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Mr. Matt Hall
Michigan Department of Environmental Quality
Air Quality Division - Permit Section
Constitution Hall
Lansing, Michigan 48933

September 26, 2008
NTH Project No. 16-050556

**RE: Response to Questions Regarding Application 25-07
Holland Board of Public Works**

Dear Mr. Hall:

The following is a response to the additional information request regarding the wind erosion emission estimates that was received via your telephone conversation on September 23, 2007.

Description of Calculations for Fugitive Emissions due to Wind Erosion for the Holland Board of Public Works Air Use Permit to Install Application # 25-07

The first step in this process was to obtain mean hourly wind data from the Tulip City Airport (BIV) meteorological surface station located in Holland, Michigan for the years 2001-2005. Following the assumption in the 1994 EPA document, *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations – Phase II*, the fastest mile wind speed is assumed to be 1.2 times the hourly mean wind speed. The governing equation utilized to predict the emission factor due to wind erosion is equation (2) from Section 13.2.5.3:

$$\text{Emission Factor (mass/area)} = k \sum P_i \text{ from } i \text{ to } N, \text{ where}$$

k = particle size multiplier, 0.5 for PM₁₀

N = number of disturbances per year

P_i = erosion potential corresponding to the observed (or probable) fastest mile of wind for the ith period between disturbances, g/m²

For the Holland Board of Public Works (HBPW), it was estimated that a disturbance could only occur between the hours of 5:00 AM and 9:00 PM which is reflective of the bulldozer operating schedule.



The erosion potential function, P_i for a dry, exposed surface is defined as:

$$P_i \text{ (mass/area)} = 58 \times (u^* - u_t^*)^2 + 25 \times (u^* - u_t^*), \text{ where}$$

u^* = friction velocity (m/s)

u_t^* = threshold friction velocity (m/s), = 1.12, from Table 13.2.5-2

Also, any time that ($u^* \leq u_t^*$), then $P = 0$

The erosion potential must be calculated separately for each potential erosion event; therefore, because the wind datum from BIV is known on an hourly basis, this calculation was repeated 8,760 times for each year, for each portion of the pile. Note, the pile was divided into three portions: a daily active area, a compacted area, and an area that is active after each shipment.

The friction velocity, u^* , is determined using the wind speed of the fastest mile from BIV and equation (1) from 13.2.5.2.

$$u(z) = (u^*/0.4) \times \ln (z/z_0), \text{ held to the constraint } (z > z_0), \text{ where}$$

u = wind speed, m/s

u^* = friction velocity, m/s

z = height above test surface, m

z_0 = roughness height, m

0.4 = von Karman's constant, dimensionless

At the reference height of ten (10) meters and assuming a typical roughness height of 0.005 meters, this equation can be rearranged to the following:

$$u^* = (0.4 \times u_s^+) \div (\ln (10/0.005)),$$

$$u^* = (0.053 u_s^+), \text{ where}$$

u_s^+ = surface wind speed distribution (m/s)



The surface wind speed distribution is found using equation (6) from 13.2.5.3:

$$u_s^+ = u_{10}^+ \times (u_s/u_r), \text{ where}$$

u_{10}^+ = fastest mile of the reference anemometer for the period between disturbances (m/s)

u_s = surface wind speed (m/s)

u_r = approach wind speed (m/s)

The ratio of (u_s/u_r) has been defined in the AP-42, Chapter 13.2.5, for two (2) types of piles with different wind flow directions; Figure 13.2.5-2 depicts contours of normalized surface wind speeds for the two piles and wind approach directions. The contours in this figure were developed from the results of wind tunnel studies as published in the *Journal of the Air Pollution Control Association*, 38 from 1988.

Because the anemometer at BIV is at a height of 10.06 meters, another variation of equation (1) must be used to “correct” the fastest mile wind speeds to a reference height of 10 meters.

$$u_{10}^+ = u_{BIV}^+ \times (\ln(10/0.005) \div \ln(z_{BIV}/0.005)), \text{ where}$$

u_{BIV}^+ = fastest mile, derived from the mean wind speed recorded by BIV (m/s, calculated separately for each hour)

z_{BIV} = height of the anemometer at BIV (10.06 m)

Therefore,

$$u_s^+ = u_{BIV}^+ \times (\ln(10/0.005) \div \ln(10.06/0.005)) \times (u_s/u_r), \text{ or}$$

$$u_s^+ = u_{BIV}^+ \times 0.999 \times (u_s/u_r)$$

Finally, the normalized surface wind speed is used to determine the threshold friction velocity from rearranging equation (1) as shown in equation (7) from 13.2.5. Furthermore, because the ratio (u_s/u_r) was found at a height of 25 cm above the surface (from AP-42), the height was also corrected.

$$u^* = (0.4 \times u_s^+) \div (\ln(0.25/0.005))$$

$$u^* = 0.10 \times u_s^+$$



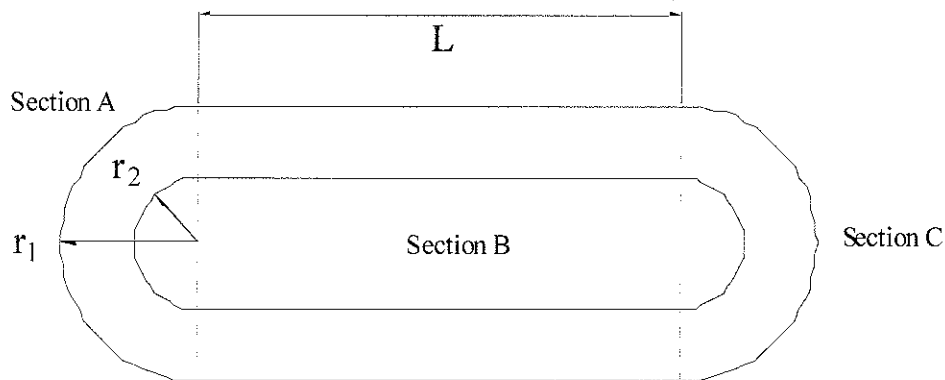
Dimensions of the Pile

The characteristics of the coal pile are very important in determining the potential fugitive emissions due to wind erosion. In essence, a fraction of the coal material at the surface of the coal pile will be in the form of fines. These fines, and their loading per unit of coal pile surface area, are referred to as the “erosion potential” for the coal pile.

Wind erosion of the fines is a function of the wind speed at the coal pile surface, the surface area of the coal pile that is not crusted (i.e. that has fines available for erosion), the number of disturbances per time period, and the threshold friction velocity associated with the material. The threshold friction velocity is a measure of the wind speed required at the surface of the material to cause erosion.

The pile will hold an estimated maximum of 503,262 tons of coal. At an average compacted density of 50 pounds per cubic foot, the pile will have a volume of 8,272,800 cubic feet of coal. The equations from the AP-42 are only applicable to either a conical or a flat-topped, oval shaped pile. For purposes of defining the coal storage pile dimensions, volume, and surface area, the coal storage pile will be treated as an oval shaped pile with the sides sloped at 37°.

Because of the irregular shape of the pile, it is necessary to divide the pile into three (3) sections.

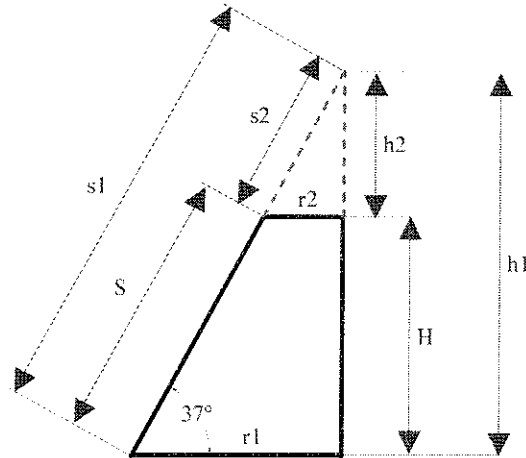


Plan View



Equations for a Cone

Sections A and C each have the shape of one-half of a flat-topped cone, therefore, the calculations for these sections are modified equations for a cone.



Profile of Section A

The calculations for a flat-topped cone follow the logic that there are really two (2) cones that share the same vertex: one small cone that has its base located at a certain height from the base of the large cone. For the coal pile at HBPW, the maximum height of the coal pile will be 45 ft, so the base of the small cone will be located at 45 feet from the base of the large cone. Therefore, the volume of the flat-topped cone can be found by establishing the volume of the large cone and subtracting the volume of the small cone. The volume of a cone is defined as:

$$V = 1/3 \times \pi \times r^2 \times h$$

V = Volume

r = radius

h = height (note this is the height from the center of the cone to the peak, and not the length of the slant)

Let the subscript “1” refer to the larger cone and subscript “2” refer to the smaller cone, then the volume of the flat-topped cone becomes:

$$V = 1/3 \times \pi \times r_1^2 \times h_1 - 1/3 \times \pi \times r_2^2 \times h_2$$



This equation can be rearranged and simplified to the following:

$$V = 1/3 \times \pi \times (r_1^2 \times h_1 - r_2^2 \times h_2)$$

The surface area will follow the same logic, with the surface area of the flat-top factored into the equation. The surface area of a cone is defined as:

$$\text{Surface Area (SA)} = \text{Area of the Base} + \text{Lateral Area}$$

Since the area of concern is only the area that is potentially exposed to erosion from wind, the area of the base is left out of the calculation, which becomes:

$$SA = \pi \times (r \times s), \text{ where}$$

r = radius

s = slant height

Letting subscript "1" refer to the larger cone and subscript "2" refer to the smaller cone and the area of the flat-top is added to the equation, then the surface area of a flat-topped cone becomes:

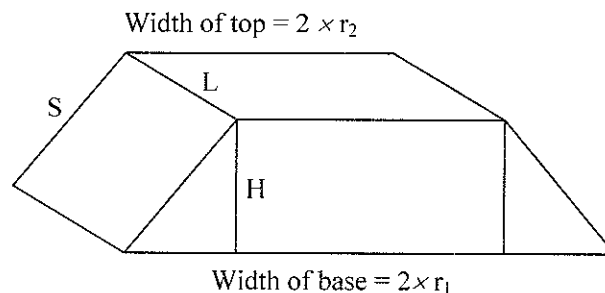
$$SA_{\text{cone}} = (\pi \times r_1 \times s_1 - \pi \times r_2 \times s_2) + \pi \times r_2^2$$

This equation can be rearranged and simplified to the following:

$$SA_{\text{cone}} = \pi \times (r_1 \times s_1 - r_2 \times s_2 + r_2^2)$$

Equations for a Trapezoid

The remaining portion of the pile, Section B, will be in the shape of a trapezoid.





The top of the trapezoid will have a width equal to the diameter at the top of the cone while the bottom of the trapezoid will have a width equal to the diameter of the base of the cone. The trapezoid will have a slope of 37° with the length of the slant equal to the length of the slant of the flat-topped cone.

Therefore, the volume of the trapezoid will be defined as:

$$V = 2 \times (1/2 \times H \times L \times (2 \times r_1 - 2 \times r_2) \div 2) + (2 \times r_2 \times H \times L)$$

This equation can be rearranged and simplified to the following:

$$V = H \times L \times ((r_1 - r_2) + (2 \times r_2))$$

For the surface area, only three (3) sides of the trapezoid will be included as the base is not exposed to the wind and the other two (2) sides are each one-half of the flat-topped cone. Therefore, the surface area of the remaining three (3) segments is calculated using the following equation:

$$SA_{\text{trapezoid}} = (S \times L) + (S \times L) + (L \times (2 \times r_2))$$

Simplifying this equation becomes:

$$SA = 2 \times L \times (S + r_2)$$

Equations for an Oval-Shaped Pile

Adding the surface area of the trapezoid (Section B) and the surface area of the cone (Sections A and C) will result in the total exposed surface area for the flat-topped oval shaped pile:

$$\text{Total Exposed SA} = \pi \times (r_1 \times s_1 - r_2 \times s_2 + r_2^2) + 2 \times L \times (S + r_2)$$

Finally, r_1 and L are approximated from the site map ($r_1 = 175$ ft and $L = 402$ ft). Once those two variables are known, the rest of the unknown variables are defined by the geometry of the shapes:



$$\begin{aligned}h_1 &= \tan(37^\circ) \times r_1 = 0.754 \times 175 \text{ ft} = 132 \text{ ft} \\s_1 &= \text{SQRT}(r_1^2 + h_1^2) = \text{SQRT}((175)^2 + (132)^2) = 219 \text{ ft} \\r_2 &= r_1 - (H \div \tan(37^\circ)) = 175 - (45 \div 0.754) = 115 \text{ ft} \\h_2 &= \tan(37^\circ) \times r_2 = 0.754 \times 115 \text{ ft} = 86.7 \text{ ft} \\s_2 &= \text{SQRT}(r_2^2 + h_2^2) = \text{SQRT}((115)^2 + (86.7)^2) = 144 \text{ ft} \\S &= s_1 - s_2 = 219 \text{ ft} - 144 \text{ ft} = 75 \text{ ft}\end{aligned}$$

Thus, the total exposed surface area can be found:

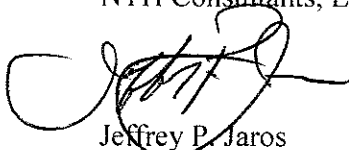
$$\begin{aligned}\text{Total Exposed SA} &= \pi \times ((175 \times 219) - (115 \times 144) + 115^2) + (2 \times 402 \times (75 + 115)) \\ \text{Total Exposed SA} &= 263,000 \text{ ft}^2\end{aligned}$$

Due to the rounding shown in this example, the Excel calculated value, as shown in Appendix B, Table B-20 of the permit application support document, is actually 262,789 ft². As previously discussed (also shown in Table B-20), the pile has been divided into three portions: a daily active area, a compacted area, and an area that is active after each shipment. These divisions are necessary to properly characterize the surface conditions of the pile. For example, in the compact area, representing 60 percent of the surface area, the bulldozer operation will cease if the wind speed exceeds 30 miles per hour. Also, because the area is compacted, a control efficiency of 80 percent was utilized in the wind erosion calculations.

Thank you for your prompt attention to this application. If you have any further questions, please feel free to contact me at (517) 484-6900.

Sincerely,

NTH Consultants, Ltd.



Jeffrey P. Jaros
Vice President

cc: David Koster, Holland Board of Public Works
Chuck Hookham, HDR
Delbert Rector, NTH Consultants, Ltd.

JPJ/mjb