of this application, the constructed disposal area at WMRDF totals 43.4-acres, and 33.5-acres has received final cover. The estimated closure schedule presented in Table 2. This schedule is only an estimate, and several factors could affect the time frames and final cover increments, including waste receipts, waste settlement effects, operational changes and future designs. Based on the anticipated landfill life under this design, final closure of the landfill is estimated to occur in the year 2046. The last increment of final cover to be constructed is estimated to be approximately 20.5 acres.

Table 2: Approximate Closure Schedule

Year	Constructed Cell Designation	Active Developed Acres	In-Place Closed Final Cover Acres
0 (2020)	Cells 1 through 5	43.4	33.5
1 (2021)	Cell 6	7.2	0
2 (2022)	n/a	0	10
3 (2023)	n/a	0	0
4 (2024)	n/a	0	0
5 (2025)	n/a	0	10
6 (2026)	Cell 7	6.2	0
7 (2027)	n/a	0	0
8 (2028)	n/a	0	10
9 (2029)	n/a	0	0
10 (2030)	Cell 8	6.3	0
11 (2031)	n/a	0	10
12 (2032)	n/a	0	0
13 (2033)	n/a	0	0
14 (2034)	Cell 9	7.5	0
15 (2035)	n/a	0	0
16 (2036)	n/a	0	10
17 (2037)	n/a	0	0
18 (2038)	n/a	0	0
19 (2039)	n/a	0	0
20 (2040)	n/a	0	0
21 (2041)	n/a	0	0

Year	Constructed Cell Designation	Active Developed Acres	In-Place Closed Final Cover Acres
22 (2042)	n/a	0	20.5
		Total Closed Acres = Year 22 =	**104.0**

Notes:

1. The area filling reported in this calculation for Cells 6 through 9 includes the expansion airspace gained with this construction permit application.
2. This schedule is an estimate only, and several factors could affect the time frames and final cover increments, including waste receipts, waste settlement effects, operational changes and future designs.
3. Acreage is approximate.

To estimate the number of workdays required during closure, the following unit rates were applied to determine approximate closure quantities anticipated for each closure component, assuming a maximum 20.5-acre increment the last year. Table 3 – Closure Schedule Production Estimate indicates that 20.5 acres could be effectively closed within six months as required by 40 CFR 257.102(f)(1)(i).

Table 3: Approximate Closure Construction Schedule - 20.5 acres

Type III Cap Component	Quantity	Units	Construction Rate per day	Rate Units	20.5 acres - Required Time in Days
Ash Grading Layer (12-inch thick)	33,073	cubic yards	3,500	cubic yards per day	9
40-mil LLDPE Cap Geomembrane	892,980	square feet	60,000	square feet per day	15
24-inch-thick Erosion Layer plus piping	66,147	cubic yards	3,000	cubic yards per day	22
6-inch-thick Topsoil Layer	892,980	square feet	100,000	square feet per day	9
Seed, fertilizer, mulch	892,980	square feet	300,000	square feet per day	3
				Workdays Required =	**58**

It is anticipated that closure construction will begin on or before May 1, 2040 in order to comply with the closure schedule. Conservatively assuming a start to finish construction schedule, the final cover construction will take approximately 16 weeks. Using these assumptions results in completion of the final cover construction on August 19, 2033. Table 4 – Conceptual Final Cover Construction Schedule Milestones contains a list of milestone dates that were developed as part of the closure construction schedule to demonstrate that closure will be completed within the self-implementing closure schedule per 40 CFR 257.102(f)(1)(i).

Table 4: Conceptual Final Cover Construction Schedule Milestones

Closure Component	Start Date	End Date
Monitor groundwater	January 1, 2021	June 1, 2042
Notification of closure	NA	May 1, 2042
40-mil LLDPE geomembrane	May 2, 2040	June 27, 2042
24-inch-thick sand layer (erosion layer)	June 28, 2040	August 2, 2042
6-inch-thick topsoil (vegetative layer)	August 3, 2040	August 13, 2042
Seed, fertilizer, mulch	August 14, 2040	August 20, 2042
Closure activities complete	NA	August 20, 2042
Certified closure report	NA	December 31, 2042

3.2 Closure Deadline Extension [40 CFR 257.102(f)(2)]

As previously indicated in Section 3.1, closure of existing CCR landfills must be completed within six months of initiating closure in accordance with 40 CFR 257.102(f)(1)(i). However, a deadline extension can be obtained as outlined in 40 CFR 257.102(f)(2) and Rule 299.4448(5) if completion of closure is not feasible within six months (e.g., shortened construction season, significant weather delays, time required for dewatering CCR, delays due to state or local permitting or approval, etc.). An extension must include a narrative description that demonstrates closure is not feasible in the required timeframe in accordance with 40 CFR 257.102(f)(2)(i, iii). The closure deadline for the JHC Landfill may be extended up to two years in one-year increments per 40 CFR 257.102(f)(2)(ii)(A).

4.0 PREMATURE CLOSURE LAYERS

Premature closure will be considered final closure of the landfill unit at any time prior to completion of the entire unit. Premature closure would require completion of the final cover on any area not previously completed. This process would be as identified in Section 2.0. In addition to the normal closure activities, the following items may also be required to be completed depending on status of the landfill at the time of premature closure.

4.1 Regrading of CCR

CCR will be regarded as needed to provide slopes that do not exceed the 4H:1V maximum and meet the two percent minimum required for proper drainage. Since the facility is closing prematurely space should be available for any CCR that must be relocated.

4.2 Perimeter Containment Berms

Perimeter containment berms may need to be constructed if closure is occurring prior to completion of all exterior cells. Interior cells usually only have a small containment berm on the floor of the cell. These berms are typically 30 - 35 feet below existing grade. In these areas a constructed clay berm would need to be built that would extend to existing grade. This berm would also have to be lined on the side slope to meet and tie into the composite liner of the cell floor. Once this was constructed and certified, as required by the quality assurance plan, either CCR or soil would be brought in to fill the void between the berm and the existing CCR.

5.0 NOTIFICATION AND DOCUMENTATION PROCEDURES

Prior to beginning partial closure or final closure of the unit the Director of EGLE will be informed that a notice of intent to close has been placed in the operating record, as required by Rule 299.4448(3).

6.0 CLOSING

Within 60 days after completion of partial or final closure of a unit, certification by a Professional Engineer licensed in the State of Michigan verifying that closure has been completed in accordance with the approved closure plan will be submitted to the director of EGLE or his designee, per Rule 299.4448(6). Closure documentation and drawings depicting closure conditions will accompany the certification. The approved closure certification will be placed in the operating record, in accordance with Rule 299.4448(8).

7.0 REFERENCES

"Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," Title 40 – Protection of the Environment Part 257 – Criteria for Classification of Solid Waste Disposal Facilities and Practices Subpart D – Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.

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APPENDIX R

Post-Closure Plan

REPORT

Appendix R - Post Closure Plan

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion Facility ID 395496

Submitted to:

Consumers Energy Company
J.H. Campbell Generating Facility
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.
15851 South US 27, Suite 50, Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

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1.0 INTRODUCTION

The intent of the post-closure plan is to assure that integrity and effectiveness of the J.H. Campbell Dry Ash Landfill (JHC Landfill) final cover is maintained over the 30-year post-closure care period, in accordance with Michigan Department of Environment, Great Lakes and Energy (EGLE) Part 115 Rule 299.4447. The JHC Landfill is anticipated to be certified closed by January 1, 2041 with the post-closure care period lasting through December 31, 2071.

Additionally, on April 17, 2015, the United States Environmental Protection Agency (EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule") to regulate the beneficial use and disposal of CCR materials generated at coal-fired electrical power generating complexes. In accordance with the CCR RCRA Rule, any CCR surface impoundment or CCR landfill that was actively receiving CCRs on the effective date of the CCR RCRA Rule (October 19, 2015) was deemed to be an "Existing CCR Unit" on that date and subject to self-implementing compliance standards and schedules. Consumers Energy Company (CEC) currently operates the JHC Landfill at the J.H. Campbell Generating Facility (JH Campbell). JH Campbell is located in West Olive, Michigan as presented in the Engineering Drawings Sheet 200-1.

2.0 FACILITY CONTACT [40 CFR 257.104(D)(1)(II)]

The post-closure point of contact for the JHC Landfill at JH Campbell is:

Michelle Marion
1945 W Parnall Road
Jackson, Michigan 49201
(517) 788-5824
michelle.marion@cmsenergy.com

3.0 MONITORING AND MAINTENANCE ACTIVITIES [40 CFR 257.104(D)(1)(I, III)]

3.1 Site Maintenance [40 CFR 257.104(d)(1)(i)]

The following general site maintenance and monitoring will be conducted to ensure the integrity and effectiveness of the final cover system:

- Fertilizer will be applied in areas of stressed or poor-quality cover vegetation as needed.
- Vegetative cover will be mowed as needed to restrict uncontrolled woody plant establishment on the cover for the remainder of the 30-year post-closure period (estimated through 2063). This includes mowing the side slopes around the perimeter of the JHC Landfill.
- Areas of erosion, including erosion from runoff or vehicle use, will be repaired by restoring the thickness of the protective cover and topsoil and seeding as necessary upon discovery.
- Erosion repairs will utilize clean soils. Typically, repair is expected to involve minor regrading, spreading of small amounts of additional soil, and reseeding. Areas of repeated erosion will be evaluated to determine if additional protection such as erosion blankets or riprap should be added.

- Groundwater monitoring system will be maintained in accordance with the Hydrogeological Monitoring Plan, prepared by TRC, in Section D of this CPA.
- The leachate collection and removal system will be maintained in accordance with applicable requirements from 40 CFR 257.70(d) and Part 115 Rule 299.4447.
- Differential settlement will be repaired as follows:
- Minor differential settlement in which no ponding can occur or in which the subsurface drainage will not be compromised shall be repaired by stripping topsoil, adding sandy soil, and replacing topsoil to attain a smooth surface before seeding.
- If differential settlement has occurred to the extent that drainage is compromised, surface soils shall be removed in the area to expose the geomembrane. The geomembrane shall be cut back and sand added to attain the line grade. Geomembrane, protective soil, and topsoil shall be replaced and seeded with repair certification maintained in the site files.

Areas requiring repair due to erosion or settlement will be identified during annual site inspections which are detailed below in Section 3.3.

3.2 Site Security

The following items comprise the site's security system and will be maintained during the post closure period: Perimeter fencing, access gates and "No Trespassing" signs. Maintenance activities may include fence repair or replacement, replacement of gates and replacement of missing signs. The security of the site will be inspected annually at a minimum, and repairs will be made as needed.

3.3 Final Cover

Inspection of the entire site will be conducted to maintain the integrity and effectiveness of the final cover. A written record of the inspection will be made and retained at the closed site or other designated location. At a minimum the following will be noted in the inspection report: any areas of settlement/subsidence as evidenced by ponding or depressions, the presence of erosion, rifts or cracks that jeopardize the final cover integrity, any areas of stressed, dead or sparse vegetation, evidence of burrowing animals, areas of slope failure, possible leachate breakouts and saturation at the toe of slope, damage to any risers or pipes that extend through the cap, any undesirable plant species capable of damaging the cap, specifically trees or tree saplings or other vegetation with invasive root systems, and sediment build-up or damage to storm water conveyance system, diversion berms and retention ponds. The inspector will assess the condition and need for repair of final cover to correct the effects of settling, subsidence, erosion, and preventing run-on and runoff from eroding or otherwise damaging the final cover. The post-closure inspection report will include a statement regarding items that were corrected and their condition.

Settlement of the landfill is anticipated but is expected to be relatively minimal and uniform. Areas of differential settlement will be repaired with additional cover soils, as required to provide adequate drainage. All eroded and scoured drainage channels will be repaired, and lining material replaced if necessary. Areas repaired as noted above will require re-establishment of vegetative cover. All reworked surfaces, and areas of failed or eroded vegetation in excess of 100 square feet cumulatively, will be revegetated.

Areas that have experienced excessive settlement may require repair of the synthetic components of the cap. If repairs to the geosynthetic are necessary, the geosynthetic installer will conduct the repairs under the direction of a certified quality assurance/quality control (QA/QC) representative. Repairs will be documented, certified and submitted to the EGLE Materials Management Division. A copy will be placed in the site's Operating Record.

3.4 Surface Water

All stormwater ditches, piping, and structures will be inspected on a quarterly basis during the first five years of the post-closure period and semi-annually during the remainder of the post-closure period. These areas will be visually inspected for significant erosion, accumulation of sediment or structural damage that could affect the integrity or performance of the stormwater management system in meeting regulatory requirements.

Areas of the stormwater management system that are found to be deficient due to erosion, sedimentation or other items will be repaired prior to the next scheduled inspection, weather permitting. Temporary ditches, structures, or piping will be used if the damaged portions impact the performance of the storm water management system. All repaired areas shall be restored in accordance with approved engineering plans.

3.5 Periodic Inspection Requirements [40 CFR 257.104(d)(1)(i)]

Periodic site inspections verifying the integrity and effectiveness of the final cover system will be conducted throughout the 30-year post-closure period (estimated through 2071) on no less than an annual basis. When and if items requiring construction and/or maintenance are identified during an inspection, CEC will schedule and conduct repairs promptly while noting the risk associated with the deficiency. During site inspections, the inspector will walk the entire closed JHC Landfill area and document the problematic items on the "General Site Inspection Sheet" provided in Appendix A.

If maintenance is required, only low ground-pressure tire or track equipment should be utilized to correct the deficiencies on closed portions of the JHC Landfill. Larger equipment can be used, but the equipment loading cannot exert more than five pounds per square inch (psi) on the liner material.

If repairs to the geosynthetics (e.g., geomembrane, geotextile, etc.) are necessary, a certified geosynthetic installer must conduct the repairs under the direction of a quality assurance representative. Repairs will be documented in a report, and a copy will be placed in the site's operating record.

3.6 Site Use Restrictions [40 CFR 257.104(d)(1)(iii)]

Currently, the identified end use for the JHC Landfill has been limited to securing the area and maintaining the site as described in Sections 3.1 and 3.2. If the area is to be developed in the future, the integrity of the geomembrane cover liner shall be confirmed with the proposed use; and institutional controls for maintaining the integrity of the geomembrane cover will be provided through an update to the post-closure plan. Once certified closed, CEC will ensure that the existing Restrictive Covenant recorded on February 12, 1999 conforms to the notation on the deed to the property required in 40 CFR 257.102(i).

Use of the site will be restricted by either fencing and gating or procedure to prohibit access other than for inspections, maintenance, and monitoring; established easements; and to restrict the use of intrusive vehicles and activities at the site.

3.7 Groundwater Monitoring

Sampling, analyses, and reporting of the data from the groundwater monitoring wells will be conducted in accordance with Section D - Hydrogeologic Monitoring Plan (HMP), prepared by TRC, and the results will be submitted to EGLE Materials Management Division. Groundwater monitoring records will be maintained at the office of the operator. The reports will include an intra-well statistical data evaluation to verify that the JHC Landfill is not impacting the groundwater. Statistics will be performed on the groundwater data per the approved monitoring plan for the site.

Sampling procedures and the groundwater monitoring program submitted by the JHC Landfill will be followed throughout the post-closure care period. If a statistically significant increase is observed, EGLE will be notified in writing and further evaluation will be performed. If corrective action becomes necessary, a plan will be developed and submitted to EGLE for approval.

Ground water monitoring wells, including equipment or structures associated with other sampling points (surface water or leachate) will be visually inspected during sampling events to ensure the integrity of the wells or other equipment or structures. If any ground water monitoring well requires significant repair, EGLE will be notified and, if required, a repair procedure submitted to EGLE as required. Ground water monitoring well repairs will be made within thirty days if possible. Repairs to other equipment or structures will be made prior to the next scheduled inspection if possible.

Results of all monitoring and statistical analysis will be provided to EGLE and a copy placed in the site's Operating Record.

The annual groundwater monitoring and corrective action reports will be:

- Maintained in the JH Campbell operating record per 40 CFR 257.105(h)(1)
- Submitted to EGLE per the notification requirement in 40 CFR 257.106(h)(1) and per the Part 115 rules.
- Posted on a publicly accessible internet website per 40 CFR 257.107(h)(1)

If additional notification is warranted, CEC will notify appropriate parties per 40 CFR 257.106(h).

Groundwater monitoring wells may require repair or replacement if they become damaged or settle excessively. The most frequent repairs are to the concrete seal at the base of the well. The dedicated sampling devices may also require cleaning and maintenance and/or replacement. Since groundwater must be monitored on a semi-annual basis, complete inspection forms will be filled out for each well semi-annually (see Section D – HMP) and repairs will be made as indicated by the inspections.

3.8 Leachate Management System Monitoring

Leachate pumps in the sumps will require repair and replacement during the 30-year post closure period. If head level build-ups are noted in any of the cells, the pumps will be removed and inspected.

The leachate management system, which consists of collection sumps and a gravity transmission system, will be operated as required throughout the specified closure period. Although the installation of a synthetic cap will greatly reduce leachate generation over the post closure period, the facility may still produce a significant amount of leachate for the first few years after closure. To manage this leachate collected by the system will be pumped from the riser to a manhole and then gravity fed to the existing leachate ponds. The overall configuration of the leachate collection system is shown on Engineering Drawing Sheet 400-2, while the gravity transfer system is shown on Engineering Drawing Sheets 600-1 through 600-3. Maintenance of this system will allow for continuous removal of leachate from the landfill throughout the 30-year post closure period.

Leachate depth in each cell and the volume of leachate removed from the unit will be measured on a monthly basis during the post closure period. If leachate levels exceed regulatory requirements, the cause of the exceedance will be determined within seven days and corrective measures will be initiated.

The performance and condition of the leachate management system will be evaluated semi-annually during the post-closure period. The evaluation will consider factors such as pump run time, number of pump cycles (if applicable) and volume of leachate pumped.

If the evaluation indicates that the functionality of any leachate collection piping has diminished, then that piping will be investigated and may be cleaned or flushed. Diminished functionality of any other component will also be investigated and, if needed, remedied by repair of the affected components.

Inoperable pumps will be replaced within seven days of discovery, if possible. Temporary measures may be implemented during this period if the leachate level in a cell exceeds regulatory levels. The site will maintain one spare pump to be used in such emergencies.

Inspection of the pumping system, transmission lines, and valve vaults, will be completed semi-annually. If the inspection indicates problems or significant damage, procedures will be implemented to determine the cause, and repairs will be initiated. Temporary interim measures will be implemented during this period, if necessary, to ensure compliance with applicable regulations.

Post closure monitoring of leachate will be annual for the parameters per the HMP.

Results of monitoring and statistical analysis will be provided to the EGLE Materials Management Division, and a copy placed in the site's Operating Record.

4.0 FACILITY END USE

Currently, there are no end use plans for the facility, other than green space. This use will not disturb the integrity of the final cover, liner, or any other component of the containment system, nor will it inhibit the function of the monitoring systems. A Perpetual Restrictive Covenant prohibits any further development of the site without the approval of the EGLE Director.

5.0 CONCLUSION

This post-closure plan has been prepared in accordance with the requirements of Part 115 of the Michigan Natural Resources and Environmental Protection Act, P.A. 451 of 1994, as amended Administrative Rule 299.4447 and with the CCR Rule 40 CFR 257.104. As required by this Rule, a copy of the approved Plan shall be placed in the Operating Record. All revisions to this plan shall be dated and submitted to the authorized regulatory agencies for review and approval, if required, and placed in the Operating Record. Following completion of the post-closure care period, the Director will be notified and a certification, signed by an independent registered professional engineer, verifying that post-closure has been completed in accordance with the plan will be placed in the Operating Record.

6.0 REFERENCES

"Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," Title 40 – Protection of the Environment Part 257 – Criteria for Classification of Solid Waste Disposal Facilities and Practices Subpart D – Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.

APPENDIX A

Post Closure Monitoring Checklist

Appendix A: JHC Dry Ash Landfill - Post Closure Inspection Checklist

Category	Survey Item	Frequency	OK?	Needs Action	Comments/Actions Needed
Entrance and Roadways	Entrance gate is present and lockable.	Yearly			
	Entrance is neat and attractive and access roads are properly graded and maintained.				
	Traffic control and information signs present, legible, and properly located.				
	All required permits and site use restrictions are posted.				
Landfill Slopes	Slopes are functioning as designed (no excessive settlement)	Yearly for the Closed Landfill			
	Toe of slope is dry and seepage is not observed.				
	Leachate seeps are not present on the landfill slopes.				
	Graded slopes are free of erosion and burrowing animals.				
	There is no exposed liner.				
	There is no ponding water on the landfill surface.				
	Final cover is free from signs of instability or failure.				
	Vegetation density and length is adequate.				
	Topsoil thickness is adequate.				
	Slopes are free from undesirable vegetation (trees, bushes, etc.)				
	Re-vegetation has been performed on disturbed areas to control erosion.				

Appendix A: JHC Dry Ash Landfill - Post Closure Inspection Checklist

Category	Survey Item	Frequency	OK?	Needs Action	Comments/Actions Needed
Facility Conditions	Shop/parking areas are free of petroleum stained soils.	Yearly			
	Leachate manhole containment is free of water.				
	Leachate manhole water level is within acceptable limits.				
	Leachate pump and controls are operating properly.				
	There are no junk containers, equipment, or trucks, etc.				
	Surplus materials and equipment are stored neatly in an appropriate storage area, out of sight from main entrance.				
	Landfill coordinate system is in place and being used.				
	Liner edge markers are in-place and visible.				
	Groundwater monitoring points are clearly marked, accessible, adequately protected, and locked.				
	Al grassed areas are mowed and maintained.				
	All ditches are clean and performing as designed.				
	All let-down pipes/chutes are installed and functioning.				
	Silt basins, fences, barriers are in place as required and in good working conditions.				
	Visual examination of storm water outfalls has been performed as required by the permits.				
Monitoring Results	Environmental monitoring results do not exceed regulatory limits.	Quarterly			
	Groundwater monitoring results show concentrations within regulatory limits.				
	Storm water outfall sampling/testing has been performed as required.				
	Groundwater, surface water, and leachate monitoring has been performed as required and the report is in the Operating Record.				

Appendix A: JHC Dry Ash Landfill - Post Closure Inspection Checklist

Category	Survey Item	Frequency	OK?	Needs Action	Comments/Actions Needed
Reporting	Up-to-date and approved design, construction, and operating plans are filed in the Operating Record.	Yearly			
	Storm water Pollution Prevention Plan (SWPPP) is up-to-date and is filed on-site.				
	Latest update of Financial Assurance instruments are filed in the Operating Record and with EGLE.				
	Leachate collection system records are reviewed to evaluate the performance of these systems.				
	Records of cell construction are filed in the Operating Record.				
	Records of quantities and dates of leachate recirculation and/or disposal are filed in the Operating Record.				

Appendix A: JHC Dry Ash Landfill - Post Closure Inspection Checklist

Category	Survey Item	Frequency	OK?	Needs Action	Comments/Actions Needed
		Comments			

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REPORT

Section G - Operations Plan

J.H. Campbell Generating Facility – Dry Ash Landfill, Type III Expansion Facility ID 395496

Submitted to:

J.H. Campbell Generating Facility

Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.

15851 South US 27, Suite 50 Lansing, Michigan, USA 48906

+1 517 482-2262

19132873

June 2021

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TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Purpose

This Operations Plan (OP) was prepared to support the J.H. Campbell (JHC) Landfill Expansion Construction Permit Application and to meet the requirements in accordance with the Part 115 of the Natural Resources and Environmental Protection Act of 1994, PA 451, as amended. The OP was outlined in accordance with the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Rules 299.4315 (Rule 315) through 299.4319 (Rule 319), and 299.4911 (Rule 911) promulgated pursuant to Part 115 Act 451.

The purpose of this OP is to provide guidance to site management and operating personnel for the day-to-day operation of the JHC facility. This plan provides an operating guide for site management to maintain the facility in compliance with the engineering design and applicable regulatory requirements. This plan may also serve as a reference source and assist in personnel training.

1.2 General

The J.H. Campbell (JHC) Dry Ash Landfill (Landfill) is an existing coal ash landfill and, as such, is licensed as a Type III low hazard industrial waste landfill. The JHC Landfill is owned and operated by Consumers Energy Company (CEC). The JHC Landfill is located in Port Sheldon Township, Ottawa County, Michigan (Site).

The JHC Landfill is currently licensed under the provisions of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, (Part 115 Rules) for the operation of a coal ash landfill. At the time of preparation of this plan, the most recent Solid Waste Disposal Area Operating License, 9542, was issued on January 23, 2019 and expires on January 23, 2024. A copy of the license is included as Appendix A of this Operations Plan.

The JHC Landfill provides disposal capacity for coal combustion residuals (CCR) (Type III waste) materials that are generated at the JHC Generating Facility. The JHC Landfill only accepts waste from the JHC Generating Facility. The expansion is intended to recapture airspace that was lost during the 2018 JHC Landfill Permit Upgrade project and to gain additional airspace to allow the JHC Generating Facility to operate to the planned end of life for the facility.

The JHC Landfill is being developed sequentially in nine distinct cells as depicted on the CPA Engineering Drawings (Sheet 400-1). All nine cells have been previously permitted and the lateral footprint for the existing and constructed cells will not change with this CPA. Cells 1 through 5 are currently constructed at the JHC Landfill with perimeter and intercell berms, both primary and secondary liner systems, and leachate collection systems. The leachate retention pond was constructed in 1993. The existing cells 1 through 5 vary in size from approximately 7 to 18 acres. The unconstructed Cells 6 through 9 vary in size from 6.2 to 7.5 acres and will have variable air space capacity and life as described on the Engineering Drawings , Sheets 400-4 through 400-8, Phasing Sequence.

The previously established JHC Landfill facility boundary consists of the acreage outlined in Table 1 below with a portion approved for waste disposal and the remaining acreage is used for ancillary landfill operations such as entrance facilities, maintenance facilities, office, support operations such as power generation, storm water management, leachate transfer and setback areas.

Table 1 includes a summary of the JHC Landfill existing permitted and proposed facility information.

Table 1: JHC Landfill Facility Summary

Landfill Item	Area (acres)
Total Facility Boundary (solid waste boundary plus ancillary areas)	410
Ancillary Areas (power generation, storm water, leachate transfer, operations, etc.)	306
Solid Waste Boundary (Cells 1 through 9)	104
Cells 1 through 5 (active areas)	43.4
Cells 1 through 4 (partially closed areas)	33.5
Cell 6 (unconstructed)	7.2
Cell 7 (unconstructed)	6.2
Cell 8 (unconstructed)	6.3
Cell 9 (unconstructed)	7.5

1.3 Engineering Plans (299.4911(1))

The Construction Permit Application (CPA) for a Type III expansion of the JHC facility includes an Engineering Drawing set, which provides detailed information related to the design of the facility. Design information related to cell layout; subgrade design; fill progression; final cover grades; landscaping; leachate collection, storage, and treatment; and storm water management; is included on the Engineering Drawings. Additional discussion related to the above-mentioned items is included in Section F - Engineering Report of the CPA.

2.0 SITE OPERATIONS PLAN

2.1 Equipment (299.4315(1) & 299.4911(2)(a))

Equipment required by operations typically includes:

- Two (2) haul dump trucks (20 – 25 cubic yards capacity each).
- One (1) tracked bulldozer.
- One (1) front end loader (optional).
- One (1) steel drum vibratory roller compactor (11 ton minimum).
- One (1) water truck.
- Equipment may be revised by Consumers Energy as operational needs change.

Haul trucks will be used to transport the ash from the ash storage silos located on site adjacent to the active filling area. Spreading and compacting operations will be performed using a bulldozer and smooth drum vibratory roller compactor (11 ton minimum) as determined in the 2016/2017 test fill operations (Golder, 2017). A new test fill may be conducted when the Owner or Engineer notes significant changes in the CCR material properties. If off-site leachate transport is required, either contracted leachate haulers or a purchased leachate transport tanker may be used for this operation. Backup equipment, if required, will either be available at the JHC Generating Facility from local contractors, or may be leased from a local implement dealer. A front-end loader and water truck will be used for on-site road maintenance and dust control.

The JHC Landfill may choose to modify its equipment fleet or may occasionally choose to retain independent contractors for earth-moving, construction, and operational services as appropriate to the facility's scheduling, manpower constraints, changing technology, and potential changes in performance requirements.

2.2 Personnel and Training (299.4315(2) & 299.4911(2)(b))

2.2.1 Personnel

The following staff are currently responsible for the operation of the JHC Landfill:

- 1 – Generation CCR Operations Lead
- 1 – Fuel Handling Manager
- 2 – Ash Handling Supervisors (1 per crew)
- 2 – Operator Crews (3-6 operators per crew)

The Generation CCR Operations Lead is responsible for assuring that landfill operations are in accordance with all applicable rules and regulations including those administered by EGLE.

The Fuel Handling Manager is the person responsible for assuring that adequate personnel and equipment are available to provide facility operation in accordance with the applicable rules and regulations.

The Ash Handling Supervisors provide support to the Generation CCR Operations Lead and Fuel Handling Manager and serves to facilitate communication to the Operators to direct the day-to-day site operation. The Ash Handling Supervisor is responsible for daily operations, administration of the facility's site development plan, and will also serve as the emergency coordinator. The quantity of Ash Handling Supervisors may be revised by Consumers Energy as operational needs change.

Operators are currently made up of two crews consisting of 4-6 operators that work an alternating 8 day on 6 day off schedule to provide 7 day a week coverage with Thursday as an overlap day. Operators are responsible for the handling, compacting, covering, and disposing of solid waste. In addition, they are responsible for the safe operation of the equipment. As the personnel most closely involved with the actual JHC Landfill operation, these employees are responsible for being alert for careless and improper actions on the part of non-employees and other persons while on the premises. Operators are also responsible for maintenance, miscellaneous site construction, and general site housekeeping. Operators will intervene as necessary to prevent accidents and report unsafe conditions to the Ash Handling Supervisor. The quantity and schedule of the operators may be revised by Consumers Energy as Operational needs change.

2.2.2 Training

JHC personnel will train affected employees on the contents of this OP. In-house training will address the following topics, at minimum:

- Health and safety
- Load inspection procedures as needed
- Identification of unsuitable waste per JHC Landfill standards
- Waste handling procedures (See Section 2.19 for Solid Waste Disposal)
- Spill prevention and response
- Recordkeeping

Selected personnel will receive additional training at approved training courses, as deemed appropriate by the JHC Site Business Manager. Documentation of training is maintained on the site or with Consumers Energy's Learning and Development .

2.3 Access Controls (299.4315(3)&(4) & 299.4911(2)(c))

Access to the active landfill site will occur through the existing gates located near the west site property lines adjacent to Lakeshore Avenue. Primary access to the site will be from the west off Polk Street. Public access to the site will be controlled to restrict usage of the site to authorized personnel, and to limit the potential of unauthorized traffic and illegal dumping of waste on the property. The following provisions will be instituted to that end:

- All public visitors are required to make an appointment with Consumers Energy Personnel prior to coming to the site.
- Then pre-approved public visitors will check-in with security located at the main security gate.
- Access onsite for visitors from the public will be with an approved CEC escort.
- No public vehicles will be allowed in the landfill area without a CEC escort.

2.3.1 Signs

A series of signs, which are currently located around the site entrance, provide the following information:

- Owner
- Unauthorized access is prohibited
- Local telephone number to contact the plant

Additionally, signage is posted for safety with the following general statements:

- Directional signs as needed
- Provisions for safety including:
  - Watch/Stop for heavy equipment / haul traffic (near silos and ash handling building)
  - Speed control (which also helps reduce dust)
  - Watch for pedestrians (as entering Lakeshore Dr.)

These signs will continue to be used during the operation of the facility. Signs may be changed or eliminated as needed. Additional signage, or new signs, will be utilized on an as-needed basis. Future changes in this policy would result in an update in the signage to address new issues and to provide appropriate direction.

2.3.2 Hours of Operation

The JHC Landfill is normally operated Monday through Sunday 6:00 AM to 4:30 PM. Hours and hauling schedules each day are determined based on production rates and fly ash levels in the silos.

Landfill construction activities including cell construction, capping etc. may occasionally be conducted beyond the normal hours of fill operation in the interest of seasonal construction constraints.

2.3.3 Usage Rules

Usage of the JHC Landfill is solely for the disposal of CCR and other CCR containing materials generated by the JHC Generating Facility. Conditioned fly ash is the main solid waste disposed of in the JHC Landfill. Fly ash is conveyed from the JHC Generating Facility through pipes into the three silos adjacent to the JHC Landfill. Bottom ash is disposed less frequently in the JHC landfill only when an excess is stockpiled on site and it cannot be sold. Bottom ash is conveyed through pipes from the JHC Generating Facility into a concrete bottom ash tank system managed by JHC personnel. Disposal of waste other than CCR or other CCR containing materials shall receive authorization by the Consumers Energy Environmental Services Landfill Compliance group prior to disposal.

2.3.4 Natural and Artificial Boundaries

The JHC Landfill is surrounded by a wooded buffer on all sides of the landfill and the ash storage building to the west. Access to the JHC Landfill facility is restricted to authorized personnel only. The JHC site is enclosed in a chain link fence and monitored by on site security staff 24 hours 7 days a week.

2.3.5 Traffic Control

Access to the site will be primarily off Polk Street. Access ramps from the elevation of Polk Street up to the perimeter dike around the cells will be constructed at widths and grades that are appropriate for the equipment and weather conditions.

Access ramps built from the perimeter dikes on to the active filling area will be constructed at widths and grades that are appropriate for the equipment and weather conditions and will be surfaced with road gravel or bottom ash. These access routes are depicted on the CPA Engineering Drawings (Sheets 400-4 through 400-8).

Haul traffic routes are determined by Ash Handling Supervisors and Operators dependent on fill placement location and elevation. All traffic on site must yield to heavy equipment and follow posted signage for traffic directions, speed, yield, stops, etc.

Contractors on site conducting construction should submit traffic flow plans for approval by the Ash Handling Supervisor and designated CEC Project Manager in order to avoid disrupting haul traffic flow when possible.

2.4 Fugitive Dust Control (299.4315(5)&(10) & 299.4911(2)(d)&(f))

Litter control (blowing papers from active area) measures will not be needed at the JHC Landfill as it only accepts ash from the JHC Generating Facility. The JHC Landfill will also not need odor control / management since CCR does not generate decomposition gases and create the presence of odors.

Fly ash is moisture conditioned in the silos to achieve optimum placement and compaction methods and to aid in dust control. The moisture added in the silos limits dust when hauling to the active area and during placement and compaction. A water tanker is on site for additional dust control in the active area if needed. Other potential procedures for dust control on active areas are detailed in the Fugitive Dust Control Plan. Temporary cover shall be installed in inactive areas, in accordance with the Fugitive Dust Control Plan (Appendix C). Daily cover will not be required.

On-site roads will be constructed when necessary to access the site, to transport fly ash from nearby storage silo to the active disposal area, to transport leachate to a water treatment facility, etc. The on-site roads located outside of the solid waste boundary will be constructed using road gravel. They shall be maintained to ensure safety and accessibility at all times and shall be treated to minimize dust, in accordance with the most recent version of the Fugitive Dust Control Plan. The current version of the Fugitive Dust Control Plan is included in Appendix C.

2.5 Large / Bulky Items (299.4315(6) & 299.4911(2)(e))

JHC Landfill does not accept large or bulky items for disposal.

2.6 Recordkeeping (299.4315 (7))

Site records for Type III landfills are not required by Part 115 Rule 315 (7), however the site maintains an operating record as per the Title 40 of the Code of Federal Regulations Section 257 (40 CFR 257), Section 105.

.

2.7 Restrictions (299.4315(8) &(9))

The following wastes shall not be disposed of at JHC Type III Landfill:

- Materials that would adversely affect the liner.
- Household waste.
- Hazardous waste, as defined in R 299.9203.
- Asbestos waste.
- Liquid waste, except for leachate recirculated under R299.4308(3).

The burning of trees, stumps, and brush at a JHC Type III Landfill are severely restricted and will be conducted only in designated areas with the permission of the solid waste control agency and other appropriate authorities. Suitable measures will be available to extinguish accidental fires.

2.8 Salvaging (299.4315(11) & 299.4911(2)(g))

JHC Landfill is designed solely for the disposal of CCR, and no salvageable materials will be disposed at the landfill.

2.9 Insect & Rodent Control (299.4315(12))

JHC Landfill is not a municipal solid waste or construction and demolition landfill therefore insect and rodent control is not an issue.

2.10 Drainage & Erosion Control (299.4315(13))

2.10.1 Drainage

Run-on to the active portions of the landfill is controlled using two methods. The first method is a perimeter berm around the landfill that creates a barrier that does not allow run-on stormwater to enter the active areas. A drainage channel exists on the outboard slope of the perimeter berm that collects stormwater from the adjacent areas and directs it towards the site's National Pollutant Discharge Elimination System (NPDES) outfall in accordance with Permit No. MI0001422. The second method is positive drainage away from the active areas so that run-off from closed areas (non-contact water) is not diverted into the leachate collection system.

Run-off from active portions of the landfill is controlled within the active landfill cells. Precipitation that comes in contact with CCR infiltrates within the unit and is collected in leachate pipes where it is then pumped from a sump to catch basins which gravity drain to a lift station where one of the two lift pumps pump the leachate into the leachate holding ponds.

2.10.2 Soil Erosion Control

In accordance with R299.4315 (13) grading of the active filling area will be done in a manner to prevent erosion. If Soil erosion in the active filling area becomes an issue it may additionally be controlled by one or a combination of the following methods:

- Install 1-2-foot fly ash berms in the active work area.
- Install temporary cover over inactive work areas.

- Place final cover as soon as side slopes have reached the final grades and lines.
- Install temporary cover in the perimeter stormwater control ditches.

2.11 Noise Levels (299.4315(14))

The JHC Landfill shall operate in such a way to maintain compliance with noise levels as specified in Part 115 Rule 299.4305(5) as measured at the common property line nearest the active work area as follows:

- Residential Property – 75 dBA
- Commercial Property – 85 dBA
- Industrial and Other Property – 90 dBA

Noise at the site from landfill construction and compaction equipment, and from waste hauling vehicles entering and leaving the facility, will be controlled by maintaining equipment mufflers. The design distance setbacks from the property boundary, as well as the distance between the surrounding residents and the JHC Landfill area, will minimize the level of equipment noise audible outside the facility. Operations at this unit are also not expected to be continuous.

Beyond equipment control features, noise mitigating features of the JHC Landfill include trees for screening on all sides of the landfill.

2.12 Monitoring (299.4315(15) & 299.4318)

The monitoring plan for groundwater monitoring wells, the primary leachate collection system and the secondary leachate collection system are described in Section D – Hydrogeological Monitoring Plan and Section F - Engineering Report of the CPA. In addition to the monitoring requirements prescribed in Section D – Hydrogeological Monitoring Plan of the CPA the primary and secondary leachate collection system pumps should be checked on a regular basis to ensure that the pumps and controls are operable. The gravity leachate conveyance system manholes should be monitored on a regular basis, especially after significant storm events, to be sure that water is not backing up due to plugging of the pipes.

2.13 Leachate (299.4315(16)&(17))

As discussed in Section F - Engineering Report of the CPA, leachate from the primary and secondary leachate collection systems, the Remedial Action Plan (RAP) pumping system, and stormwater run-off from active landfill areas (contact water) will be collected in the sumps and pumped to a gravity transfer lines which flows to the existing leachate retention ponds. The leachate retention ponds have adequate capacity to handle the run-off from the design storm.

2.14 Closure & Post Closure Care (299.4317)

Final cover shall consist of 30 inches of soil (24 inches of local sand and a 6-inch-thick vegetative support layer) and a flexible membrane liner which will meet the requirements of R 200.4915. The side slopes of the fill area shall not be steeper than 4H:1V as depicted on the CPA Engineering Drawings (Sheet 400-3). Gradually sloping benches will be installed at not greater than 30-foot vertical intervals on the 4H:1V side slopes. These benches will slope to armoured drainage channels which will lower stormwater runoff from the final cover across the perimeter roads down to the perimeter ditch. On top of the fill, the slope of the final cover will be a minimum of 2%.

Erosion control measures shall be instituted during closure and throughout the post closure period to minimize erosion of the final cover. The measures shall comply with Part 91 of the act. All final covered areas shall be seeded and stabilized as soon as practical after placement of final cover. Appropriate seed for the soil type, slope, and moisture condition shall be selected for this purpose. A final landscaping plan for the JHC Landfill is included on Sheet 800-1 of the CPA Engineering Drawings.

After final cover has been placed on portions of the landfill the condition of the cover shall be inspected at least semi-annually to determine the extent of any erosion or inadequacy of the vegetative cover. Final cover depths shall be maintained for a period of 30 years after the final cover is certified in accordance with R 299.4317. Areas where erosion has reduced the soil cover thickness shall be repaired by placing additional soil and re-grading the areas. Any areas repaired in such a manner, or areas where vegetative cover is inadequate, shall be reseeded, fertilized and mulched as described in the Fugitive Dust Control Plan (Appendix C).

The leachate collection pipe system should be cleaned at least initially by jetting or flushing. Leachate collection system cleanout locations are shown on the CPA Engineering Drawings (Sheet 400-2).

2.15 White Goods and Recyclable Materials (299.4911(2)(h)&(i))

JHC Landfill does not accept or dispose of white goods or recyclable materials.

2.16 Asbestos Waste Receipt and Disposal (299.4911(2)(l))

JHC Landfill does not accept or dispose of regulated asbestos-containing material.

2.17 Daily Cover (299.4316 & 299.4911(2)(j))

Daily cover will not be required at JHC Landfill since it is not a construction and demolition waste landfill, however Owner will minimize fugitive dust in accordance with the Fugitive Dust Control Plan (Appendix C).

2.18 Response Action Plan (299.4319)

The Response Action Plan (RAP) for the JHC Landfill can be found in Section I of the main CPA.

2.19 Solid Waste Receipt and Disposal Operations (299.4911(2)(k))

The only waste material disposed of in the JHC Landfill will be CCR or CCR containing wastes generated from the JHC Generating Facility. No liquids, putrescible, or gas generating wastes will be disposed of in the landfill site. The only liquid introduced into the site, other than precipitation, will be leachate recirculated from various collection systems for the control of dust and water for the establishment and maintenance of vegetation on any areas containing vegetative temporary cover. Dust control chemicals may also be used with prior approval of the EGLE. .

2.19.1 Ash Placement

2.19.1.1 Subgrade Preparation

- Standing water shall be drained and ice, snow, and debris removed from the area where ash placement will occur.
- In areas where CCR placement will occur on the temporary cover, any vegetation which has become established shall be removed or mowed prior to subsequent ash placement.
- .

2.19.1.2 CCR Placement

In general, Operations will follow the placement procedures determined from the test fill that was conducted in 2016 through 2017. A new test fill may be conducted if the Owner or Engineer notes significant changes in the CCR material properties.

General CCR and CCR containing wastes placement procedures include the following items, which may change based on operational needs at the time of placement:

- CCR is transported to the site by trucking from the nearby silos with a moisture content conditioned to within the acceptable range as determined by the test fill program prior to compaction.
- Fly ash will generally be spread in horizontal layers not exceeding 6 inches in compacted thickness. Each layer will be compacted by operation of the compaction equipment over the fill at not greater than the maximum speed allowed (2-3 mph).
- The fill shall be compacted to a minimum of 85% of the standard proctor maximum dry density measured by ASTM 698.
- Field adjustment by the addition of water is an acceptable means of moisture content adjustment.
- The interim side slopes of the fill shall not be steeper than 4H:1V at the site perimeter nor steeper than 3H:1V toward the cell interior.

When bottom ash is placed in large quantities for construction of internal dikes within the landfill, for dike construction, temporary cover placement or as waste, it shall be placed and compacted in the same manner as the CCR, as discussed above.

2.20 References

Golder Associates Inc. (Golder). July 27, 2017. J.H. Campbell Landfill Test Fill – Test Fill Construction, Observation, and CCR Material Testing Program – 2016/2017 Report.

APPENDIX A

Copy of Current Operating License

Michigan Department of Environmental Quality
Waste Management and Radiological Protection Division

SOLID WASTE DISPOSAL AREA OPERATING LICENSE

This license is issued under the provisions of Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, MCL 324.11501 et seq., and authorizes the operation of this solid waste disposal area (Facility) in the state of Michigan. This license does not obviate the need to obtain other authorizations as may be required by state law.

FACILITY NAME: JH Campbell Landfill

LICENSEE/OPERATOR: Consumers Energy Company

FACILITY OWNER: Consumers Energy Company

PROPERTY OWNER: Consumers Energy Company

FACILITY TYPE(S): Type III Low Hazard Industrial Landfill

FACILITY ID NUMBER: 395496

COUNTY: Ottawa

LICENSE NUMBER: 9542

ISSUE DATE: January 23, 2019

EXPIRATION DATE: January 23, 2024

FACILITY DESCRIPTION: The JH Campbell Landfill, a Type III low hazard industrial landfill, consists of 410 acres located in SE 1/4 of Section 10, the SW 1/4 of Section 11, the NW 1/4 of Section 14, and portions of Section 15, T6N, R16W, Port Sheldon Township, Ottawa County, Michigan, as identified in Attachment A and fully described in this license.

AREA AUTHORIZED FOR DISPOSAL OF SOLID WASTE: Cells 1, 2, 3, 4, and 5.

RESPONSIBLE PARTY: Mr. Kevin Starken, Sr. Engineer
Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748
616-738-3241

RENEWAL OPERATING LICENSE: This License Number 9542 supersedes and replaces Solid Waste Disposal Area Operating License Number 9446 issued to Consumers Energy Company on July 16, 2015.

This license is subject to revocation by the Director of the Michigan Department of Environmental Quality, if the Director finds that this Facility is not being constructed or operated in accordance with the approved plans, the conditions of a permit or license, Part 115, or the rules promulgated under Part 115. Failure to comply with the terms and provisions of this license may result in legal action leading to civil and/or criminal penalties pursuant to Part 115. This license shall be available through the licensee during its term and remains the property of the Director.

THIS LICENSE IS NOT TRANSFERABLE.

Rhonda S. Oyer

Rhonda S. Oyer, Manager, Solid Waste Section
Waste Management and Radiological Protection Division

The licensee shall comply with all terms of this license and the provisions of Part 115 and the administrative rules implementing Part 115 (Part 115 Rules). This license includes the license application and any attachments to this license.

1. The licensee shall operate the Facility in a manner that will prevent violations of any state or federal law.

2. The following portions of the Facility are authorized to receive solid waste by this license:

   a. **ACTIVE PORTIONS NOT AT FINAL GRADE:** The area(s) identified as portions of Cells 1, 2, 3, and Cell 4 were authorized to receive waste by the previous license. This area's total acreage is 36.42 acres.

   b. **CONSTRUCTED AREAS CERTIFIED WITH THIS APPLICATION:** The area(s) identified as Cell 5 were not authorized to receive solid waste by the previous license, but are authorized to receive waste by this license. This area's total acreage is 7 acres.

3. The following portions of the Facility **WILL BE** authorized to receive solid waste by this license following approval by the Michigan Department of Environmental Quality (MDEQ) of construction certification:

   UNCONSTRUCTED AREA(S) WITH FINANCIAL ASSURANCE: The area(s) identified as Cells 6-9 (formerly noted as Cells 6-7), totaling 27.1 acres, are included in the calculation of financial assurance as required by Section 11523 of Part 115. This portion(s) of the Facility shall be authorized to receive waste, as part of this license, when acceptable certification is submitted to the MDEQ, as required by Section 11516(5) of Part 115, and determined by the MDEQ to be consistent with Part 115 and the Part 115 Rules. The certification shall verify that construction of this area(s) was in accordance with the Construction Permit(s) listed in Item 8 of this license, Part 115, and the Part 115 Rules.

4. The following portions of the Facility are **NOT** authorized to receive solid waste by this license:

   CLOSED UNIT(S) OR A PORTION OF A UNIT WHERE THE FINAL COVER HAS BEEN CERTIFIED CLOSED AND ACCEPTED BY THE MDEQ: The following unit(s) and/or portion(s) are closed:

   PRE-EXISTING UNIT(S): The unit(s) identified as Cells B, C, D-South, D-Mid South, D-Mid, D-North, F, G-1, G-2, H, J, and K had final closure certified on pursuant to the Consumers Energy Remedial Action Plan prepared on August 9, 1999, and last revised January 31, 2008. This certification was reviewed and approved by the MDEQ. This area's total acreage is 142 acres.

5. The attached map (Attachment A) shows the Facility, the area permitted for construction, monitoring points, leachate storage units, site roads, other disposal areas, and related appurtenances.

6. Issuance of this license is conditioned on the accuracy of the information submitted by the Applicant in the Application for License to Operate a Solid Waste Disposal Area (Application) received by the MDEQ on October 1, 2018, and any subsequent amendments. Any material or intentional inaccuracies found in that information is grounds for the revocation or modification of this license and may be grounds for enforcement action. The licensee shall inform the MDEQ's Waste Management and Radiological Protection Division (WMRPD), Grand Rapids District Supervisor, of any inaccuracies in the information in the Application upon discovery.

7. This license is issued based on the MDEQ's review of the Application, submitted by Consumers Energy Company, for the JH Campbell Landfill, dated September 19, 2018, and revised on January 19, 2019. The Application consists of the following:

   a. Application Form EQP 5507.

   b. Application fee in the amount of $2,500.00.

   c. Certification of construction by Ms. Tiffany D. Johnson, P.E., dated September 25, 2018.

   d. Waste Characterization: N/A.

e. Restrictive Covenant:

The February 12, 1999, restrictive covenant on 410 acres is on file at the Ottawa County Register of Deeds recorded on March 16, 1999, as Liber 2601 pages 25-27. A copy is on file with the MDEQ.

f. Perpetual Care Fund Agreement, established as a standby trust account, signed by Mr. Dennis D. Dobb, Vice President, Generation and Engineering Services, Consumers Energy Company, on January 16, 2015, was executed by the MDEQ on March 9, 2015.

g. Financial Assurance.

i. Financial Assurance Required:

The amount of financial assurance required for this Facility was calculated based on the calculation worksheet form EQP 5507A entitled, "Form A, Financial Assurance Required," and includes a Surety Bond of $20,000.00 per acre of licensed landfill, and the Perpetual Care Fund requirement.

The Facility has provided financial assurance totaling $1,545,885.00 based on the requirements of Section 11523 of Part 115, consisting of a combination of the Perpetual Care Fund established under Section 11525 of Part 115, and the bonding requirements of Section 11523 (1)(a) of Part 115. The financial assurance mechanisms used by the Facility are summarized below in Items ii and iii, respectively.

ii. Financial Assurance Provided Via a Perpetual Care Fund:

The Perpetual Care Fund Agreement statement showed a balance of $545,885.00 in the Facility's Perpetual Care Fund as of September 30, 2018

iii. Financial Assurance Provided Via Bond:

The following financial assurance has been received from the Applicant to meet the amount of financial assurance required:

Irrevocable Letters of Credit	$1,000,000.00
Total Amount Received:	$1,545,885.00

8. The following documents approved with Construction Permit Number(s) 0229 issued to the Consumers Power Company on December 15, 1993, are incorporated in this license by reference:

a. Environmental Assessment titled "Environmental Assessment, JH Campbell Ash Storage Facility, Solid Waste Disposal Area Expansion," prepared by Consumers Power Company, dated August 1993, and revised November 19, 1993.

b. Hydrogeological Report titled "Hydrogeological Study Addendum for the Proposed JH Campbell Ash Storage Facility Expansion Project," prepared by STS Consultants Ltd., and dated August 18, 1993.

c. Hydrogeological Monitoring Plan titled "Proposed Groundwater Monitoring Program, JH Campbell Ash Storage Facility," prepared by Consumers Power Company, dated July 31, 1993, revised November 19, 1993, and December 2, 1993.

d. Topographic Maps prepared by STS Consultants Ltd. and dated August 12, 1993.

e. Engineering Report titled "JH Campbell Ash Storage Facility, Solid Waste Disposal Area Expansion (Coal Ash, Type III Landfill)," prepared by Consumers Power Company, dated August 12, 1993, and revised November 19, 1993.

f. Engineering Plans titled "JH Campbell Ash Storage Facility," prepared by STS Consultants Ltd., dated August 12, 1993, and revised November 19, 1993.

g. Operation Plans contained in the engineering report titled "JH Campbell Ash Storage Facility, Solid Waste Disposal Area Expansion (Coal Ash, Type III Landfill)," prepared by Consumers Power Company, dated August 12, 1993, and revised November 19, 1993.

h. Construction Quality Assurance Plans titled "Construction Quality Assurance Program, JH Campbell Ash Storage Facility, Solid Waste Disposal Area Expansion," prepared by STS Consultants Ltd., dated August 12, 1993, and revised November 19, 1993.

9. The following additional documents, approved since the issuance of the construction permit(s) referenced in Item 8, are incorporated in this license by reference:

   a. Hydrogeologic Monitoring Plan, JH Campbell Ash Storage Facility, September 16, 1996.

   b. Consumers Energy Remedial Action Plan prepared August 9, 1999, and last revised January 31, 2008.

   c. Agreement for a Limited Site-Specific Criteria-Based Remedial Action (RAP-Landuse-WHMD-2005-2) dated July 13, 2005.

   d. Dry Ash Landfill Cells 5-9 Construction Permit Upgrade. Including Sheets 1-16 and upgraded site CQA Plan.

10. Consent Order/Judgment Number: WMRPD Consent Order Number 115-01-2018 entered on December 21, 2018.

11. The licensee shall repair any portion of the certified liner or leachate collection system that is found to be deficient or damaged during the term of this license unless determined otherwise by the MDEQ.

12. The licensee shall have repairs to any portion of the certified liner or leachate collection system recertified by a registered professional engineer in accordance with R 299.4921 of the Part 115 Rules and approved by the MDEQ before receiving waste in that portion of the certified liner or leachate collection system. The licensee shall submit the recertification to the MDEQ's WMRPD, Grand Rapids District Office Supervisor, for review and approval.

13. The licensee shall conduct hydrogeological monitoring in accordance with the approved hydrogeological monitoring plan, dated September 16, 1996. The sampling analytical results shall be submitted to the MDEQ's WMRPD, Grand Rapids District Office.

14. Modifications to the approved hydrogeological monitoring plan referenced in Item 13 may be approved, in writing, by the WMRPD, Grand Rapids District Supervisor. Proposed revisions must be submitted in a format specified by the MDEQ.

15. Leachate may be recirculated if a leachate recirculation plan has been approved, in writing, by the WMRPD, Grand Rapids District Supervisor.

16. Modifications to approved engineering plans that constitute an upgrading, as defined in R 299.4106a(l) of the Part 115 Rules, may be approved, in writing, by the WMRPD, Grand Rapids District Supervisor.

17. Requests for alternate daily cover may be approved, in writing, by the WMRPD, Grand Rapids District Supervisor.

18. Leakage Control Criteria:

    Cells 1-5 are part of an unmonitorable unit that has a double liner system that is capable of detecting and collecting leakage through the primary flexible membrane liner. The action flow rate for Cells 1-5 is five gallons/acre/day. The response flow rate for Cells 1-5 is 25 gallons/acre/day. The action flow rate for Cells 6-9 will be five gallons/acre/day. The response flow rate for Cells 6-9 will be 25 gallons/acre/day.

19. **VARIANCES**: The licensee is granted the following variance(s) from Part 115 and/or the Part 115 Rules:

    a. R 299.4310(1): Vertical isolation to groundwater, granted December 15, 1993.

    b. R 299.4315(4): Continuous supervision of unloading waste, granted December 15, 1993.

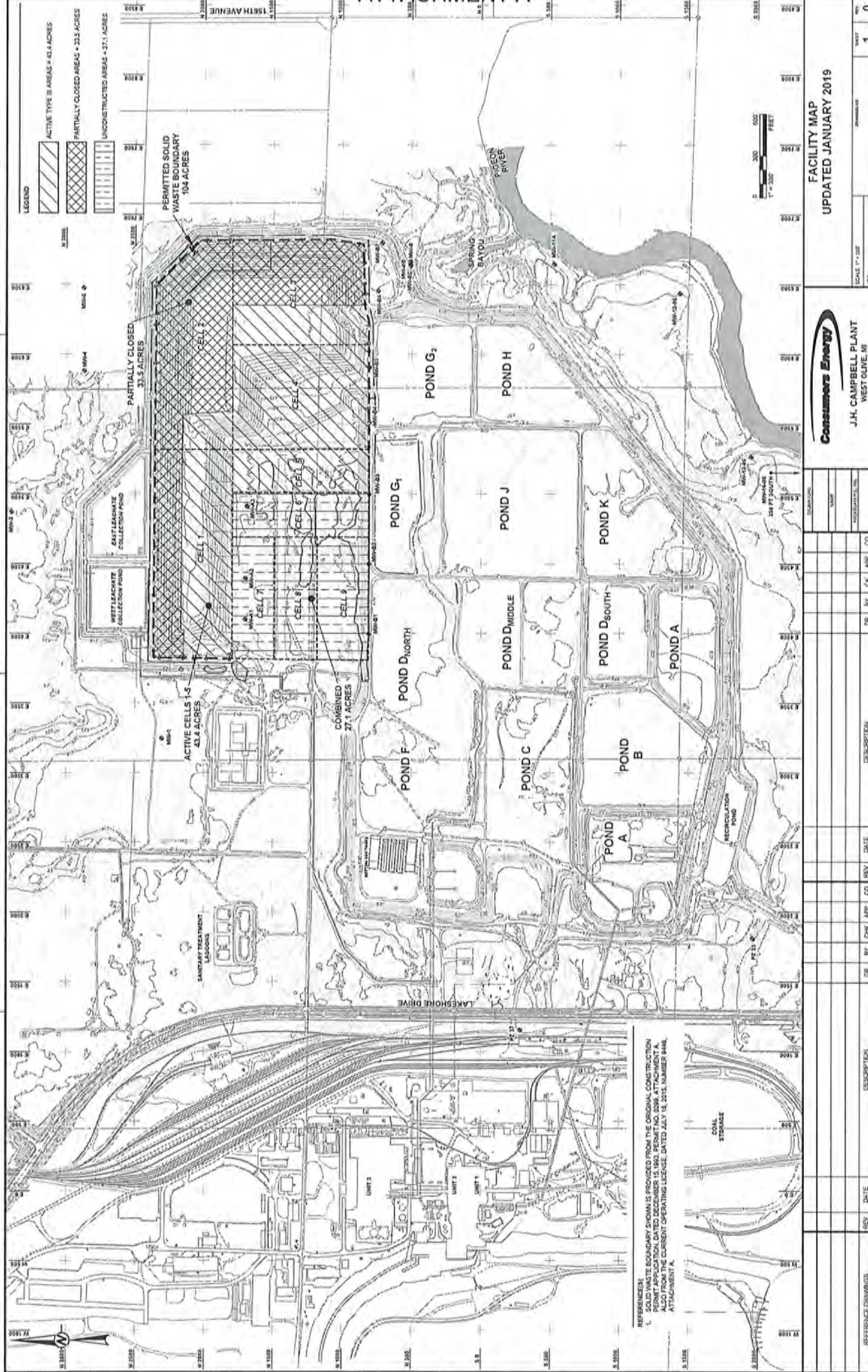
20. **SPECIAL CONDITIONS**:

    WMRPD Consent Order 115-01-2018 authorizes the closure of Pond A with waste in place.

21. **TERM**: This license shall remain in effect until its expiration date, unless revoked or continued in effect, as provided by, the Administrative Procedures Act, 1969 PA 306, as amended, or unless superseded by the issuance of a subsequent license.

END OF LICENSE

ATTACHMENT A



APPENDIX B

Copy of Current Financial Assurance

Quick Search | Advanced Search | Solid Waste Management | Recent Sites

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395496 / MID041409954 CONSUMERS ENERGY J H CAMPBELL COMPLEX
17000 CROSWELL ST, WEST OLIVE, MI 49460

Financial Assurance Data (8)

Open Financial Assurances

Financial Assurance Type	Account / Project Number	Current Balance	Bond Anniversary Date
Perpetual Care Fund	679312	$0.00	

Account Number:	679312	**Current Balance:**	$0.00
PCF Type:	STANDBY TRUST	**Current Balance Date:**	8/15/2019
Date Signed by Facility:	1/16/2015	**PCF Has Been Released:**	No
Date Executed by DEQ:	3/9/2015	**PCF Max:**	$10,000,000.00
Grantor:	CONSUMERS ENERGY COMPANY		

Disposal Area Types (0 records):

Perpetual Care Fund	K08691265	$576,752.00	

Account Number:	K08691265	**Current Balance:**	$576,752.00
PCF Type:	PCF BOND	**Current Balance Date:**	10/30/2020
Date Signed by Facility:	12/11/2014	**PCF Has Been Released:**	No
Date Executed by DEQ:		**PCF Max:**	$10,000,000.00
Grantor:	JH CAMPBELL LANDFILL		

Disposal Area Types (0 records):

Financial Instrument - Letter of Credit	SLT 332009	$1,000,000.00	

Account Project Number:	SLT 332009	**Current Balance:**	$1,000,000.00
Instrument Type:	LOC - Letter of Credit	**Current Balance Date:**	5/19/2003
Anniversary Date:		**Original Balance:**	$1,000,000.00
Bond Status:	Active	**Effective Date:**	5/19/2003
Bond Status Date:	10/12/2017	**Continuous Bond:**	Yes
Grantor:	CONSUMER ENERGY COMPANY		

Disposal Area Types (0 records):

Financial Instrument - Letter of Credit	CPCS-637065	$685,400.00	

Account Project Number:	CPCS-637065	**Current Balance:**	$685,400.00

Instrument Type:	LOC - Letter of Credit	**Current Balance Date:**	3/13/2008
Anniversary Date:		**Original Balance:**	$205,620.00
Bond Status:	Active	**Effective Date:**	5/13/2005
Bond Status Date:	4/18/2019	**Continuous Bond:**	Yes
Grantor:	CONSUMERS ENERGY COMPANY		

Disposal Area Types (0 records):

Financial Instrument - Letter of Credit	CPCS-637066	$159,600.00

Account Project Number:	CPCS-637066	**Current Balance:**	$159,600.00
Instrument Type:	LOC - Letter of Credit	**Current Balance Date:**	3/13/2008
Anniversary Date:		**Original Balance:**	$47,880.00
Bond Status:	Active	**Effective Date:**	5/13/2005
Bond Status Date:	10/12/2017	**Continuous Bond:**	Yes
Grantor:	CONSUMERS ENERGY COMPANY		

Disposal Area Types (0 records):

Total Open Financial Assurances: $2,421,752.00

Cost Estimate Data

Cost Estimate Type	Amount	Date
Closure / Post-Closure	$1,545,885.00	1/18/2019
Corrective Action	$845,000.00	6/13/2012
Other	$0.00	
Total Cost Estimate Data	$2,390,885.00	

Financial Assurance Action (0)

Due Date	Completion Date	Action

APPENDIX C

Annual CCR Fugitive Dust Control Report (November 2019)

Consumers Energy

J.H. Campbell Electric Generating Complex
17000 Croswell
West Olive, MI
SRN: B2835

Fugitive Dust Control Plan for Coal Combustion Residuals (CCR)

Date: 11/22/2019
Rev: 03

Table of Contents

1.0 INTRODUCTION

The purpose of this Fugitive Dust Control Plan (FDCP) is to describe the measures adopted at the J.H. Campbell (JHC) electric generating complex for minimizing fugitive dust emissions from coal combustion residual (CCR) handling operations (also known as ash handling operations). The JHC facility is located at 17000 Croswell in West Olive, Michigan and is a coal-fired electric generating power plant consisting of three boilers, Units 1, 2, and 3. This plan has been developed in accordance with the CCR regulations stipulated in 40 CFR Part 257.80. The scope of this plan includes active CCR units as well as their corresponding roads, handling and control equipment, and associated activities therein. A site Fugitive Dust Plan Coordinator (FDPC) has been appointed and is responsible for ensuring adequate resources are provided for controlling fugitive dust, as well as implementing the monitoring and recordkeeping requirements of this plan. This FDCP has been certified by a qualified professional engineer and is placed in the Facility's CCR Operating Record and on the Consumers Energy website. The initial FDCP was posted and made available to the public on October 19, 2015. All revisions of this document shall be posted to the operating record and public website, with a notification sent to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) within thirty (30) days of that posting.

The CCR facility consists of separate dry and wet ash handling systems and the CCR disposal area is divided into two primary components:

- Wet ash bottom ash tanks
    - Wet ash, comprised of bottom ash from the main burner area of the boilers, is sluiced by water into the bottom ash tanks where it is temporarily stored and dewatered, and then hauled off-site for beneficial reuse.
- Dry ash disposal facility (i.e., landfill).
    - Dry fly ash (DFA) from Units 1 and 2 [comprised of particulate matter (PM) that falls out from the economizer and air heater portions of the Unit 1 and 2 boilers] and DFA and Economizer ash from Unit 3 is conveyed to the dry ash silos
    - DFA consists of coal ash that has been collected from the pulse jet fabric filters (PJFF) from each boiler, which are used as the PM control devices for the boiler units
    - DFA is either sold for beneficial re-use (dependent upon ash characteristics) or disposed of in the on-site landfill.
    - The dry ash disposal facility is a permitted landfill and includes two (2) leachate contact water retention ponds that cover an area of approximately five (5) acres.
- CCR Surface Impoundments
    - Notifications of intent to initiate closure of Bottom Ash Ponds Units 1-2, Bottom Ash Pond Unit 3, and Pond A were made available on the Consumers Energy CCR Rule Compliance Data and Information webpage in 2017 and 2018.
    - Bottom Ash Ponds Units 1-2 and Bottom Ash Ponds Unit 3 are being closed by removal of CCR pursuant to 40 CFR 257.102(c). Removal of bottom ash has been completed for both units.
    - Pond A is being closed with CCR in place pursuant to 40 CFR 257.102(d). Construction of the final cover system has been completed.

The appropriate control activities selected for the site are based on good engineering practices that were developed in accordance with Michigan's Fugitive Dust Regulations under Act 451 of 1994, Rule 324.5524, as required by the site's Renewable Operating Permit and the Engineering Plans for the solid waste disposal area (Operating License 9542, 2019; Construction Permit 0299, 1996)as required for solid waste disposal licensing under EGLE. The following sections outline the FDCP.

2.0 CCR Operations

2.1 DFA Handling System

The DFA handling system consists of a pneumatic collection system that transfers the DFA from the collection hoppers to storage silos. The ash handling system is comprised of five (5) transfer tanks, vacuum and pressure conveying systems, and three (3) ash disposal silos (A, B, and C). From the PJFF dust collection hoppers, the DFA is pneumatically conveyed through hard piping under vacuum through filter separators to transfer tanks. The DFA is then pneumatically pressure transferred to the disposal silos (A, B, or C). PM emissions from the transfer process and tank displacement are controlled by bin vent filters. The DFA is held in the disposal storage silos until transferred to the on-site licensed landfill or shipped off-site for beneficial re-use. Silos A or B may also be used as a sales silo. The DFA evacuation system is not operated unless the equipment and control systems are installed and operating properly.

2.2 Dry Ash Landfill Operations

2.2.1 ***Silo Operation/Truck Loading***

From disposal Silos A, B or C, the DFA is conditioned with water and/or another approved suppressant. Proper conditioning of the DFA with water and/or suppressant is to achieve a moisture content that will minimize wind dispersal and provide proper stability characteristics for the landfill, but will not result in free liquids, to the extent possible. A vacuum fan is located on the mixer floor of the silos, which draws PM from the mixing activity as well near the loading chute. The air/dust mix is discharged back into the controlled storage silo. The truck loading station shall not be operated unless adequate PM emission controls are employed. Any ash spillage shall be cleaned up and disposed of properly to minimize track-out. The following operational controls are also in place:

- The appropriate moisture characteristics shall be maintained during the truck loading process.
- Transport truck bodies shall be maintained in good condition and properly closed to prevent leakage.
- Truck bodies shall be filled in a manner that minimizes fugitive emissions during transport.
- Transport operations shall be suspended if the current conditions indicate that operations cannot be conducted in a controlled manner.

DFA may also be hauled off-site for beneficial re-use from Silos A and B. The haul trucks are pneumatically loaded from the silos through a chute that is gasket sealed to the truck hatch, which is equipped with a vacuum fan to recover displacement air and send back into the silo. The contractor is responsible for cleaning up any spills that may occur during the loading process.

2.2.2 ***Ash - placement and storage***

Conditioned ash is placed in the active landfill cell by haul trucks and further wetted as required to minimize dusting during spreading by the bulldozer. The conditioned ash piles are to be flattened and compacted as they are deposited, utilizing water as necessary. A bulldozer may also be used for shaping the piles/slopes. All dumping, dozing, and excavating activities are visually monitored for dusting and activities are suspended if there is excessive dusting or when there are exceptionally high wind speeds. The following operational controls are utilized for ash placement and storage:

- Active areas shall be limited in size to the extent feasible. When fugitive dust can no longer be controlled from any former active areas, the procedures for inactive work areas shall be implemented.

- Water application shall be the primary means of fugitive dust control on active areas. Water may be applied by water truck, vacuum truck, water cannon, or irrigation system.

- Commercial dust control additives may be used subject to review and approval by Consumers Energy and EGLE.

- Ash dozing, loading, unloading and placement shall be suspended when the current conditions indicate that such activities cannot be conducted in a controlled manner.

- Where possible, active areas shall be located to take advantage of protective berms to reduce wind velocity over the active area.

- Bottom ash may be applied over compacted fly ash as a temporary measure to control fugitive dust.

The following general procedures are in place for fugitive dust control of inactive cell areas:

- Inactive areas are formerly active areas that will be inactive for three (3) months or more.

- Fugitive dust control shall be provided for inactive areas, if conditions change such that fugitive dust is consistently being generated, through means such as irrigation, bottom ash, straw mat, or vegetative cover installation, stabilization and maintenance.

2.3 WET ASH - BOTTOM ASH HANDLING

The wet ash handling system consists of a conveying system and active bottom ash tanks. Bottom ash from all three boilers is water sluiced to the corresponding tank. The overflow and discharge of the bottom ash tanks is conveyed into the NPDES ditching system and recirculation pond. From the recirculation pond, effluent is discharged through an NPDES permitted outfall (002A) into the Pigeon River. The bottom ash tanks are generally in a wet condition and do not usually require active fugitive dust control.

Solids from the bottom ash tanks are sold for beneficial reuse or are placed in the licensed landfill (can be used for cover). These solids are removed from the bottom ash tanks with a loader or removed using a long-armed excavator to decant within the tank prior to transferring to the lined bottom ash storage pad~~.~~ Haul trucks then transport the ash to the landfill or re-use destination. Activities may be suspended in high wind conditions and the site shall wet the material if Fugitive Dust is consistently generated.

2.4 ROADS

Fugitive PM emissions may be generated from trucks and other heavy equipment traveling on the site haul roads and entering/exiting the site. A water truck is used to wet roads as needed to minimize fugitive PM emissions from truck travel on the site roadways. Routinely accessed un-paved roadways have been improved with an aggregate cover (21AA) in order to minimize dusting and track-out; dust suppressant is applied annually as an additional option. There is a site wide speed limit of 25 mph on non-paved roads to minimize PM generation.

3.0 MONITORING/RECORDKEEPING

3.1 MONITORING

The entire CCR system shall be monitored through visual checks of process equipment and the corresponding particulate matter control devices. The following monitoring is conducted to ensure conformance to the previously stated operational controls:

- All alarms from the dry fly ash collection system bin vent filters shall be responded to promptly.

- Daily:
  - The transfer tank bin vent filter exhaust and the vacuum pump exhaust breather shall be inspected for signs of dust and the ash equipment building and the transfer tanks shall be inspected for signs of fly ash leaks
  - With the DFA system in operation, all pressure piping from the transfer tanks to the valves located on the ash trestle shall be inspected
  - With the DFA system in operation, the vacuum piping from the PM control devices to the transfer tanks shall be inspected
  - With the DFA system in operation, all pressure piping from the point at which the piping exits the ash trestle to the point it enters the ash silos shall be inspected
  - All PM control device exhaust stacks shall be monitored for visible emissions

- Weekly, pressure gauge differential readings for the particulate matter control devices shall be recorded.

- Results of all inspections shall be recorded. If PM is visible from any vacuum or pressure piping, the maintenance department shall be promptly notified; a maintenance request notification shall be submitted and the FDPC shall be notified. The site maintains spare parts for routine repairs of the control and monitoring equipment.

The following control measures are utilized for the landfill operations:

- Active landfill cell areas shall be visually inspected daily to determine if the ash surface requires moisture to prevent fugitive dust formation.
- Records of all dust inspections shall be retained.
- If water application is indicated by the inspection, water shall be applied at a rate sufficient to control dust emissions.

- A fugitive dust record is maintained that includes events of visible emissions that are observed reaching the landfill or site boundary, as well as of suspended activities. The date, cause and corrective action taken shall be logged relative to suspended activities.
- Fugitive dust control techniques and/or activities which are used for any of the various site activities to control fugitive dust are documented.

3.2 RECORDKEEPING

The following records shall be retained for a period of at least five (5) years:

- All actions taken to control CCR fugitive dust
- Record of all citizen complaints
- Summary of any corrective measures taken

4.0 CITIZEN COMPLAINTS

All complaints, concerns and/or inquires that result in an action being taken shall be documented in the site External Communication Log. Any complaint shall be acted upon through internal communication procedures. Environmental Services and Legal shall be notified of any citizen complaint regarding CCR fugitive dust. In accordance with the CCR regulation, the complaint log and resultant actions will be summarized in the annual report.

5.0 PLAN ASSESSMENTS/AMENDMENTS

The FDCP shall be audited utilizing Consumers Energy Compliance Assurance guidance once per year, coordinated by the site FDPC in order to periodically assess the effectiveness of the control plan. Results of the audit shall be reported to site management, Environmental Services, and legal counsel as necessary.

This FDCP may be amended at any time provided that revisions are logged and the revised plan is placed in the facility's operating record. The FDPC is responsible for amending the written plan whenever there is a change in site conditions that would substantially affect the written plan in effect. All amendments to the fugitive dust control plan must be certified by a qualified professional engineer. A notice shall be sent to EGLE within 30 days of when the plan is revised.

6.0 ANNUAL REPORTING

Environmental Services personnel shall prepare an Annual CCR Fugitive Dust Control Report that includes a description of the actions taken by plant personnel or contractors to control CCR fugitive dust, a record of all citizen complaints, and a summary of any corrective actions taken. The report shall be reviewed by site management, Environmental Services, and Legal prior to posting to the operating record. The first annual report is due no later than 14 months after placing the plan in the facility's operating record and subsequent plans shall be completed one year after the date of posting the previous report. A notice shall be sent to EGLE within 30 days of posting the annual report.

7.0 CERTIFICATIONS

CCR Fugitive Dust Plan, Professional Engineer Certification:

By means of this certification, I attest that I am familiar with the requirements of provisions of 40 CFR Part 257.80, that I or my designated agent have visited and examined the facility, that this CCR FDP has been prepared in accordance with good engineering practices, including consideration of applicable industry standards, and with the requirements of this Part, that procedures for required fugitive dust minimization activities, monitoring, and reporting have been established and that the Plan is adequate for the facility.

Bethany Swanberg, P.E.
Professional Engineer

6201068551
License Number (MI)

Bethany Swanberg
Professional Engineer (Signature)

12/11/19
Date of Plan Certification

CCR Fugitive Dust Plan Management Approval:

This Plan is certified as being prepared in accordance with good engineering practices. Thus, this Plan has the full approval of Consumers Energy Company Management. I am at a level of sufficient authority to commit the necessary resources to implement this Plan as described. I have appointed the following representative as the Fugitive Dust Plan Coordinator: Kevin D. Starken

Neil J. Dziedzic
Plant Business Manager

03 DEC 2019
Date

8.0 REVISION HISTORY

Revision Number	Date of Revision	Reason(s) for Revision
0	10/13/15	Original Edition
1	12/15/16	Updated after AQCS on-line and BC Cobb Plant closure
2	12/10/18	Updated after installation of new bottom ash tanks and Annual Fugitive Dust Audit
3	11/22/19	State environmental agency nomenclature change from MDEQ to EGLE

GOLDER

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REPORT

Section H - Construction Quality Assurance Program

J.H. Campbell Generating Facility - Dry Ash Landfill, Type III Expansion Facility ID 395496

Original Submittal to EGLE Approved: December 15, 1993

Revision 1: March 2, 2018

Current Revision: June 2021

Submitted to:

Consumers Energy Company

J.H. Campbell Generating Facility
Consumers Energy Company
17000 Croswell Street
West Olive, Michigan 49460-9748

Submitted by:

Golder Associates Inc.

15851 South US 27, Suite 50

Lansing, Michigan 48906

+1 517 482-2262

19132873

June 2021

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TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Summary of 2018 and 2020 Updates

The Consumers Energy Company (CEC) J.H. Campbell Dry Ash Landfill, located in West Olive, Michigan, Construction Quality Assurance Plan (CQA Plan) has been updated to include upgraded elements, updated Michigan Department of Environment, Great Lakes and Energy – Materials Management Division (EGLE) guidance, and specification updates. The following updates have been included.

- Updates of specifications, as needed.
- Addition of the geosynthetic clay liner (GCL) installation and testing specifications.
- Updated flexible membrane liner installation and testing specifications, which include updated test methods, no allowance of vehicles on the geosynthetics, and updated interface shear requirements.
- Addition of the geonet, geotextile and geocomposite installation and testing specifications.
- Addition of the granular soils installation and testing specifications.
- Addition of the piping installation and testing specifications.
- Addition of the sumps, pumps, and electric requirements.
- Additional of the final cover elements for future closure projects.

1.2 Objectives

The purposes of the CQA Plan are to provide minimum requirements for construction observation, testing, and documentation activities to be performed during closure and to verify that construction landfill cells and constructed final cover meets or exceeds design requirements and specifications contained in the approved J.H. Campbell Dry Ash Landfill Construction Permit and achieves regulatory and local requirements. The plan details sampling and testing programs to be carried out during cell and final cover construction. The primary goal of the CQA Plan is to provide a means of evaluating the quality of the constructed cell or final cover so that the intent of the design is achieved.

1.3 Design Summary

In general, the J.H. Campbell Dry Ash Landfill includes the following major components:

- Subgrade (structural fill)
- Geomembrane (high density polyethylene (HDPE) and linear low density polyethylene (LLDPE))
- Geosynthetic Clay Liner (GCL)
- Geocomposite drainage layers
- Geotextile separation and cushion layers
- Geonet
- Soil protective layer
- Soil drainage layer (including aggregate for the sumps)
- Piping, pumps, and electrical systems for leachate collection and transfer
- Soil erosion layer

- Vegetative layer (topsoil)
- Storm water features
- Final grading, seeding, mulching, and fertilizing to establish vegetation to protect the completed final cover system

1.4 Standards, Specifications and References

- American Society of Testing and Materials (ASTM)
  - ASTM C 33/C33M-16e1 - Standard Specification for Concrete Aggregates
  - ASTM D 422-63(2007)e2 - Standard Test Method for Particle-Size Analysis of Soils
  - ASTM D 638-14 - Standard Test Method for Tensile Properties of Plastics
  - ASTM D 746-14 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
  - ASTM D 751-19 - Standard Test Methods for Coated Fabrics
  - ASTM D 792-13 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
  - ASTM D 854-14 - Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
  - ASTM D 1004-13 - Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting
  - ASTM D 1204-14 - Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature
  - ASTM D 1238-13 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
  - ASTM D 1556/D 1556M-15e1 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
  - ASTM D 1557-12e1 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))
  - ASTM D 1586-11 - Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
  - ASTM D 1587/D1587M-15 - Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
  - ASTM D 1603-20 - Standard Test Method for Carbon Black Content in Olefin Plastics
  - ASTM D 1693-15 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
  - ASTM D 1785-15e1 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
  - ASTM D 2167-15 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
  - ASTM D 2434-68(2006) - Standard Test Method for Permeability of Granular Soils (Constant Head)

  - ASTM D 2487-17e1 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
  - ASTM D 6938-17a - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
  - ASTM D 2937-17e2 - Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
  - ASTM D 2974-20e1 - Standard Test Methods for Determining the Water (Moisture) Content, Ash Content, and Organic Material of Peat and Other Organic Soils
  - ASTM D 3080/D3080M-11 - Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
  - ASTM D 3441-16 - Standard Test Method for Mechanical Cone Penetration Testing of Soils
  - ASTM D 4437/D4437M-16(2018) - Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes
  - ASTM D 6392-12(2018) – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
  - ASTM D 4643-17 - Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
  - ASTM D 4767-11(2020) - Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
  - ASTM D 4944-18 - Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
  - ASTM D 4972-19 – Standard Test Methods for pH of Soils
  - ASTM D 5889/D5889M–18 – Standard Practice for Quality Control of Geosynthetic Clay Liners
  - ASTM D 5321/D5321M-20 – Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
- Solid Waste Management Act Administrative Rules promulgated pursuant to Part 115 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 115 Rules).
- 2012 Michigan Department of Transportation – Standard Specifications for Construction.
- Geosynthetics Research Institute (GRI) – Standard Specifications for Geomembrane, Geocomposite, Geotextile and Geosynthetic Clay Liner (GCL).
- United States Environmental Protection Agency Coal Combustion Residuals Rule (CCR Rule), Code of Federal Regulations (CFR) 40 CFR 257.

2.0 RESPONSIBILITY AND AUTHORITY

Owner/Operator - The Owner and Operator of the JHC Landfill is Consumers Energy Company (CEC), which has ultimate responsibility for the design, construction, and operation of the ash disposal unit.

Regulatory Agency - The Michigan Department of Environment, Great Lakes and Energy (EGLE). The J.H. Campbell Dry Ash Landfill (JHC Landfill) is a Type III solid waste disposal area under the authority of the EGLE Grand Rapids, Michigan office. The Permitting Agency is responsible for reviewing the permit application for the solid waste disposal facility application to assure compliance with the State Regulations. The

Permitting Agency is also responsible for reviewing construction quality assurance documentation to confirm that the facility was constructed as permitted.

Design Engineer - The Design Engineer is responsible for the design of the facility. The Design Engineer shall assure the design meets the construction and operational requirements of the Owner/Operator and meets or exceeds the minimum requirements of the Regulatory Agency.

The Design Engineer will resolve unexpected conditions or unanticipated problems during construction which may require changes to the permitted design. Changes from the permitted design shall require approval of the Owner and Design Engineer such that the original design objectives are still maintained. However, changes will meet the requirements of the Part 115 Rules.

Construction Contractor - The Construction Contractor (Contractor) has overall responsibility for construction of the facility and implementing quality control procedures during construction.

The Contractor is contractually bound to construct the facility in accordance with the permit application.

Construction Quality Assurance Engineer - The Construction Quality Assurance Engineer (CQA Engineer) shall be a Professional Engineer registered in the state of Michigan with experience in civil engineering and construction projects. The CQA Engineer may be an employee of CEC or this role may be contracted out to a qualified consultant.

The CQA Engineer is responsible for implementation of the CQA Plan and certifying that the facility has been constructed in accordance with the permit application. The CQA Engineer does not have the authority to approve design or field changes but may make recommendations to the Design Engineer and Owner.

The CQA Engineer may direct additional CQA personnel in the field during construction to implement the requirements of the CQA Plan

Construction Quality Assurance Officer - The Construction Quality Assurance Officer (CQA Officer) is a designated representative of CEC who is responsible for certificates of construction. The CQA Officer will be a professional engineer registered in the state of Michigan with experience in solid waste unit construction and closure. The CQA Officer is responsible for supervising the inspection and testing quality assurance (QA) requirements of this section. The CQA Officer is also responsible for the preparation of a construction certification report following construction to document the completed observations, measurements, and testing. The report will include a certification statement signed by the CQA Officer that construction meets or exceeds design requirements and specifications and achieves regulatory and local requirements.

The specific responsibilities for administering the CQA program are the responsibility of the CQA Officer and will include the following at a minimum:

- Reviewing plans and specifications for clarity, completeness, and compliance with the approved closure plan and applicable regulations
- Educating and training QA personnel on requirements and procedures outlined in the CQA program
- Scheduling and coordinating QA activities
- Supervising field personnel
- Confirming that QA data are accurately recorded and maintained
- Verifying that raw QA data are properly recorded, reduced, summarized, and interpreted
- Providing associated organizations with reports on CQA activities and results

- Identifying non-conforming construction and verifying corrective measures

Construction Quality Assurance Technician - The Construction Quality Assurance Technician(s) [CQAT(s)], under the direct supervision of the CQA Officer, will be present to perform observations and testing during the construction activities.

Licensed Land Surveyor - The Licensed Land Surveyor shall provide equipment and personnel needed to perform surveying activities as required by the construction project. The Licensed Land Surveyor shall be licensed in the State of Michigan.

Testing Laboratory - The Testing Laboratory is responsible for providing soil and/or geosynthetic testing as required in the project's plans and specifications.

3.0 MEETINGS

The meeting requirements for the CQA program include a preconstruction meeting, construction progress meetings, and special meetings. The meetings are to be documented and minutes will be transmitted to parties identified at the preconstruction meeting.

3.1 Preconstruction Meeting

A preconstruction meeting will be held prior to the start of construction and will be attended by principal parties (CEC, Contractor, CQA Officer) involved in the project. The Michigan Department of Environmental Quality (EGLE) will be notified as soon as possible in advance of the preconstruction meeting in the event a representative wishes to attend. The purpose of the meeting is to:

- Exchange the following information: business addresses, phone numbers, and e-mail addresses of the Owner (CEC), Engineer, CQA Officer, and pertinent personnel for the Contractor
- Resolve any uncertainties following the award of the construction contract
- Review work scope
- Conduct a site walkthrough and inspection
- Discuss the Contractor's overall construction schedule and anticipated work hours
- Discuss project administration
- Review status of submittals required to be transmitted
- Discuss any appropriate design modifications or clarifications
- Discuss the Contractor's surface water and dust management plan
- Discuss the schedule and procedures of the geomembrane installation
- Discuss CEC's emergency notification and operating practices for emergency situations
- Review project methods, site security, and safety

3.2 Progress Meetings

Progress meetings will be held prior to the beginning of each major phase or on an "as needed" basis. The day of week and time of day will be determined and agreed upon prior to the meetings. The meetings will be conducted by CEC. The purpose of the meetings will be to:

- Review coordination of work

- Review schedule
- Review the previous work activities and accomplishments
- Review the status of the Contractor's submittals
- Identify the Contractor's personnel and equipment assignments for the upcoming work
- Discuss any existing or potential construction problems and their respective corrective actions
- Review non-conformance list

Owner's site representative shall document each meeting and distribute copies of minutes to designated parties.

3.3 Special Meetings

Special meetings may be held on the site when the urgency of a construction problem precludes delaying discussion until the next scheduled meeting. Any supervisor/superintendent can request such a meeting through their line of authority (i.e., subcontractors through their Contractor).

Possible solutions will be discussed, and an acceptable solution will be selected. This solution will be implemented, provided it does not conflict with or require a change to the plans, in which case, it must be submitted to the Design Engineer for review.

The Design Engineer will resolve unexpected conditions or unanticipated problems during construction which may require changes to the permitted design. Changes from the permitted design shall require approval of the Owner, Design Engineer, and the EGLE such that the original design objectives are still maintained. Changes shall meet the requirements of the Part 115 Rules.

Owner's site representative shall document each special meeting and distribute copies of minutes to designated parties.

4.0 CERTIFICATION

The CQA Engineer will prepare a construction documentation report that includes the information collected during implementation of the CQA Plan and complies with the Part 115 Rules, R299.4313.

The report shall be stamped by the CQA Engineer, who is a Professional Engineer licensed in the State of Michigan which states that the facility was constructed in conformance with the permit application approved by the EGLE and any Design Engineer/Owner approved modifications.

5.0 CONSTRUCTION OBSERVATIONS

5.1 Daily Reports

The CQAT(s) collects samples and performs or observes the CQA testing required by the CQA Plan. A daily inspection report is prepared by each CQAT(s) for each day they are onsite observing the construction and kept in a record book which is to be made available to CEC on a daily basis. The report will contain (typically) the following information:

- Date
- Type of observations
- Summary of weather conditions such as minimum and maximum temperatures, wind speed, and any precipitation
- Summary of any meetings held and attendees

- Equipment and personnel on the project
- Name and titles of Contractor supervisors and Quality Control personnel
- Summary of construction activities and locations
- Description of offsite materials received
- Calibration and recalibration of test equipment
- Description of procedures used
- Test locations, procedures, results, and test data sheets
- Summary of samples collected
- Personnel involved in daily observations and sampling activities
- Signature of the technician
- Description of delays in construction activities
- Detailed description of any problems or non-conforming construction and resolution/alternatives for each situation
- Summary of failed testing and corrective actions completed
- Ensuring that proper lifts or equipment are used to ensure the minimum contact pressure required at the liner
- Record of and field modifications made to the design or if hot or cold weather placement procedures for liner installation are in effect

5.2 Photographs

The CQAT(s) will coordinate with CEC personnel to ensure sufficient photographs are taken to document construction problems, non-conforming work, and related repairs taken before and after the problem or non-conforming work is corrected. The CQAT(s) will photo-document significant construction activities in a Photographic Log or in the daily report with date the photograph was taken, and description noted.

Photographs approved by CEC security will be provided to the CQA Officer for inclusion in the Certification Report. At the end of the project, photographs will be retained by CEC.

5.3 Test Data Sheets

At a minimum, the CQAT(s) will record field test data results on separate forms listed below:

- Daily field report
- Certificate of acceptance of prepared subgrade (Geosynthetic subgrade)
- Certificate of acceptance of installed geosynthetic liner
- Initial roll inventory
- Panel placement summary
- Trial weld summary
- Panel seaming summary

- Repair summary
- Non-destructive test summary
- Destructive test summary - field
- Destructive test summary – laboratory
- Field compaction summary

Independent consultants or laboratories engaged by the CQA Officer will submit their test results on forms acceptable to and approved by the CQA Officer.

5.4 Documentation and Record Storage

The daily records maintained during construction activities include but are not limited to the following:

- Daily observation reports
- Test data sheets
- Test data from independent consultants or laboratories (if any)
- Field book maintained by each CQAT(s)

Daily records will be copied and forwarded to the CQA Officer on generally a daily basis.

6.0 FOUNDATION PREPARATION, CLEARING AND GRUBBING

1) General

    a. Prior to construction of a new Type III landfill cell, the horizontal limits of each phase shall be cleared, grubbed and the subgrade prepared.

2) Investigation Methods

    b. Visual observation that the areas beneath the external dike, interior dikes, each cell floor, and storm water ditches have been cleared and grubbed of topsoil, vegetation and roots.

    c. Visual observation that topsoil has been stockpiled separately for future use.

    d. Survey of the subgrade for conformance with the permit documents.

    e. Visual observation of subgrade proof rolling for deflection within the limits of the external dike construction.

3) Documentation Records

    f. Daily field report.

    g. Extent of observation (provide sketch, if necessary).

    h. Survey drawing of subgrade.

4) Acceptance Criteria

    i. Survey grade elevations of ±0.2 foot for subgrade on a 100-foot grid for areas within the external dikes and ±0.1 feet for the perimeter ditch and pipe trenches.

5) Topsoil and vegetation, including root system, must be removed from within the limits of the external dikes and perimeter ditch.

6) During proof rolling using a loaded haul truck or loaded front end loader, deflections shall be less than one inch.

7) Corrective Action - If non-conformance with acceptance criteria is noted, the CQA Officer shall inform the Owner and Contractor so the non-conforming item(s) can be corrected. Subgrade shall be regraded as necessary to meet acceptance criteria.

8) Failure to meet deflection criteria will require additional compaction and/or removal and replacement of yielding material.

7.0 GENERAL EARTHWORKS

1) General earthwork construction will include placement of soil to create the perimeter dikes, the internal landfill dikes, access ramps and the landfill and leachate retention pond subgrade areas. Each of these features shall be constructed to the limits and elevations shown on the drawings.

2) Materials

   a. Unclassified Fill - Unclassified fill used in dike construction, access ramp construction and for subgrade fill may consist of any mineral soil free of organic matter or deleterious material. Such materials must be placed and compacted at a moisture content that will result in a substantially unyielded surface when subjected to proof rolling.

   b. Select Fill - Select fill must be placed **for at least the final one foot** of any dike or subgrade surface that will be in direct contact with a flexible membrane liner (FML) in areas where fill is required to achieve the design elevations. Select fill must be classified as SP, SW, SM, or SP-SM in accordance with ASTM D 2487. Select fill must have 100% by weight finer than the No. 4 sieve and/or be rocked picked for areas that will be adjacent to geomembrane.

   c. Structural Fill - Structural fill must be classified as SP, SW, SM, or SP-SM in accordance with ASTM D 2487.

3) Laboratory - Unclassified fill soils shall be tested for their maximum density in accordance with ASTM D 1557 (modified Proctor method) at a rate of one test per 5,000 cubic yards of material placed. Select and Structural fill material shall also be tested for maximum density at a rate of one test per 5,000 cubic yards according to ASTM D 1557. Samples of select fill material shall also be tested at a rate of one test per 1,000 cubic yards for: grain size distribution in accordance with ASTM D 422 and Unified Soil Classification in accordance with ASTM D 2487.

4) Field Testing - Field density tests shall be performed on a 100 foot grid pattern per lift of unclassified or select fill material placed. A minimum of three field density tests per day of fill placement shall be performed. In-place moisture content testing of the compacted soils shall be performed at the same rate as the field density testing. Lift thicknesses and compaction equipment used for each type of material placed shall be documented. The finished elevation of each material type placed shall be determined on a 100 foot grid pattern using surveying methods.

5) Acceptance Criteria

   a. Laboratory – Select and Structural Fill shall be classified as SP, SM, SP-SM or SW in accordance with ASTM D 2487. In addition, Select Fill material must contain 100% by weight passing the No. 4 sieve or be rocked picked for areas that will be adjacent to geomembrane.

   b. Field - Fill materials must be compacted to greater than or equal to 90% of the maximum modified Proctor dry density as determined by ASTM D 1557. Compacted fill material shall be placed in 12 inch maximum lift thicknesses. Where select fill soil is required, the minimum thickness, measured vertically at any point, shall be greater than 12 inches after compaction.

6) Surveyed elevations of completed earthwork shall be within +/- 0.2 foot of design elevations at any point of measurement. In addition, slopes on the landfill cell floor must be within ±0.1% of the design slope between any two points of measurement spaced 100 feet apart.

7) Documentation Records

   a. Field Daily Reports – Field daily reports shall include, at a minimum, the following information.

      i. Source and type of samples taken for laboratory analysis.
      ii. Location of in-place field tests.
      iii. Elevation of tests and/or lift number.
      iv. Field moisture content.
      v. Dry density.
      vi. Wet density.
      vii. Test method used.
      viii. Material type.
      ix. Name of firm and person performing test.
      x. Survey notes referencing coordinates and elevation of feature surveyed, if available.

   b. Laboratory Test Reports – Laboratory test reports shall include the following.

      i. Proctor tests shall list the maximum wet density, maximum dry density and optimum moisture content along with a complete description of the soil type and unified soil classification.
      ii. Grain size analysis test results shall be plotted on a chart with sieve size or particle size on the x-axis and percent coarser or finer on the y-axis, and shall include the unified soil classification, along with a written description of the soil type.

8) Corrective Action

   a. In the event a single test does not meet the acceptance criteria, two additional tests may be performed in the same vicinity or on samples obtained from the same vicinity/batch/stockpile. If two additional tests meet the acceptance criteria, the original failing test may be replaced. Should either retest fail, the original failure will stand.

   b. Excessive lift thicknesses shall be cut to a maximum of 12 inches and the surface recompacted.

   c. In areas where failing field density tests are recorded the area shall either be recompacted, the water content adjusted, the material removed and replaced, or other soil may be blended and recompacted until passing results are obtained.

   d. Any soils failing to meet the gradation or classification requirements for their intended use shall be removed and replaced with acceptable material.

e. Any feature with elevations or slopes which are determined to be outside the allowable tolerances, shall be regraded or material added to create surface elevations within the allowable tolerances.

8.0 SUBGRADE ACCEPTANCE

Once the Geosynthetic subgrade is obtained, the subgrade will be smooth drum rolled. Ruts or irregular surfaces, stones larger than 0.75 inches, debris, and any existing dense vegetation will be eliminated prior to placement of the geomembrane. The geosynthetic subgrade will be documented by survey and compared to the design elevations. The maximum allowable difference from documented grades to design grades is +/- 0.2 foot. If the documented top of geosynthetic subgrade differs from the design grades by more than +/- 0.2 foot, the subgrade will be regraded and redocumented. Once acceptable, the CQAT will document subgrade acceptance with the certificate of soil surface acceptance form provided in Appendix A.

9.0 GEOSYNTHETIC CLAY LINER

Geosynthetic Clay Liners (GCLs) consist of a reinforced low hydraulic conductivity montmorillonite-rich expansive clay (bentonite) core, supported by geotextile and/or geomembranes which are held together by needling, stitching or chemical adhesives.

Geotextile Related GCL is one in which two geotextiles are used respectively as cap and carrier to the bentonite. Cap and carrier designations in this section refer to respective orientations during manufacturing. This may or may not be the as-placed orientation in the field. It can be internally reinforced by needle punching or stitching.

The GCL required for this project is a standard GCL product with bentonite encased by a non-woven, needle punched geotextile on top and a woven geotextile on the bottom, internal reinforced by needle-punching. The woven side of the GCL shall be installed down against the geocomposite, the non-woven side should be installed up against the geomembrane. A typical product type would be a Bentomat ST, or equal.

9.1 Materials

The GCL Manufacturer shall submit copies of the GCL roll Quality Control (QC) Certificates to the CQA Engineer for review and approval. These certificates shall be supplied at the minimum frequency as detailed in the Standard Practice for Quality Control of Geosynthetic Clay Liners (ASTM D 5889) and in the latest revision of GRI-GCL3. The results reported on the GCL roll QC Certificates shall, at a minimum, meet the property values detailed in the latest revision of GRI-GCL3. The GCL Manufacturer shall submit a signed statement that the material supplied, at a minimum, meets these specifications.

9.2 Geosynthetic Contractor Submittals

The Geosynthetic Contractor shall submit to the Owner the following information prior to the start of the GCL installation:

- Schedule of GCL delivery and installation.
- Drawings of construction details for other features as required by the Design Engineer or CQA Engineer.

The CQA Engineer shall verify that submittals required of the Geosynthetic Contractor have been received and meet the requirements of the CQA Plan. The schedule and drawings submitted by the Geosynthetic Contractor, once approved by the CQA Engineer, shall be the basis of the GCL deployment.

9.3 GCL Delivery and Storage

The Geosynthetic Contractor or Owner shall perform the following:

- Prepare the GCL roll storage area to protect the GCL from dirt, mud, dust, moisture, and damage prior to deployment. The GCL rolls shall be protected against vandalism, adverse weather, and other hazards.

The rolls should be stored to allow access for roll identification. The integrity and legibility of roll labels must be maintained during storage. The rolls must be protected from the elements by the application and maintenance of a proper cover.

- Instruct personnel of the proper handling techniques so as not to damage any of the GCL rolls.
- Be responsible for off-loading the GCL rolls when delivered to the job-site.
- Assure that the GCL rolls are packaged, shipped, and stored on-site in such a manner that the GCL rolls are not subjected to damage or moisture.
- Identify and separate damaged rolls from undamaged rolls and store these rolls at a location designated by the Owner until disposition of the damaged roll(s) are determined.
- Store the GCL rolls per the GCL Manufacturer's recommendations.

The CQA Officer shall perform the following:

- Inspect the GCL roll storage area to verify compliance with the CQA Plan.
- Visually inspect the surface of GCL rolls for visible defects and/or damage.
- Compare the roll number against the GCL Manufacturer's QC Certifications for compliance with the specifications and the CQA Plan. Any damage detected shall be documented and the Geosynthetic Contractor shall be notified.

9.4 GCL Installation

The GCL can be deployed on the subgrade which has been inspected and accepted by the CQA Engineer and the Geosynthetic Contractor.

9.4.1 Weather Conditions

The Geosynthetic Contractor shall not deploy the GCL material during precipitation events or on areas with frost or precipitation accumulation. The GCL material shall not be deployed on softened or unstable subgrade.

9.4.2 Placement

GCL panels shall be placed in a controlled manner to prevent damage to the GCL materials or other in-place material. Any such damage shall be repaired by the Geosynthetic Contractor.

Personnel working on the GCL shall not smoke, wear damaging shoes, or engage in other activities which could damage the material. The Geosynthetic Contractor shall provide protection of the GCL from equipment or concentrated personnel traffic associated with the project.

GCL panels shall be deployed in such a manner as to be in contact with the material directly beneath it and preclude folds, wrinkles which may become folds, and bridging. Any wrinkle, fold, or bridging that is observed shall be removed through realignment of the GCL panel or cutting and repairing the panel in accordance with the CQA Plan.

Each adjoining GCL panel shall be overlapped a minimum of 6-inches on each side and a minimum end-to-end overlap of 12-inches, or greater if required by the Geosynthetic Contractor's Installation QC Procedures or the GCL Manufacturer's recommendations. The minimum overlap shall be indicated by a line, or series of lines spaced no more than 50 feet on the exposed surface of the GCL panel. The overlap area shall be free of dirt, gravel, and debris. The overlap shall be maintained to prevent seam openings during the installation and covering process. The Geosynthetic Contractor is responsible for assuring that the GCL panels remain overlapped throughout the installation process and until the overlying material is placed. Bentonite clay granules, or other approved supplement, shall be applied between the GCL layers in the overlap area as required by the GCL Manufacturer's specifications and the Geosynthetic Contractor's Installation QC Procedures.

Horizontal GCL seams on side slopes greater than 5 percent shall be minimized. If horizontal seams are required due to the length of the side slope, horizontal seams shall be bounded on each side by continuous panels and horizontal seams shall be staggered by a minimum distance of 25 feet. Overlap (shingle) the GCL panels such that any fluid flowing across the seams would flow from the top panel to the underlying panel. Panels shall be placed such that the up-slope panels overlie those down-slope.

Placement of the GCL shall be in such a manner as to reduce the risk of water infiltration into the bentonite clay portion of the GCL. The GCL shall be covered with a geomembrane and/or soil material as required by the project design, as soon as practical, to provide maximum protection against the elements. The Geosynthetic Contractor shall direct storm water drainage away from the GCL by construction of temporary storm water diversion berms, or other similar structures.

Premature hydration of the GCL prior to completion of the sand drainage layer installation may be cause for removal of the hydrated material, as directed by the CQA Officer, at no expense to the Owner.

If the bentonite clay of the GCL becomes prematurely hydrated, the CQA Officer shall inspect the material to ensure the integrity of the GCL has not been compromised. The CQA Officer shall inspect the material to ensure that significant thinning of the GCL has not occurred, that the reinforcing geotextile fibers have not been broken causing the internal strength of the GCL to be reduced, or that other properties of the GCL have not been detrimentally affected. The CQA Officer shall also consult with the Design Engineer to ensure that the stability of the liner shall not be affected. If the CQA Officer finds that the integrity and or stability of the GCL has been compromised, the Geosynthetic Contractor shall either install new GCL over the compromised GCL or replace the compromised GCL, as directed by the CQA Officer after consultation with the Design Engineer, at no expense to the Owner.

The Geosynthetic Contractor shall not install more GCL panels than can reasonably be covered with geomembrane that same day. The Geosynthetic Contractor shall also limit the installation of GCL panels during periods of impending bad weather such that the amount of uncovered GCL panels is minimized.

The Geosynthetic Contractor shall clean the work area daily by removing scrap material and other debris associated with the geosynthetic activities and dispose of it properly.

No wheeled vehicles shall traverse directly on the geosynthetics.

The CQA Officer shall observe and document the GCL deployment to verify that provisions of the CQA Plan have been followed.

9.4.3 Temporary Anchoring

The Geosynthetic Contractor is responsible for the temporary anchoring of the GCL during construction. The Geosynthetic Contractor shall use sandbags or other means necessary to restrain the GCL without damage and to prevent the material from being pulled from proper alignment. Areas of damage caused by improper or insufficient temporary anchoring shall, as determined by the CQA Engineer and required by the Owner, be repaired or removed, disposed, and replaced at the expense of the Geosynthetic Contractor.

9.4.4 Permanent Anchoring

The Earthwork Contractor is responsible for the permanent anchoring of the GCL material. Permanent anchoring shall comply with the specifications and shall be installed as soon as practicable following repairs and testing of the GCL material and the installation of the overlying materials.

9.4.5 Repairs

Holes, tears, or damage to the GCL material shall be repaired by placing a patch extending a minimum of 1-foot in directions beyond the edges of the defect. Bentonite clay granules or other supplement shall be applied between the GCL panel and the patch as required by the GCL Manufacturer's specifications and the Geosynthetic Contractor's Installation Quality Control Procedures.

GCL panels with holes or tears extending more than 25 percent across the panel width shall be removed and replaced or covered by a single patch. GCL panels, or portions of panels, which contain excessive patching, as determined by the Owner, shall be removed and replaced, or repaired with a single patch.

The CQA Engineer shall verify and document that GCL repairs are performed as required by the CQA Plan.

9.5 Geomembrane Placement

The placement of geomembrane on the GCL shall be discussed and agreed upon by the appropriate parties in attendance at a construction meeting. The cover material shall be placed the same day that the GCL is installed. Therefore, only the amount of GCL which can be covered the same day shall be deployed. The placement of cover material shall be performed so as not to induce excessive stresses or slippage of the GCL. **For this project, the GCL shall be installed with the woven geotextile side down.**

9.6 GCL Acceptance

The Geosynthetic Contractor shall retain ownership and responsibility of the GCL until acceptance by the Owner. The Owner shall accept the GCL when:

- Required documentation from the GCL Manufacturer and the Installation Contractor has been received and accepted.
- The geosynthetic installation is complete. The GCL material is intact and is not in a hydrated condition.
- Verification that repairs are complete.
- The geosynthetic installation has been accepted in a final approval notice signed by the Geosynthetics Installer and the CQA Engineer.

10.0 FLEXIBLE MEMBRANE LINERS

Geomembranes are synthetic membrane liners with very low permeability. They are used in landfill lining, capping, and other fluid control systems. This section is applicable to field and factory fabricated panels of smooth and textured linear low density polyethylene (LLDPE) and high density polyethylene (HDPE) materials but is not valid when using geomembranes manufactured with other materials such as polyvinyl chloride (PVC).

10.1 Materials

10.1.1 Resin

The geomembrane manufacturer shall provide the following information prior to delivery of the geomembrane to the job-site:

- The resin supplier's name, resin production facility, resin identification, and production date of the resin.
- A copy of the quality control certificates issued by the resin supplier.
- Results of tests conducted by the resin supplier to verify the raw material quality including specific gravity and carbon black content.
- A certification from the resin supplier that the polymer used in the geomembrane meets the criteria of the specifications.

- Reports of tests or a certification by the manufacturer verifying the quality of the raw materials including specific gravity and melt flow index. These tests shall be performed at a frequency of at least one per resin batch but not less than once per 180,000 pounds of resin used in the manufacturing of the geomembrane.
- A certification that reclaimed polymer is not added to the resin and that polymer recycled during the manufacturing process does not exceed 2 percent of the resin.

The CQA Engineer shall review the submittals provided by the manufacturer to verify compliance with the requirements of the specifications.

10.1.2 Geomembrane

The geomembrane manufacturer shall perform the following:

- Provide a certification that the geomembrane manufactured for this project meets the following criteria:
  - The geomembrane contains no more that 1 percent by weight of additives, fillers, or extenders, excluding carbon black.
  - The geomembrane is without holes, cracks, thin spots, tears, punctures, blisters, undispersed raw materials, roughness other than produced due to texturing, or any other indication of contamination.
  - HDPE geomembrane and resin must conform to the minimum properties of the specifications and the latest revisions to Geosynthetic Research Institute Test Method GRI-GM13.
  - LLDPE geomembrane sheets and resin for construction of landfill cover must conform to the minimum properties of the specifications and the latest revisions to Geosynthetic Research Institute Test Method GRI-GM17.
- Provide test results for direct shear tested in accordance with ASTM D 5321. Test results shall be provided for each new material type and/or resin type and shall include interfaces and normal loads as approved by the CQA Engineer. Minimum acceptable friction angles are 11 degrees for smooth geomembrane and 17 degrees for textured geomembrane. If acceptable direct shear test results are not available from the geomembrane manufacturer, the CQA Engineer shall perform direct shear testing in accordance with ASTM D 5321 for each material type, utilizing the project specific configuration (i.e., interface configuration and normal loads). Interface shear testing from previous projects may be used if the material types and manufacturers are the same.
- Provide a copy of the manufacturer's geomembrane properties and quality control requirements, and instructions for geomembrane delivery, storage and handling.
- Provide QC Certificates which represent each roll of geomembrane to be delivered to the job site. Each QC Certificate shall include:
  - Roll number, geomembrane type, thickness, manufacturer, date of production, and roll dimensions. Each finished roll shall be identified by a number corresponding to the particular batch of resin used.
  - The manufacturer's test results on samples from rolls of the same production lot, which verify that the rolls meet the requirements of the specifications. These samples shall be tested to confirm that the requirements of the specifications are met, except that testing for environmental stress crack resistance and low temperature impact need not be performed. The test data shall be identified by roll number.
  - Certification that the roll meets the requirements of the specifications.
- The manufacturer is responsible for the production of extrusion beads and/or welding rod from polyethylene resin which shall meet the requirements of the specifications.

The CQA Engineer shall verify that the manufacturer's submittals meet the requirements of the specifications.

10.2 Geosynthetics Contractor Submittals

The Geosynthetics Contractor or Owner shall obtain the following information prior to the start of geomembrane installation:

- Schedule of geomembrane installation.
- Panel layout drawings.
- Drawings of construction details for anchor trenches, sumps and other features as required by the Contractor.
- A resume for the Master Seamer to be assigned to the project. A Master Seamer must be present on-site during geomembrane seaming operations and shall have completed seaming on at least 1,000,000 square feet of polyethylene geomembrane, using both extrusion and fusion welding methods.
- A resume for each Seamer to be assigned to the project. Each Seamer shall have seamed a minimum of 100,000 square feet of polyethylene geomembrane.
- A resume for each Seamer subsequently assigned to the project shall also be submitted. Seamer apprentices or assistants do not need the requisite experience as long as they are working under the direct supervision of a qualified Seamer.

The CQA Engineer shall verify that submittals required of the Geosynthetics Contractor have been received and meet the requirements of the CQA Plan. The schedule and drawings submitted by the Geosynthetics Contractor, once approved by the CQA Engineer, shall be the basis of geomembrane deployment.

10.3 Geomembrane Delivery and Storage

The Geosynthetics Contractor shall perform the following:

- Assure that the geomembrane rolls or panels are packaged, shipped, off-loaded, and stored on-site in such a manner that the rolls are not subjected to damage.
- Prepare the roll storage area to protect the geomembrane from dirt, mud, dust, and damage prior to deployment. The geomembrane shall be protected against vandalism, adverse weather, and other hazards.
- Be responsible for off-loading of the geomembrane rolls when delivered to the job-site.
- Instruct personnel of the proper handling techniques so as not to damage any of the geomembrane rolls.
- Assure that the geomembrane material is not folded. Folded geomembrane material shall be rejected.
- Stack the geomembrane rolls per the manufacturer's recommendations, but no more than five rolls high.
- Identify and separate damaged rolls from undamaged rolls and store these rolls at a location designated by the Owner until the disposition of the damaged rolls is determined.

The CQA Officer shall perform the following:

- Inspect the geomembrane roll storage area to verify compliance with the CQA Plan.
- Document the following information for liner material delivered to the Site:
  - Storage location,

   - Name of the manufacturer and fabricator,
   - Name, type and thickness of the liner,
   - Batch code,
   - Panel number (if prefabricated),
   - Date of fabrication, and
   - Physical dimensions.
- Observe the material off-loading and storage of geomembrane rolls to verify compliance with the requirements of the CQA Plan.
- Visually inspect the surface of geomembrane rolls for visible defects and/or damage. Any damage detected shall be documented.

10.4 Geomembrane Installation

10.4.1 Anchor Trench

The CQA Engineer shall verify that the anchor trench has been constructed according to the requirements of the specifications and the construction drawings. The CQA Officer shall observe and document the placement of the geomembrane in the anchor trench and the placement of the anchor trench backfill material as required by the specifications. The anchor trench shall not be backfilled until the destructive and non-destructive testing of the seams to be buried has met specifications.

The Earthwork Contractor shall perform the following:

- Construct anchor trenches to the nominal dimensions shown on the engineering plans and specifications with rounded edges and maintain trenches until properly backfilled.
- Provide for adequate drainage of the anchor trench.
- Backfill the anchor trench according to the engineering plans and specifications and the CQA Plan.

10.4.2 Weather Conditions

The CQA Engineer shall verify and document that geomembrane seaming is performed only during weather conditions which are considered acceptable, as described by this CQA Plan in the following sections.

The Geosynthetics Contractor shall:

- Not weld during precipitation events, in the presence of excess moisture (i.e., heavy fog or dew, in an area of ponded water), or during conditions of winds which affect the control of the welding temperatures (unless engineering controls are installed).
- Ensure that field seaming is not performed in adverse weather conditions that could impair the quality of the geomembrane installation unless protective structures or other methods are used to maintain seam integrity during construction.

Welding performed at ambient temperatures below 40 degrees Fahrenheit (measured 6 inches above the geomembrane), shall be performed in accordance with the following procedures:

- CQA Officer shall monitor and record ambient air temperatures at an interval not to exceed 30 minutes, from a location 6-inches above the geomembrane. If seaming is occurring in an enclosed structure, recorded temperatures shall be those in the enclosure.

- Additional trial weld samples shall be performed for each 5 degree change in ambient temperature when performing seaming below 40 degrees Fahrenheit. This provision will not require interruption of field seaming of panels before a continuous seam is completed.
- Extrusion welding shall be performed only with a hot air pre-heat operating immediately in front of the extrusion nozzle.
- A specimen will be obtained from the end of each fusion welded seam that exceeds 25 feet in length, exclusive of cross-seams. The specimen will be field-tested for peel adhesion. The result of peel testing will be recorded as a pass/fail on the CQA Officer's Panel Seaming Form.
- Destructive sample test frequency may be increased based on observation and determinations of the CQA Officer.

The cold weather seaming procedures may be revised or modified. These changes will be submitted to EGLE for review and approval before implementation.

10.4.3 Deployment Methods

The Geosynthetics Contractor shall install the geomembrane according to the panel layout drawings previously submitted to the Owner. Any changes to the panel layout must be approved by the Owner. The geomembrane shall be deployed in a manner so as to be in a loose and relaxed condition at the time of geomembrane seaming.

No wheeled vehicles shall traverse directly on the geosynthetics.

The CQA Engineer shall observe and document the deployment of the geomembrane to verify that the provisions of the CQA Plan are met.

10.4.4 Prevention of Damage

The Geosynthetics Contractor shall be responsible to assure that:

- Installation personnel do not use equipment or tools that may damage the geomembrane.
- No installation personnel shall smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane.
- The method used to unroll the panels shall not cause scratches or crimps in the geomembrane and shall not damage the supporting soil.
- The method used to deploy the geomembrane shall minimize wrinkles.
- Bridging of grade changes by the geomembrane shall be removed as directed by, and at the discretion of the CQA Officer.
- Adequate loading (i.e., sandbags or similar items that shall not damage the geomembrane) shall be placed on the geomembrane to prevent uplift and relocation of panels by wind.
- Direct contact with the geomembrane shall be avoided.

The CQA Officer shall perform the following activities regarding geomembrane placement:

- Verify that each panel is clearly identified, and its location noted.
- Verify and document that the panel deployment proceeds according to the panel layout drawing and that pertinent information including panel overlap is recorded.
- Visually observe the geomembrane for uniformity, damage and imperfections, including any of the following: holes, cracks, thin spots, tears, punctures, blisters or foreign material.

10.4.5 Field Panel Identification and Deployment

The Geosynthetics Contractor shall assign each field panel a unique identification number consistent with the panel layout drawings submitted to the Owner. The Geosynthetics Contractor shall deploy field panels according to the panel layout drawing. Each panel deployed shall be recorded by the Geosynthetics Contractor. Identification number, location, and date shall be recorded.

The CQA Officer shall perform the following activities regarding geomembrane placement:

- Verify that each panel is clearly identified, and its location noted.
- Verify and document that the panel deployment proceeds according to the panel layout drawing and that pertinent information including panel overlap is recorded.
- Visually observe the geomembrane for uniformity, damage and imperfections, including any of the following: holes, cracks, thin spots, tears, punctures, blisters or foreign material.

10.4.6 Geomembrane Panel Thickness Measurements

Panel thickness measurements shall be provided by the geomembrane manufacturer on the material certifications. The CQA Engineer will document that thickness measurements provided by the manufacturer are consistent with field measurements by measuring the thickness of each roll on the leading end and sides of the roll.

10.5 Seaming Specifications

10.5.1 General Procedures

The Geosynthetics Contractor shall perform the following:

- Overlap (shingle) the geomembrane panels such that any fluid flowing across the seams would flow from the top panel to the underlying panel.
- Orient seams located on slopes steeper than 5 percent parallel to the fall of the slope, unless approved by the Design Engineer. Horizontal seam on side slopes greater than 5 percent should be minimized. If horizontal seams are required due to the length of the side slope, horizontal seams shall be bounded on each side by continuous panels and horizontal seams shall be staggered by a minimum distance of 25-feet. Panels shall be placed such that the up-slope panels overlie those down-slope. Geomembrane panels placed on slopes shall extend a minimum 5-feet beyond the toe of the slope.
- Clean the seam area such that the seam area is free of moisture, dust, dirt, debris, and foreign matter of any kind prior to seaming.
- Align seams with the least possible number of wrinkles and "fishmouths". "Fishmouths" are to be cut, removed, and patched.
- Field seam only in weather conditions which shall not impair the quality of the geomembrane, unless approved by the CQA Engineer.

The CQA Engineer shall verify that geomembrane Seamers meet the experience requirements of the CQA Plan, and that a Master Seamer who meets the experience requirements of the CQA Plan is present on-site whenever seaming is conducted. The CQA Officer shall observe and document the geomembrane seaming activities to verify that the requirements of the CQA Plan are met.

10.5.2 Trial Welds

The Geosynthetic Contractor shall perform the following:

- Begin geomembrane seaming only after geomembrane equipment and Seamers have successfully completed trial welds.
- Perform trial welds at: (1) at the beginning of each seaming period; (2) at least once each 5 hours or seaming or (3) as directed by the CQA Engineer if materials, equipment or environmental conditions have changed since the last successful trial weld. Also, each operator and seaming unit combination will make at least one test seam each day prior to commencing seaming operations.
- Perform trial welds using similar materials and in the same surroundings and environmental conditions as the production welds.
- The trial weld shall be generally of 5-feet long for self-propelled seaming devices, and 3-feet for hand-held devices.
- One-inch wide cut-outs of the trial weld shall be subject to shear and peel adhesion testing at the Site. A minimum of two cut-outs shall be tested for bonded seam strength (shear), and an additional three cut-outs shall be tested for peel adhesion using a digital readout tensiometer and the testing procedures of ASTM D 6392.

A trial weld sample shall be considered passing, according to the following table (Table 1) and the latest revision of GRI-GM19a, for specimens tested in shear and peel adhesion.

Table 1: Field and Laboratory Seam Requirements

Property	Test Method	40 mil Smooth/Textured LLDPE	40 mil Smooth/Textured HDPE	60 mil Smooth/Textured HDPE
Shear Strength – **Fusion** Weld (Hot Wedge) – pounds per inch (ppi)	ASTM D 6392 – GRI-GM19a	60	80	120
Peel Strength – **Fusion** Weld (Hot Wedge) –ppi	ASTM D 6392 – GRI-GM19a	50	60	91
Shear Strength – **Extrusion** Weld ppi	ASTM D 6392 – GRI-GM19a	60	80	120
Peel Strength – **Extrusion** Weld ppi	ASTM D 6392 – GRI-GM19a	44	52	78

Seam sample requirements shall be in accordance with EGLE's Operational Memo 115-19, latest revision. For trial welds, specimens must meet the seam strength criteria with 0% incursion into the welded area.

A failed trial weld shall not be retested. The seaming equipment and the Seamer that produced the failed trial weld shall not be allowed to weld the project geomembrane until deficiencies or conditions are corrected and successful trial welds are achieved.

The CQA Officer shall observe the trial weld preparation and testing and verify that requirements of the CQA Plan are met. The CQA Officer shall document trial welds, test results, and appropriate responses.

10.5.3 Seaming and Testing Equipment

Approved processes for field seaming are fusion and extrusion welding. Fusion welding shall be the primary seaming method, with extrusion welding used for geomembrane repairs. Proposed alternate processes shall be documented and submitted by the Geosynthetics Contractor to the CQA Engineer for approval prior to use in the field.

The Geosynthetics Contractor shall:

- Use extrusion welders and dual track fusion welders for field seaming. Extrusion welders shall be equipped with gauges to indicate the temperature in the welder and the pre-heat nozzle temperature.
- Provide a field tensiometer with proof of calibration certification for on-site shear and peel adhesion tests. This device shall meet the requirements for testing shear and peel adhesion according to ASTM D 6392.
- Provide air pressure/vacuum pump, air pressure measuring devices, and vacuum boxes with the capabilities for air pressure and vacuum box testing as required in the CQA Plan.
- Provide a coupon die and press to produce weld coupons in the field for shear and peel adhesion testing.
- If portable gasoline-powered electric generators need to be used on the geomembrane, use a protective lining and a splash pad large enough to collect spilled fuel under the generator.

10.5.4 Seam Preparation

10.5.4.1 Extrusion Welding

The Geosynthetics Contractor shall:

- Overlap the geomembrane panels to be welded a minimum of 3-inches. Unless approved by the Engineer, extrusion welding shall not be used as the primary field seaming method.
- Clean the geomembrane panel prior to seaming to assure that the area is clean and free of moisture, dirt, dust, and debris.
- For geomembranes greater than 60 mils in thickness, the edge of the upper geomembrane to be extrusion welded shall be bevelled with a hand grinder at a 45 degree angle prior to tacking into place.
- Weld the geomembrane within 15 minutes of grinding and cover abraded areas with extrudate.
- Purge the extruder prior to beginning the seam to remove heat degraded extrudate from the barrel of the extrusion machine.
- Keep the welding rod clean and dry.
- The welding technician shall legibly mark the following information on the geomembrane at the start of each seam or repair:
  - Date and start time,
  - Technician identification, and
  - Welding machine identification.

The CQA Engineer shall verify and document that geomembrane seam overlapping and preparation for extrusion welding is performed as required by the CQA Plan.

10.5.4.2 Fusion Welding

The Geosynthetic Contractor shall perform the following:

- Overlap the geomembrane panels a minimum of 4 inches.

- Clean the geomembrane seam area prior to seaming to assure that the area is clean and free from moisture, dirt, dust, and debris. No grinding is required for fusion geomembrane welding.
- Use a protective, moveable layer ("rub sheet") directly below the overlap of geomembrane that is to be seamed, if required to prevent build-up of moisture between the panels.
- The welding technician shall legibly mark the following information on the geomembrane at the start of each seam:
  - Date and start time,
  - Technician identification, and
  - Welding machine identification.

The CQA Engineer shall verify and document that geomembrane overlapping and preparation for fusion seaming is performed as required by the CQA Plan.

10.6 Non-Destructive Seam Testing

The Geosynthetic Contractor shall perform non-destructive tests on field seams and repairs over their full length. Test equipment required for non-destructive testing shall be furnished and operated by the Geosynthetics Contractor. Where the seam cannot be non-destructively tested, as determined by the CQA Officer, the Geosynthetics Contractor shall submit to the CQA Officer an alternate testing method for approval. Non-destructive testing shall be performed as the seaming work progresses, not at the completion of field seaming.

The CQA Officer shall observe and document the results of non-destructive seam testing. The CQA Engineer shall verify that the test methods meet the requirements of the CQA Plan, and document that seams which fail non-destructive tests are repaired according to the CQA Plan.

10.6.1 Air Pressure Testing

Air pressure testing is applicable to double fusion welding which produces a double seam separated by an air channel.

The Geosynthetics Contractor shall perform the following:

- Conduct air pressure testing wherever determined feasible by the CQA Officer on dual track fusion seams.
- Use the following equipment for air pressure testing of dual track fusion seams:
  - An air pump or pressure tank equipped with a pressure gauge capable of generating and sustaining a minimum pressure of 50 pounds per square inch (psi) and mounted on a cushion to protect the geomembrane. The air pump may be manual, or motor driven.
  - A pressure gauge capable of indicating the air pressure in 1.0 psi increments within the test range and equipped with a sharp needle.
- Use the following procedures when performing air pressure testing:
  - Seal the air channel at both ends of the seam area to be tested.
  - Insert a pressure gauge or other approved pressure gauge into both ends of the channel created by the dual track fusion welding. Means of pressurizing must be provided.
  - Energize the air pump to a minimum pressure of 27 psi for 60 mil geomembrane and 24 psi for 40 mil geomembranes, the valve shall be closed, and the pressure shall be sustained for 5 minutes. Long

seams may require a stabilization period prior to the start of the testing period to account for pressure equalization and temperature fluctuations.

- If there is a loss of pressure exceeding 3 psi for 60 mil geomembrane and 4 psi for 40 mil geomembranes, or if the pressure does not stabilize, the faulty area shall be located, repaired, and retested.
- Ensure that the air channel is not obstructed by releasing air from the end of the seam opposite the pressure gauge and observe the resulting pressure drop.
- Remove the pressure gauge and seal the holes.

10.6.2 Vacuum Box Testing

Vacuum box testing is applicable to extrusion welded seams. Fusion welded seams which cannot otherwise be air-pressure tested may be vacuum box tested with the prior approval of the CQA Engineer.

The Geosynthetics Contractor shall:

- Use the following equipment for vacuum pressure testing:
  - A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft gasket attached to the bottom, a valve assembly, and a vacuum gauge.
  - A vacuum pump assembly equipped with a pressure controller and pipe connections.
  - Additional fittings and connections as needed to perform the tests.
- Use the following procedure when performing the vacuum pressure testing:
  - Trim excess geomembrane sheet overlap, if any.
  - Apply a soapy solution to a length of the geomembrane approximately 12-inches by 48 inches along the seam (approximately the length of the vacuum box).
  - Place the vacuum box over the wetted area and apply pressure to seal the box over the seam. Apply a minimum vacuum pressure of five (5) psig to the interior of the box.
  - For a period of approximately 10 seconds, examine the geomembrane seam through the viewing window for the indication of soap bubbles.
  - If no bubbles appear, release the vacuum and move the vacuum box to the next area of the seam, with a minimum 3-inch overlap. Repeat the process.
  - Mark areas where soap bubbles formed and repair the seam as required in the CQA Plan. Retest the repaired seam.

10.7 Destructive Seam Testing

The purpose of destructive testing is to evaluate seam strength. Destructive seam testing shall be performed as the seaming work progresses, not at the completion of field seaming. This destructive testing shall not apply to minor repair work. Repairs with a maximum diagonal dimension of less than 8 feet (approximately two times the size of a seam destructive sample patch) will be considered minor. No destructive testing shall occur within sumps.

10.7.1 Sampling

The Geosynthetic Contractor shall:

- Obtain at least one destructive test sample per day per seaming crew or machine, or every 500-feet of seam, whichever is greater, from locations specified by the CQA Engineer. Additional destructive test samples shall be taken as directed by the CQA Engineer.
- Cut the destructive test samples as seaming progresses in the locations designated by the CQA Officer. The destructive test samples shall be generally 12-inches wide by 45 inches long, with the seam centered lengthwise. One cut-out from each end of the sample shall be field tested prior to destructive testing. The remaining sample is to be cut into thirds (two 15-inch samples, one 12-inch sample), with two pieces given to the CQA Engineer (one 15-inch laboratory sample and one 12-inch archive sample) and the other sample retained by the Geosynthetics Contractor.
- For extrusion welded seams or extrusion welded repairs that have a diagonal dimension greater than 8-feet, a trial weld sample may be used as the destructive sample, if the trial weld is extrusion welded immediately after the repairs were performed.
- Label samples with the location and seam number and record the date, location, panel numbers, direction of fusion/extrusion welding, seam number, welding machine and welding technician.
- Repair holes in the geomembrane resulting from obtaining the destructive test samples. Patches shall be vacuum tested.

The CQA Engineer shall:

- Determine and identify the locations for destructive test sampling.
- Verify and document that the Geosynthetics Contractor's destructive sampling and testing procedures meet the requirements of the CQA Plan.
- Send the destructive test samples to an off-site laboratory for testing described below. On-site destructive testing performed in a controlled environment by qualified individuals of the CQA Engineer may be utilized in place of an off-site laboratory, if approved by the Owner.
- Verify and document that destructive test results meet the requirements of the CQA Plan. Observe and document subsequent activities relating to the repair and patching of the destructive test sample location.
- Locate and document the destructive test sample locations on the panel layout drawing.

10.7.2 Testing

The CQA Engineer shall perform the following:

- Test destructive samples for bonded seam strength (shear) and for peel adhesion. Samples from dual track welds shall be tested for peel adhesion on both tracks of the seam independently.
  - Cut out ten, 1-inch wide replicate specimens from the destructive test sample. Test five specimens for shear and five specimens for peel strength in accordance with ASTM D 6392. The passing criteria is per Table 1 and the most recent revision of GRI-GM-19a.

10.8 Destructive Test Failure

The Geosynthetic Contractor shall ensure that the following procedures are followed if a sample fails a field destructive test:

- Retrace the welding path to an intermediate location (at a distance of approximately 10 feet from each side of the failed test), at the CQA Engineer's discretion, and take additional destructive test samples. If this test passes the CQA Plan criteria, then the seam shall be repaired between that location and the original failed test location. If the test fails, the process is repeated. Failed test samples must be bounded by passing test samples or the point at which the particular seaming device was taken out of service.

- A laboratory destructive test of a previously performed trial weld may be used as a bounding sample for a failed destructive test.
- Over the length of seam failure, either cut out the old seam, reposition the panel and reseam, or install a cap-strip, as required by the CQA Engineer.
- In lieu of installing a cap-strip over a failed fusion-welded seam, the Geosynthetics Contractor may elect to extrusion weld the upper flap of the fusion seam to the lower geomembrane, provided that the upper flap has a 2-inch minimum extension beyond the fusion weld.
- Vacuum test extrusion weld repairs. Additional destructive samples shall be taken at the discretion of the CQA Engineer.

10.9 Defects and Repairs

The CQA Officer shall perform the following:

- As each geomembrane panel is deployed, or as soon as possible after deployment, observe the geomembrane surface for damage and imperfections including holes, cracks, thin spots, tears, punctures, blisters, and foreign material. The surface of the geomembrane shall be clean at the time of the CQA Officer's observations.
- Identify, mark, and observe non-destructive testing of suspect locations.
- Verify and document that defects found as a result of (1) the inspection and testing of suspected areas; (2) non-destructive tests; (3) destructive tests; and (4) any other inspection or observation, are identified for repair.
- Verify and document that identified defects are appropriately repaired in accordance with the CQA Plan. Repair equipment, materials, and procedures are subject to the approval of the CQA Engineer.
- Verify and document that repairs are non-destructively tested and either pass the test or are again repaired and tested until passing test results are achieved.
- Record the locations and types of defects and record the repairs and non-destructive testing at these locations.

The Geosynthetic Contractor shall perform the following:

- Clean the geomembrane surface prior to inspection of the geomembrane by the CQA Officer. The geomembrane surface shall be brushed, blown, or washed if the amount of dust or mud inhibits observations.
- Perform non-destructive tests of each suspect location in the presence of the CQA Officer. Each location that fails the non-destructive tests shall be marked by the CQA Officer and repaired according to the procedures in the CQA Plan.
  - Repair any portion of the geomembrane which exhibits a flaw or fails a destructive or non-destructive test as follows:
  - Small holes shall be repaired by extrusion welding. If the hole is larger than ¼ inch, the hole is to be patched.
  - Failed seams shall be repaired in accordance with Section 10.8.

- Tears shall be repaired by patching. Where the tear is on a slope or an area of stress and has a sharp edge, the tear is to be rounded by cutting prior to patching.
- Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by large patches.
- Surfaces of the geomembrane which are to be patched shall be abraded and cleaned no more than 15 minutes prior to the repair. Abraded areas shall be covered by extrudate. No more that 5 percent of the thickness shall be removed by abrading.
- Folded geomembrane that has been creased or otherwise damaged shall be replaced. Patching shall be permitted with the approval of the CQA Engineer.
- Patches shall be round or oval in shape, made of the same geomembrane, and extend a minimum of 6-inches beyond the edge of the defect. Patches shall be of the same compound and thickness as the geomembrane being repaired.
- Surfaces must be clean and dry at the time of repairs. Seaming equipment used in the repairs must be approved by the CQA Engineer. Repair procedures, materials, and techniques must be approved by the CQA Engineer.

- Perform non-destructive tests on each repair location. Repairs that pass the non-destructive test shall be noted as an acceptable repair. Failed tests indicate that the repair shall be repeated and retested until a passing test is achieved. The CQA Engineer may also require a destructive seam test sample to be taken from a repaired seam. Acceptance of the repaired seam shall then also be subject to the sampling, testing, and acceptance criteria of the CQA Plan.

10.10 Geomembrane Acceptance

The Geosynthetic Contractor shall retain ownership and responsibility of the geomembrane installation until acceptance by the Owner. The Owner shall accept the geomembrane installation when:

- The geomembrane installation is complete.
- Verification that field seams and repairs, including associated testing is complete.
- The geosynthetic installation has been accepted in a final approval notice signed by the Geosynthetics Installer and the CQA Engineer.

11.0 GEONET, GEOTEXTILE, AND BONDED GEOCOMPOSITE MATERIALS

The proposed design may include the options to install geonet, geotextile, and/or bonded geocomposite materials as indicated in the specifications for drainage and stability purposes in the landfill cover and base liner. This section of the CQA Plan addresses geonet, geotextile, and bonded geocomposite materials for use in the landfill liner system and/or the final cover.

11.1 Submittals

The manufacturer of the geonet, geotextile, and bonded geocomposite shall submit the following:

- Manufacturer's specifications and certification stating that the materials meet or exceed the applicable requirements of the specifications.
- Manufacturer's instructions for handling and storage of the geonet, geotextile, and/or the bonded geocomposite.

- Manufacturer's QC test results for geonet, geotextile, and/or bonded geocomposite. These test results shall identify each roll of bonded geocomposite with the corresponding roll identifications of the geonet and geotextiles incorporated therein such that the results of the following tests can be positively correlated with the geocomposite roll identification. The testing shall be performed by the manufacturer as follows:
  - The geonet shall be sampled at a minimum frequency of one sample for each 100,000 square feet delivered to the job-site and shall be tested by the manufacturer to verify that the requirements in the specifications are met.
  - The geotextile shall be sampled at a minimum frequency of one sample for each 100,000 square feet delivered to the job-site and shall be tested by the manufacturer to verify that the requirements in the specifications are met. Testing for UV Resistance is not required. Certification by the manufacturer that the UV Resistance requirement is achieved shall be provided.
  - The bonded geocomposite shall be sampled at a minimum frequency of one sample for each 100,000 square feet delivered to the job-site. The geonet and the geotextile from the geocomposite samples shall be certified that the requirements of the specifications are met.

The CQA Engineer shall verify and document that the information submitted by the manufacturer meets the requirements of the specifications.

11.2 Materials

11.2.1 Geonet

The geonet shall be comprised of HDPE and shall meet the minimum average roll values outlined in the specifications.

11.2.2 Geotextile

The geotextile shall consist of continuous filament, needle punched, non-woven material and shall meet the minimum average roll values outlined in the specifications.

11.2.3 Geocomposite

The bonded geocomposite shall be comprised of a geonet heat bonded to geotextile. The geonet shall meet the requirements of the specifications. The geotextile shall be not less than 6 oz/yd2 and shall meet the requirements of the specifications. Additionally, the geocomposite shall meet the requirements of the specifications.

11.3 Material Delivery, Handling, and Storage

The Geosynthetics Contractor or Owner shall perform the following:

- Assure that the geonet, geotextile, and bonded geocomposite rolls are packed, shipped, off-loaded, and stored by appropriate methods to prevent damage. The Geosynthetics Contractor shall be responsible for replacing any damaged or unacceptable material at no cost to the Owner.
- Protect the materials from mud, dust, dirt, and other damaging conditions. The manufacturer's procedures for shipping, handling, and storage shall be followed.
- Assure that the geonet, geotextile, and the bonded geocomposite rolls are clearly labeled with the manufacturer's name, roll number, lot number, and batch number. Information shall be provided by the manufacturer which clearly identifies the corresponding roll information for the geonet, and geotextiles incorporated into the geocomposite.

The CQA Officer shall observe the off-loading of the geonet, geotextile, and the bonded geocomposite and shall visually inspect the surface of rolls for defects and/or damage and document any observed damage to any of the rolls.

11.4 Material Deployment

The Geosynthetics Contractor shall perform the following:

- Assure that geonet, geotextile, and bonded geocomposite materials are handled in a manner to prevent damage.
- Assure that no materials are placed over the geomembrane until required documentation regarding the geomembrane installation is complete.
- Assure that the surface on which the materials are to be placed does not contain stones or excessive dust that could cause damage to any geosynthetic component.
- In periods of high winds, weight geosynthetic components with sandbags or similar material. The Geosynthetics Contractor shall be responsible for damage to the geosynthetic components resulting from wind damage.
- Cut the geonet, geotextile, and bonded geocomposite materials using an approved cutter. Care must be taken to protect the underlying geomembrane when the materials are being cut in-place.
- Assure that no personnel working on the geosynthetic materials shall smoke, wear damaging shoes, or engage in other activities that could damage the materials.

No wheeled vehicles shall traverse directly on the geosynthetics.

The CQA Officer shall observe and document the deployment of geonet, geotextile, and bonded geocomposite to verify that the provisions of the CQA Plan are met.

11.5 Field Seams

The Geosynthetic Contractor shall perform the following:

- Field seams for geonet:
  - The overlap for seams shall be 4-inches along panel edges and 6-inches at panel ends.
  - Adjacent panels of the geonet shall be joined using self-locking nylon straps placed at 5 feet intervals along the seam length on the sides and at one foot intervals along the seam length at the ends. Only ties which do not damage the underlying geomembrane shall be used. Metal ties shall not be allowed.
  - Ties shall be white or brightly coloured for easy identification.
  - Where more than one layer of geonet is installed, overlaps must be staggered, and layers tied together.
  - Orient seams located on slopes steeper than 5 percent parallel to the fall of the slope, unless approved by the Design Engineer. Horizontal seams shall be minimized. If horizontal seams are required due to the length of the slope, horizontal seams shall be bounded on each side by continuous panels and horizontal seams shall be staggered by a minimum distance of 25-feet.
- Field seams for geotextile:
  - The overlap for seams shall be at least 4-inches.

- The geotextile shall be continuously sewn between panels. Alternate methods of bonding the geotextile must be approved by the CQA Engineer prior to use.
- The thread used to sew the geotextile panels together shall meet the manufacturer's requirements.
- Orient seams located on slopes steeper than 5 percent parallel to the fall of the slope, unless approved by the Design Engineer. Horizontal seams shall be minimized. If horizontal seams are required due to the length of the slope, horizontal seams shall be bounded on each side by continuous panels and horizontal seams shall be staggered by a minimum distance of 25-feet.

- Field seams for bonded geocomposite:
  - The overlap for seams shall be 4-inches along panel edges and 6-inches along panel ends.
  - Adjacent panels of the geonet shall be joined using self-locking nylon straps placed at 5 feet intervals along the seam length on the sides and at 1-foot intervals along the seam length on the ends. Butt seams between roll ends shall be covered by a piece of geotextile overlapped 6-inches on each side of the geocomposite seam, and heat bonded in place. Only ties which do not damage the underlying geomembrane shall be used. Metal ties shall not be allowed.
  - Ties shall be white or brightly coloured for easy identification.
  - The geotextile shall be continuously sewn between panels. Alternate methods of bonding the geotextile must be approved by the CQA Engineer prior to use.
  - The thread used to sew the geotextile panels together shall meet the manufacturer's requirements.
  - Orient seams located on slopes steeper than 5 percent parallel to the fall of the slope, unless approved by the Design Engineer. Horizontal seams shall be minimized. If horizontal seams are required due to the length of the slope, horizontal seams shall be bounded on each side by continuous panels and horizontal seams shall be staggered by a minimum distance of 25-feet.

The CQA Officer shall observe and document the seaming of geonet, geotextile, and bonded geocomposite to verify that the following requirements of the CQA Plan are met:

- Observations that synthetic drainage materials are placed according to the placement plan.
- Observations and measurements to ensure that the overlap of synthetic drainage materials or geotextiles specified in the design and this CQA Plan are achieved.
- Observations to verify that the synthetic drainage materials and geotextiles are placed free from excessive wrinkles or folds.
- Observations to verify that weather conditions are appropriate for the placement of the synthetic drainage layer or geotextile materials and that exposure to rain, wind, and direct sunlight during and after installation is in compliance with the manufacturer’s recommendations.

11.6 Defects and Repairs

The Geosynthetic Contractor shall repair any holes or tears in the geosynthetic materials as follows, using patches made from the same material:

- Damaged areas of geotextile shall be repaired by sewing or heat-bonding a patch in place with a 12-inch overlap in directions.
- Damaged areas of geonet shall be repaired by placing a patch overlapping 2-feet beyond the edges of the hole or tear in directions.

- A geonet patch shall be secured to the original geonet every 6-inches using nylon ties. If the damaged area comprises over 50 percent or more of the geonet roll width, the damaged area shall be cut out and the two portions of the geonet shall be joined.
- Damage to a bonded geocomposite shall be repaired as noted for geonets and the upper geotextile of the patch shall be sewn or heat-bonded to the upper geotextile of the geocomposite.

The CQA Officer shall observe and document the repairs made to the geonet, geotextile, and bonded geocomposite to verify that repairs are made according to the requirements of the CQA Plan.

11.7 Material Acceptance

The Geosynthetics Contractor retains ownership and responsibility for the geonet, geotextile, and bonded geocomposite materials until accepted by the Owner.

The Owner shall accept the geosynthetic components installation when:

- Required documentation from the manufacturer and the Geosynthetics Contractor has been received and accepted.
- The installation is complete.
- The completion of field seams and repairs, including associated testing, is verified.
- Written certification documents, including drawings, sealed by the CQA Engineer have been received by the Owner.

11.8 Material Protection

The quality assurance procedures indicated in this Section are intended to assure that the installation of adjacent materials does not damage the geosynthetic components. The quality assurance of the adjacent materials themselves is covered in separate Sections of this CQA Plan.

The CQA Engineer shall verify that installation procedures of adjacent components are consistent with current geosynthetic state-of practice such as:

- Whenever possible, placement of soil material over geosynthetics should be done during the coolest part of the day to minimize the development of wrinkles in the geosynthetics.
- In general, soil materials should be placed in an upslope direction and should be pushed away from tie-in areas toward the anchor trench.
- Equipment used to place soil materials shall not be driven directly on the geosynthetic materials.

12.0 GRANULAR SOILS

Granular materials used in the landfill construction project for drainage layers, protective soil layers and pipe bedding shall meet the requirements of the specifications and this section of the CQA Plan.

12.1 Materials

The granular soils and select aggregates used in the leachate collection and removal system shall meet the following requirements:

- The granular soil and drainage aggregate shall be free of organic material, debris, trash, clay clods, or other deleterious material. No sharp-edged rocks or hard objects shall be allowed.
- The granular soil drainage layer shall have maximum particle size of 1-1/2 inches, if used in conjunction with a protective geotextile. Granular soil drainage layer shall have 98% of the particle size less than 3/8-

inch, if placed in direct contact with the geomembrane. The granular soil drainage layer shall be comprised of clean subangular material of durable non-carbonate origin and shall be free of any materials capable of damaging the liner material.

- Granular drainage soils shall have a minimum permeability of 1 x 10^{-3} cm/sec when used with a geonet and shall have no more than 5 percent by weight passing the #200 US Standard Sieve by washing.
- Protective layer granular soils shall have a minimum permeability of 1 x 10^{-3} cm/sec when placed above granular drainage soils and shall have no more than 5 percent by weight passing the #200 US Standard Sieve by washing.
- The drainage aggregate used around the leachate collection system piping shall, at a minimum, be comprised of durable non-carbonate origin and meet the requirements of the approved Engineering Plans and/or Construction Drawings.
- In no instance shall the drainage aggregate be placed directly on the FML.
- The following criteria shall be met to demonstrate that the granular drainage soil will not migrate into the granular protective soil:
  - D_{15} of drainage soil/ D_{85} of protective soil $\leq$ 5

    where:
  - D_{15} = the soil particle size at which fifteen percent (15%) of the particles are finer; and
  - D_{85} = the soil particle size at which eighty-five percent (85%) of the particles are finer.
- If a successful demonstration is made, a filter medium between the two materials is not required.
- If the demonstration is unsuccessful, then a geosynthetic filter fabric will be incorporated into the drainage soil construction to prevent fine soil particles of the granular protective soil from migrating into the drainage soil. The filter fabric shall provide soil particle retention that meets the following criteria, or an equivalent criterion:
  - (A) O_{95} of the geotextile < 2 x D_{85} of the granular drainage soil.
  - (B) O_{95} of the geotextile > 2 x D_{15} of the granular drainage soil.

    where:
  - O_{95} = the apparent opening size of the geotextile at which ninety-five percent (95%) of the soil particles will be retained.
- Samples of granular soil and aggregate shall be obtained on a frequency of at least one per every 1,000 cubic yards placed and tested for grain size distribution using a sieve analysis in accordance with ASTM D 422.
- Granular soil and aggregate samples shall be obtained on a frequency of at least one sample per every 2,500 cubic yards placed and tested for hydraulic conductivity in accordance with ASTM D 2434.
- The granular soil samples shall be collected and tested by the CQA Officer. The CQA Engineer shall verify that the test results meet the requirements of the CQA Plan.

12.2 Construction Methods / Placement

The Contractor shall install the granular soils in accordance with the following:

- Low ground-pressure tire or track equipment shall be utilized for work on the granular soil materials whenever the thickness of the granular soil material is less than 24-inches. The granular soil beneath roadways for transporting material over the cell floor and side slopes shall be at least 2-feet thick at times. Excessive rutting shall be prevented. No portion of any earthmoving equipment shall be allowed to contact the underlying geomembrane material at any time.
- Granular soil material shall be placed to minimize stresses on the underlying geomembrane. Placement of granular soil shall generally proceed by pushing the granular soil up the side slope. No granular soil shall be allowed to fall or slide into place down the side slope.

The CQA Officer shall perform the following:

- Observe the placement of the granular soil and document soil material uniformity and the presence or absence of foreign materials.
- Observe for potential and actual damage to the geomembrane during granular soil placement. When damage is suspected, the geomembrane surface shall be exposed to verify its condition. Actual damage to the geomembrane shall be documented and corrective action shall be taken in accordance with procedures outlined in the CQA Plan.
- Observe construction procedures to prevent the transport of fine soil particles by surface water run-off into the leachate collection system.
- Observe and document that the granular soil material meets the material specifications, placement procedures and thickness requirements of the specifications and the CQA Plan.

12.3 Survey

The Surveyor shall survey the granular soil layer on a minimum 200 foot grid system to verify the granular soil layer thickness. Alternately, direct depth checks may be used by the CQA Engineer to determine the granular soil layer thickness. Locations where the granular soil layer thickness is less than that required shall be increased to meet the specifications. The CQA Engineer shall document the placement of additional granular soil material to meet the requirements of the specifications and CQA Plan.

13.0 PIPING

Piping used in the landfill construction project shall meet the requirements of the specifications.

13.1 Pipe Materials

The pipe manufacturer shall provide the CQA Engineer with the following information:

- Documentation that the pipe provided to this construction project that the pipe meets the specifications and requirements of the Construction Plans.

The CQA Engineer shall review the manufacturer's information to verify that the specifications and CQA Plan requirements are met.

13.2 Delivery and Storage

The CQA Engineer or Owner shall obtain the following information when the pipe is delivered to the job-site:

- Name of manufacturer.
- Product type and identification number.
- Pipe diameter; and

- Pipe Wall Thickness Schedule or Standard Dimension Ratio.

The pipe shall be protected during shipment from excessive heat or cold, puncture, or other damage. The pipe shall be stored on-site in a manner to protect it from damage.

The CQA Engineer or Owner shall inspect the pipe delivery paperwork to ensure that the information is correct. The CQA Officer shall document the pipe material conditions in the daily summary report.

13.3 Pipe Installation

The pipe shall be joined by methods as defined by the pipe manufacturer.

The CQA Engineer or Owner shall perform the following:

- Inspect the pipe material for compliance with the specifications.
- Observe and document the placement and backfill of the pipe for compliance with the specifications.
- Observe and document the placement and joining of the pipe for compliance with the specifications.
- Observe and document the placement of any filter materials, if used, around the pipe for compliance with specifications.

The Contractor shall perform the following:

- Pipe placement shall not be performed in the presence of excessive moisture.
- Prepare the pipe subgrade condition and slope according to the specifications.
- Join the pipe sections according to the pipe manufacturer's specifications.
- Backfill the pipe according to the specifications.

The Surveyor shall survey the installed pipe every 100 feet and at appurtenances to verify that the pipe grade is in conformance with the specifications.

14.0 SUMPS, PUMPS AND ELECTRICAL

Construction records shall include an inspection and testing of the sump, leachate removal and detection equipment, and any other associated equipment or structures to ensure that the design specifications including material and equipment specifications, coating specifications, and mechanical and electrical equipment installation specifications, are met.

The CQA Engineer shall review, compare, and document the following:

- Sump size;
- Working sump volume, verified in the field;
- Effective stone porosity;
- As-built leachate removal pump on/off levels programmed into pump control system. Levels shall be documented in inches along with the corresponding as-built elevations of the constructed sump;
- A description of the installed pump location;
- The pump cycle time, pump run rate, and the time required to remove liquids within the effective sump volume. This test may be conducted with storm water collected in the cell, or water from an on-site source; and,

- A description of the sump material and seam quality.

15.0 FINAL COVER SOIL EROSION LAYER

Erosion layer cover soils will be placed over geosynthetics in the final cover system. Erosion layer soils must be either SM, SW, or SP. Since these soils are placed adjacent to the geosynthetics, there will be no stones larger than 0.75 inches, and they will be free of materials that could harm the geosynthetics.

The soil source will be approved by CEC and free of contaminants prior to hauling onsite. Material will be spread to the thickness shown by the plans with low ground pressure [not exceeding five pounds per square inch (psi)] by low ground pressure equipment and pushed up-slope to prevent tensioning of the geosynthetics. Temporary haul roads for normal ground pressure vehicles will be a minimum of 36 inches thick.

During protective cover soil placement, the CQAT(s) will observe the following:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material
- Removal of stones or other debris
- Confirmation that underlying 40 mil LLDPE geomembrane remains in place and minimal number of wrinkles to the maximum extent feasible
- Control of protective cover layer thickness over the geosynthetics in areas of hauling
- Evaluate degree of compaction by visual, qualitative means

The CQAT(s) will perform the following testing prior to and during soil erosion layer final cover placement:

- Collect one sample per source for contaminant testing at the request of CEC from potential borrow sites
- Collect a minimum one sample per 5,000 cubic yards of placed material and/or when the material source changes for grain size determination in accordance with ASTM D422 and Unified Soil Classification in accordance with ASTM D2487. The soil erosion layer cover samples shall be collected and tested by the CQAT (s). The CQAT (s) will verify that the test results meet the requirements of the project specifications, drawings and CQA Plan
- Document testing and observations in the daily report and with construction photographs in accordance with this CQA Plan
- The Licensed Land Surveyor shall survey the top of final cover on a 100-foot grid system to verify the soil erosion layer thickness. Alternately, direct depth checks may be used to determine the protective layer thickness. Locations where the protective layer thickness is less than that required on the engineering plans shall be increased to meet the project specifications. The CQA Officer will document the placement of additional soil material to meet the requirements of the CQA Plan. Elevations shall be referenced to United States Geologic Survey (USGS) datum. Grade tolerance is +1.0 to 0.0 at high design points (top of soil erosion layer), from the engineering plans and maintaining slope minimums and soil erosion layer thickness minimums indicated in the engineering plans and specifications.

16.0 FINAL COVER TOPSOIL

The topsoil will be the final six inches of the final cover system. This material shall be locally available topsoil with a minimum 2.5 percent organic matter and pH between 6.4 and 7.5 to support the establishment of vegetation and retain moisture. Testing of the topsoil for organic content will be in accordance with ASTM D2974.

The CQAT(s) will observe the following during topsoil placement:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material
- Removal of stones or other debris
- Control of soil erosion layer and topsoil thickness over the geosynthetic layer in areas of hauling

The CQAT(s) will perform the following testing prior to and during topsoil placement:

- Collect sample for contaminant testing at the request of CEC from potential borrow sites
- Collect and test a minimum of one sample per 5 acres of material placed and/or when the material source changes for grain size determination in accordance with ASTM D422, for organic content, and pH in accordance with ASTM D4972, “Standard Test Method for pH of Soils”
- Document testing and observations in the daily report and with construction photographs in accordance with this CQA plan

The maximum allowable difference from documented grades to design grades is +0.2/- 0.0 foot. If the documented top of topsoil differs from the design grades by more than +0.2/- 0.0 foot, the topsoil and/or soil erosion layer will be regraded and redocumented.

17.0 SITE RESTORATION

The following section describes the CQA requirements for the site restoration such as final cover seeding, fertilizing, and mulching. Miscellaneous activities (i.e., road grading) required for complete site restoration are included in this section.

17.1 Erosion and Sediment Control

The CQAT(s) will monitor the installation of erosion and sediment control features. This includes the documentation of temporary silt fencing, location of silt check dams, and temporary ditching. The CQAT(s) will document the type and quantity of material installed.

Documentation of the maintenance of the features will be recorded following major storm events and weekly per the site’s National Pollutant Discharge Elimination System (NPDES) permit and by a qualified construction storm water operator.

17.2 Seeding, Fertilizer, and Mulch

The final cover topsoil will be prepared for seeding and mulching in accordance with typical MDOT standards. Alternative seed mixtures may be proposed and approved by CEC. The CQAT(s) will document material and equipment delivered to the site for the seeding operation. In general, the CQAT(s) will record the following information:

- Seed types and quantities delivered to the site
- Type and quantity of fertilizer delivered
- Type and quantity of lime or other soil amendments
- Area seeded and rate of seed application on a daily basis
- Area fertilized or limed and rate of application on a daily basis
- Copies of soil nutrient test results from Contractor

- Type and quantity of mulch applied

17.3 Documentation

The CQAT(s) or CEC personnel will document the limits of site restoration and dates of seeding as the work progresses. Installation procedures and types of equipment used for the work will be recorded. Photographs of typical procedures will be taken in accordance with this CQA Plan. The data will be reported in the final documentation report.

While onsite, the CQAT(s) will document any repairs to the erosion controls or areas that are reseeded. Calculations and/or confirmation will also be provided that demonstrate the seeding equipment does not exceed five psi at the geomembrane.

18.0 STORM WATER MANAGEMENT

This section describes the requirements for the CQAT(s) during construction of the storm water control features associated with cell or final cover construction.

18.1 Culverts and Drain Tile

Culverts and drain tile will be placed in the final cover as shown in the contract documents in accordance with manufacturer's recommendations for installation. The CQAT(s) will record the type, size, and quantity of the culverts and drain tile placed. The culverts and drain tile will be field verified by survey at junctions and every 100 feet along the length following installation. Culverts and drain tile used in the project shall meet the requirements of the contract documents.

18.2 Bench Drains and Perimeter Ditches

Bench drains and perimeter ditches will be graded with cover soils to meet the lines and grades provided in the contract documents. Once bench drains and perimeter ditch grades meet tolerances required by the specifications, the bench drains and perimeter ditches will be overlain with 6-inches of topsoil and restored in accordance with Section 17.0 – Site Restoration of the CQAP.

18.3 Documentation

The final cover documentation report will provide a drawing that shows stormwater management features that were constructed. The report will contain information on methods for installation and the types of material used. Any repair or replacement will be documented.

19.0 CONSTRUCTION CERTIFICATION REPORT

A Construction Certification Report will be prepared under the direction of the CQA Officer in accordance with Rule 921 of Part 115. The report will contain, at a minimum, the following information:

- Daily field reports
- Detailed narrative describing the construction activities in chronological order
- Analysis and discussion of CQA testing performed with summaries of test results
- Raw data and test reports performed during construction
- Detailed description and documentation of material, equipment types, and specifications
- Discussion of any construction material or equipment which deviated from the engineering plan and reason for deviation
- Photographs documenting aspects of construction

- Correspondence and documentation with EGLE concerning rule exceptions or CQA changes
- Record drawings containing:
  - Existing site grades prior to construction
  - Geosynthetic subgrade elevations (contours)
  - Protective cover thickness and measurement locations
  - Pipe invert grades
  - Geomembrane panel layout diagram including seam locations and types, repair locations, destructive sample locations, and anchor trench location
  - Location of field tests
  - Final site grades

Based on the review of the data and the CQA Officer's personal observations during construction, the CQA Officer will certify that cell of final cover construction has been prepared and constructed in conformance with the engineering plans and specifications, the CQA Plan, and the requirements of applicable EGLE rules.

20.0 REFERENCES

- Geosynethics Research Institute (GRI)
- GRI GM 6 – Pressurized Air Channel Test for Dual Seamed Geomembranes.
- GRI GM 9 - Cold Weather Seaming of Geomembranes.
- GRI GM 13 - Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.
- GRI GM 17 - Test Methods, Test Properties, and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes.
- GRI GM 19a - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.
- GRI Test Method GT 12(a) – ASTM – Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.
- GRI Test Method GT 13(a) – ASTM – Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate.

APPENDIX A

CQA Field Forms

GOLDER **DAILY FIELD FORM**

PROJECT OVERVIEW				
Project Title:	Dry Ash Landfill Cell/Cover	**Project Number:**		**Date:**
Client:	Consumers Energy Company	**Site/Location:**	J.H. Campbell, West Olive, Michigan	
GAI Personnel:		**Arrival/Departure Time:**		
Contractor(s):		**Contractor(s) Rep:**		

SITE CONDITIONS	
Weather (AM):	**Temperature:**
Weather (PM):	**Temperature:**
Precipitation:	**Wind:**

EQUIPMENT ON SITE

SUMMARY OF CONSTRUCTION
Construction:

Golder CQA ACTIVITIES AND TEST RESULTS
•

SUMMARY OF SURVEYOR'S ACTIVITIES
•

SUMMARY OF PROBLEMS AND RESOLUTIONS

SUMMARY OF MEETINGS/DISCUSSIONS HELD (ATTENDEES AND ISSUES)

SUMMARY OF INCIDENTS / ACCIDENTS / HEALTH AND SAFETY ISSUES

PHOTOGRAPHS

SUBMITTED BY Golder **CQA Officer:** **Signature:**

GEOSYNTHETIC INSTALLATION MONITORING REPORT

PROJECT NUMBER: ______________ **PROJECT TITLE:** ______________

OWNER: ______________ **CONTRACTOR:** ______________

LOCATION: ______________ **CONTRACTOR REP:** ______________

DATE: ______ **S M T W R F S**

GEOSYNTHETIC DEPLOYMENT:

TRIAL SEAMING:

SEAMING:

NON-DESTRUCTIVE TESTING:

DESTRUCTIVE TESTING:

GENERAL REMARKS:

SUBMITTED BY:

____

GOLDER FORM: R2-0899

(JANUARY 2005)

GOLDER ASSOCIATES INC.

SPECIFICATION / DESIGN CLARIFICATION FORM

PROJECT NUMBER: ____________________ **PROJECT TITLE:** ____

OWNER: ______________________________ **CONTRACTOR:** ____

LOCATION: ______________________________

Form Number [ ]

Location / Reference of Clarification:

[ ]

Clarification Made:

[ ]

Approved by Designer: ____

Name Company Date

Approved by Owner: ____

Name Company Date

Received by the Golder Representative: ____

Name Date

Remarks: [ ]

Attachments: [ ]

GOLDER ASSOCIATES INC.

FIELD MOISTURE / DENSITY TEST RECORD

NUCLEAR GAUGE METHOD

ASTM D 6938

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________

OWNER: ______________________ **CONTRACTOR:** ______________________

LOCATION: ______________________ **DATE TESTED:** ______________________

TEST NUMBER								
TEST LOCATION	**N**							
	E							
ELEVATION								
DEPTH								
THICKNESS OF LIFT								
DENSITY COUNT								
MOISTURE COUNT								
WET DENSITY, pcf								
MOISTURE %								
DRY DENSITY, pcf								
MATERIAL DESCRIPTION								
MAX DRY DENSITY, pcf								
OPTIMUM MOISTURE, %								
% COMPACTION								
DIFF FROM O.M.C.								
PASS/FAIL (DENSITY)								
PASS/FAIL (MOISTURE)								

SPECIFICATIONS:

See Window Attached **% STANDARD / MODIFIED**

See Window Attached **% OF O.M.C.**

DAILY STANDARD COUNTS:

MOISTURE ______________________

DENSITY ______________________

TESTED BY: ______________________ **CHECKED BY:** ______________________ **DATE:** ____________

GOLDER FORM S17-0699

(JANUARY 2005)

GOLDER ASSOCIATES INC.

PUMP TEST REPORT

PROJECT NUMBER: ______________ **PROJECT TITLE:** ______________
OWNER: ______________ **CONTRACTOR:** ______________
LOCATION: ______________ **CONTRACTOR REP:** ______________

DATE [ ] **S M T W T F S**

DESIGN

Pump On Elevation: ______________
Pump Off Elevation: ______________

FIELD MEASUREMENTS

PUMP ON

Time Pump On: ______________
Elevation of T.O.P. or Reference: ______________
Depth to H2O from T.O.P. or Reference: ______________
Volume at Flow Meter: ______________
Transducer Reading: ______________

PUMP OFF

Time Pump Off: ______________
Elevation of T.O.P. or Reference: ______________
Depth to H2O from T.O.P. or Reference: ______________
Volume at Flow Meter: ______________
Transducer Reading: ______________

COMMENTS:

PREPARED BY: ______________

GOLDER FORM R1-0699
(JULY 2008)

GOLDER ASSOCIATES INC.

GEOSYNTHETIC INVENTORY CONTROL LOG

PROJECT NUMBER: ____________ **PROJECT TITLE:** ____________
OWNER: ____________ **CONTRACTOR:** ____________
LOCATION: ____________

MATERIAL TYPE : GEOMEMBRANE GEONET GEOTEXTILE GCL OTHER ____________
DATE OF ARRIVAL: ____________ **DATE OF INVENTORY:** ____________
MATERIAL MANUFACTURER: ____________ **INVENTORY MONITOR:** ____________
PRODUCT IDENTIFICATION: ____________ **CONDITION IN TRUCK:** ____________
TRUCK TYPE: ____________ **UNLOADING METHOD:** ____________

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			QC CERT Y / N	CONF. SAMP. Y / N	OTHER ______	REMARKS
			LENGTH	WIDTH	THICKNESS OR WEIGHT				
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Golder Form: G2
(January 2005)

REVIEWED BY: ____________ **DATE:** ____________

GOLDER ASSOCIATES INC.

CERTIFICATE OF ACCEPTANCE OF SOIL SURFACE

GEOSYNTHETIC INSTALLER COMPANY	______________________	PROJECT LOCATION	______________________
ADDRESS	______________________	PROJECT OWNER	______________________
	______________________		______________________

I, the Undersigned, the duly authorized representative of

do hereby accept the area of soil surface bounded by

and shall be responsible for maintaining its integrity and suitability in accordance with the project specifications from this date to the completion of the installation.

NAME	SIGNATURE	TITLE	DATE

CERTIFICATE OF ACCEPTANCE RECEIVED BY QA / QC MANAGER

NAME	SIGNATURE	TITLE	DATE

CERTIFICATE OF ACCEPTANCE RECEIVED BY OWNER

NAME	SIGNATURE	TITLE	DATE

GEOSYNTHETIC PANEL DEPLOYMENT LOG

PROJECT NUMBER: ____________ **PROJECT TITLE:** ____________________
OWNER: ____________________ **CONTRACTOR:** ____________________
LOCATION: ____________

GEOMEMBRANE: Secondary Primary Closure Other: ____________________
SUBGRADE CONDITION: (Surface Compaction Protrusions Dessiccation Excessive Moisture)
REMARKS: ____

TRANSPORT EQUIPMENT: ____

PANEL #	ROLL NUMBER	DEPLY'D LENGTH	AMBIENT AIR TEMP	OBS'D OVERLAP	MONITOR	THICKNESS MEASUREMENTS		REMARKS
						LEAD	SIDE	
						/ / / /	/ / / /	
						/ / / /	/ / / /	
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						/ / / /	/ / / /	
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Golder Form: G2-TSS **REVIEWED BY:** ______ **DATE:** ____________

(January 2005)

GOLDER ASSOCIATES INC.

GEOMEMBRANE TRIAL SEAM LOG

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________
OWNER: ______________________ **CONTRACTOR:** ______________________
LOCATION: ______________________

[ ] **TF - # = FUSION** **DATE** ______________
[ ] **TX - # = EXTRUSION** **SHEET NUMBER** ______________

				TEMPERATURES				TEST RESULTS					
SAMPLE NUMBER	APPROX. TIME	WELDING MACHINE NUMBER	WELD TECH.	AMBIENT AIR TEMP.	PREHEAT OR MACHINE SPEED	EXTRUDER	NOZZLE OR WEDGE	INSIDE PEEL STRENGTH	OUTSIDE PEEL STRENGTH	SHEAR STRENGTH	PASS OR FAIL	MON.	REMARKS **
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NOTE: ADHESION FAILURE OF TRIAL SEAM SAMPLES SHALL BE NOTED IN THE REMARKS COLUMN

GOLDER FORM: G12-TSS **REVIEWED BY:** __________ **DATE:** ______________
(January 2005)

GOLDER ASSOCIATES INC.

GEOMEMBRANE SEAM LOG

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________
OWNER: ______________________ **CONTRACTOR:** ______________________
LOCATION: ______________________

PASSING TRIAL SEAMS

☐ **FUSION**

☐ **EXTRUSION**

MACHINE # _______________

NO.	TIME	TECH ID

DATE ______________

DESTRUCTIVE LENGTH CARRY-OVER FROM PREVIOUS LOG ________

SHEET NUMBER ______________

	SEAM NUMBER	SEAM SECTION* START POINT	FINISH POINT	APPROX. START TIME	AMB. AIR TEMP.	WELD TECH.	PREHEAT OR MACH. SPEED	MACHINE TEMPERATURES: DIGITAL SET WEDGE OR BARREL NOZZLE	INDICATOR WEDGE OR BARREL NOZZLE	APPROX. LENGTH WELDED	LENGTH FROM PREVIOUS DESTR.	DESTR. NUMBER	MON.	REMARKS	** NON-DESTRUCTIVE TEST DATE	MON.
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17	/	-						-	-							
18	/	-						-	-							
19	/	-						-	-							
20	/	-						-	-							

* REFERENCE SEAM ENDPOINTS FROM AN END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM.

DAILY TOTAL ______

DESTRUCTIVE LENGTH CARRY-OVER ______

** COLUMNS TO BE USED BY THE DATA REVIEWER ONLY

GOLDER FORM: G13-0699
(January 2005)

REVIEWED BY: ______________ **DATE:** ______________

GOLDER ASSOCIATES INC.

GEOMEMBRANE DEFECT LOG

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________
OWNER: ______________________ **CONTRACTOR:** ______________________
LOCATION: ______________________

SHEET NUMBER ______________

DEFECT CODE	DEFECT LOCATION SEAM, PANEL OR REPAIR NO.	DEFECT LOCATION DESCRIPTION	DEFECT TYPE	LOG DATE	MON.	REMARKS	** REPAIR DATE	** TEST DATE
A								
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N								
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Q								
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V								
W								
X								
Y								
Z								

B - UNDISPERSED RESIN BEAD
BO - FUSION WELDER BURN
BS - BOOT/SKIRT FOR FML PENETRATION
CO - CHANGE OF OVERLAP
CR - CREASE
D - INSTALLATION DAMAGE
DS-# - DESTRUCTIVE TEST NUMBER

EXT - EXTENSION
FM - FISHMOUTH
FS - FAILED SEAM LENGTH
FTS - FIELD TEST STRIP
HT - HEAT TACK BURN
IO - INSUFFICIENT OVERLAY (UNDER SPEC.)
MD - MANUFACTURER/DELIVERY DAMAGE

SI - SOIL SURFACE IRREGULARITY
SL - SLAG ON TEXTURED SHEET
T - THREE PANEL INTERSECTION
VL - VACUUM TEST LEAK
WR - WRINKLE
WS - WELDER RESTART
OTHER ______________________

REVIEWED BY: ____________ **DATE:** ____________

** COLUMNS TO BE USED BY THE DATA REVIEWER ONLY.

GOLDER FORM: G18-0699
(January 2005)

GOLDER ASSOCIATES INC.

GEOMEMBRANE REPAIR LOG

PROJECT NUMBER ____________________ PROJECT TITLE: ____________________
OWNER: ____________________ CONTRACTOR: ____________________
LOCATION: ____________________

PASSING TRIAL SEAMS

NO.	TIME	TECH	NO.	TIME	TECH

MACHINE NUMBER: ____________________
DATE: ____________________
SHEET NO: ____________________

	DEFECT CODE	REPAIR DATE	APPRX. TIME	REPAIR TYPE	APPRX. DIM.	WELD TECH.	MON.	REMARKS
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	DEFECT CODE	REPAIR DATE	APPRX. TIME	REPAIR TYPE	APPRX. DIM.	WELD TECH.	MON.	REMARKS
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REPAIR TYPE: P - PATCH, C - CAP, RS - RECONSTRUCTED SEAM, G&W - GRIND WELD

REVIEWED BY: __________ **DATE** ____________

GOLDER FORM: G19-tss

(January 2005)

GOLDER ASSOCIATES INC.

GEOMEMBRANE VACUUM TEST LOG

PROJECT NUMBER: ____________________ **PROJECT TITLE:** ____________________
OWNER: ____________________ **CONTRACTOR:** ____________________
LOCATION: ____________________

REPAIRS

	DEFECT CODE	TEST DATE	TECH ID	DEFECTS * *	OBS. TEST	MON.	REMARKS
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45							

REPAIRS

	DEFECT CODE	TEST DATE	TECH ID	DEFECTS * *	OBS. TEST	MON.	REMARKS
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
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74							
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77							
78							
79							
80							
81							
82							
83							
84							
85							
86							
87							
88							
89							
90							

* * RECORD QUANTITY OF LEAKS DETECTED AND REFERENCE NEW DEFECT CODE IN REMARKS.

GOLDER FORM: G17-tss **REVIEWED BY:** ___________ **DATE** ______________

(January 2005)

GOLDER ASSOCIATES INC.

GEOMEMBRANE SEAM NON-DESTRUCTIVE TEST LOG

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________

OWNER: ______________________ **CONTRACTOR:** ______________________

LOCATION: ______________________

DATE: ______________________

SHEET NUMBER: ______________________

	SEAM NUMBER	SEAM SECTION * FROM	TO	VACUUM OR PRESSURE	TECH ID	TIME START	FINISH	PRESSURE INITIAL	FINAL	OBS. TEST	RESULTS PASS/ FAIL	SEAM COMPLETE NO	YES	MON.	REMARKS
1	/	-				:		:				|			
2	/	-				:		:				|			
3	/	-				:		:				|			
4	/	-				:		:				|			
5	/	-				:		:				|			
6	/	-				:		:				|			
7	/	-				:		:				|			
8	/	-				:		:				|			
9	/	-				:		:				|			
10	/	-				:		:				|			
11	/	-				:		:				|			
12	/	-				:		:				|			
13	/	-				:		:				|			
14	/	-				:		:				|			
15	/	-				:		:				|			
16	/	-				:		:				|			
17	/	-				:		:				|			
18	/	-				:		:				|			
19	/	-				:		:				|			
20	/	-				:		:				|			

*** REFERENCE SEAM ENDPOINTS FROM AND END OF SEAM (EOS), A REPAIR NUMBER,**
OR A POINT LOCATION ON THE SEAM (i e, REFERENCE POINT, DISTANCE, DIRECTION FROM REF. PT.)

GOLDER FORM: G16-tss
(January 2005)

REVIEWED BY: ______________________ **DATE:** ______________________

GOLDER ASSOCIATES INC.

GEOMEMBRANE SEAM DESTRUCTIVE SAMPLE LOG

PROJECT NUMBER: ____________________ **PROJECT TITLE:** ____________________
OWNER: ____________________ **CONTRACTOR:** ____________________
LOCATION: ____________________

SHEET NUMBER ____________________

	DESTRUCTIVE				FIELD TEST RESULTS			LAB TEST		
	SAMPLE NUMBER	SEAM NUMBER	MACHINE NUMBER	DATE REMOVED	PEEL SHEAR (PASS/FAIL)	MON.	DATE SHIPPED	STATUS (PASS/FAIL)	DATE OF NOTIFICATION	REMARKS
1		/		/ /	:		/ /		/ /	
2		/		/ /	:		/ /		/ /	
3		/		/ /	:		/ /		/ /	
4		/		/ /	:		/ /		/ /	
5		/		/ /	:		/ /		/ /	
6		/		/ /	:		/ /		/ /	
7		/		/ /	:		/ /		/ /	
8		/		/ /	:		/ /		/ /	
9		/		/ /	:		/ /		/ /	
10		/		/ /	:		/ /		/ /	
11		/		/ /	:		/ /		/ /	
12		/		/ /	:		/ /		/ /	
13		/		/ /	:		/ /		/ /	
14		/		/ /	:		/ /		/ /	
15		/		/ /	:		/ /		/ /	
16		/		/ /	:		/ /		/ /	
17		/		/ /	:		/ /		/ /	
18		/		/ /	:		/ /		/ /	
19		/		/ /	:		/ /		/ /	
20		/		/ /	:		/ /		/ /	
21		/		/ /	:		/ /		/ /	
22		/		/ /	:		/ /		/ /	

REVIEWED BY: ____________ **DATE:** ____________

GOLDER FORM: G20-0699
(JUNE 1999)

GOLDER ASSOCIATES INC.

FAILED DESTRUCTIVE SAMPLE TRACKING LOG

PROJECT NUMBER: ____________________ **PROJECT TITLE:** ____________________
OWNER: ____________________ **CONTRACTOR:** ____________________
LOCATION: ____________________

DESTRUCTIVE NUMBER ____________ **PASSING SAMPLE IN DIRECTION P** ____________
DATE ____________ **MACHINE NUMBER** ____________ **PASSING SAMPLE IN DIRECTION N** ____________
MONITOR ____________ **SEAMER(S) ID** ____________

CHRONOLOGICAL SEAMING ORDER		
SEAM OR REPAIR NO.	SEAM DATE	START TIME
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		
________ / ________ SEAMING SHEET # _____ LINE # _____		

START POINT	ILLUSTRATED RECORD OF DESTRUCTIVE SAMPLE TRACKING AND SEAM RECONSTRUCTION	FINISH POINT

----------> -----------> ----------> DIRECTION OF SEAMING ---------> ----------> ---------->

PANEL #
PANEL #

PANEL #
PANEL #

PANEL #
PANEL #

PANEL #
PANEL #

INITIAL DESTRUCTIVE NO. ___________

PANEL #
PANEL #

FAIL

PANEL #
PANEL #

PANEL #
PANEL #

PANEL #
PANEL #

PANEL #
PANEL #

CONTINUED
Y / N
SHEET NO.
____

(P)
PREVIOUS"
DIRECTION

/ \

\ /

(N)
"NEXT"
DIRECTION

CONTINUED?
Y / N
SHEET NO.
____

NOTE: COMPLETE SEAMING ORDER INFORMATION FROM FIELD SEAMING LOGS. COMPLETE ILLUSTRATION SECTION FROM DIRECT OBSERVATION OF THE SEAMS.
ILLUSTRATE FOLLOW-UP DESTRUCTIVE SAMPLES, CAPS AND/OR RECONSTRUCTED SEAMS AND REFERENCE REPAIR NUMBERS.
GOLDER FORM: G21-0699

(JUNE 1999)

REVIEWED BY: ____________ **DATE:** ________

GOLDER ASSOCIATES INC.

GOLDER
MEMBER OF WSP

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