Technical Appendix

Overview

This updated health risk assessment evaluates worst-case exposure to chemicals likely to be released from the energy recovery engine that is to be installed at the Alpha Ridge Landfill. The engine will combust landfill gas (produced from the decomposition of municipal solid waste) and convert a portion of the released energy into electricity. Currently, landfill gas is combusted in an enclosed flare and none of the energy is recovered. The addition of an energy recovery engine will handle most of the landfill gas produced at the Alpha Ridge Landfill, with a smaller portion continuing to be flared.

Chemicals of Potential Concern (COPCs)

The risk assessment focuses on the chemicals identified in testing of the Alpha Ridge Landfill flaring system. All of the chemicals detected in the 2012 testing of the landfill gas flare are evaluated, as are chemicals detected in the sampling of raw landfill gas in 2010 and 2012 (Avogadro, 2012; Analytical Solution, 2010). The chemicals of potential concern (COPCs) evaluated thus include:

- 23 COPCs that were identified and quantified in the effluent of the flare: these COPCs are evaluated at the highest rates measured in any of three separate stack effluent test runs;
- 20 COPCs detected in landfill gas influent to the flare, but not detected in the effluent: these COPCs are assumed, conservatively, to be present in flare effluent at the laboratory detection limits; and
- 30 COPCs found in landfill gas influent, but not included on the analyte list for the flare effluent testing: these COPCs are assumed to be emitted at levels that conservatively assume low rates of COPC destruction during combustion, based on testing at similar facilities.

Table 1 lists and quantifies these chemicals of potential concern (COPCs).

Estimation of COPC Emissions

The primary method of estimating emissions relies on stack test measurements taken after landfill gas has been combusted. For chemicals detected in the stack testing of the flare, the COPC emission rates are estimated as:

$$E_{flare} = E_{test} \frac{Q_{flare}}{Q_{total}}$$

Equation 1

$$E_{engine} = E_{test} \frac{Q_{engine}}{Q_{total}}$$

where the terms are:

E_{test} emission rate of the chemical measured from the existing flare (g/s);
Q_{flare} 120 cfm = 0.0566 m^3/s (based on design plans);
Q_{engine} 350 cfm = 0.1652 m^3/s (based on design plans); and
Q_{total} the total flow rate landfill gas, equal to Q_{flare} plus Q_{engine} = 470 cfm = 0.2218 m^3/s.

To be conservative, the maximum emission rates E_{test} measured in any of the three test runs of the January 2012 stack test of the flare are used, as listed in Table 1. The values in Table 1 are expressed in units of lb/hr, and are converted to units of g/s by multiplying by 453.6 g/lb and dividing by 3600 s/hr.

A second method is used to estimate the emissions rates of COPCs that were not included as analytes in the flare effluent testing (so that their concentrations cannot be inferred from the flare testing *per se*). This method relies on the fact that the flare combusts most but not all of the incoming material. For the chemicals detected in pre-combustion landfill gas samples, then, emissions after combustion are estimated as:

$$E_{flare} = C_{lfg} Q_{flare} \left(1 - D_{flare}\right)$$

$$E_{engine} = C_{lfg} Q_{enqine} \left(1 - D_{engine}\right)$$

Equation 2

where the subscripts *flare* and *engine* refer to the existing landfill gas combustion flare and the proposed energy recovery engine, respectively, and the terms are:

E the emission rate to the atmosphere from the *flare* and *engine* sources (g/s);
C_{lfg} the concentration of the COPC measured in landfill gas (g/m^3);
Q the inlet flow rate of landfill gas to be combusted by the source (m^3/s); and
D the destruction efficiency (fraction) of the COPC during source combustion.

The equation above relies on measurements and parameters collected prior to combustion. Note that the values of E, Q, and D differ for the flare and engine. The source-specific values of Q (as described above, also) and D used in this evaluation are:

Q_{flare} 120 cfm = 0.0566 m^3/s (based on design plans);
Q_{engine} 350 cfm = 0.165 m^3/s (based on design plans);
D_{flare} 0.86 = 86% (U.S. EPA, 2008); and
D_{engine} 0.86 = 86%.[1]

The flow rates Q derive from design conditions for the landfill gas treatment system and are based on present levels of gas production. As the rate of gas production decreases with time, the utilization rate of the flare will decrease, and hence also its emissions. However, to be conservative, we ignore the fact that emission rates will decrease over time, and assume instead

[1] The destruction efficiency of the energy recovery engine is conservatively assumed to be the same as that of the flare. EPA (2008) lists a range of 86% to >99% destruction for enclosed flares based on plentiful data, with a typical value of 97.7%. EPA also provides a range of 95% to >99% for internal combustion engines, with a typical value of 97.2%. Assuming only 86% destruction for both devices should overestimate emissions by more than a factor of 10 for those COPCs that rely on Equation 2.

that emissions will remain at presently estimated rates over a period of thirty years. The destruction efficiencies D of landfill gas chemicals are taken at the low end of ranges for similar devices as compiled by the U.S. EPA (2008) in its characterization of landfill gas combustion emissions. Selection of low-end values for D is expected to result in overestimation of actual emission rates of landfill gas COPCs.

As noted above, chemicals detected in the 2010 landfill gas sample but not sought in the 2012 sampling and testing (such as reduced sulfur compounds) are also considered here. COPC concentrations are listed in Table 1 as volumetric ratios V_{lfg} in units of parts per million (ppm) to be consistent with sample analysis reports. They are related to concentrations in units of mass per volume by the following correlation, as derived from the ideal gas law:

$$C_{lfg} = V_{lfg} \frac{MW_{COPC}}{24500} \qquad \text{Equation 3}$$

where the terms are:

C_{lfg}	the concentration of the COPC measured in landfill gas (g/m^3);
V_{lfg}	the volumetric ratio of the COPC measured in landfill gas (ppm);
MW_{COPC}	the molecular weight of the COPC (g/mol); and
24500	a numerical constant from application of the ideal gas law at standard temperature (25˚C) and pressure (1 atm).

Concentrations of COPCs in Ambient Air

Predictions of COPC concentrations in air are determined with SCREEN3, a screening-level Gaussian plume dispersion model developed and distributed by the U.S. EPA (1995). SCREEN3 predicts concentrations directly downwind from emission sources and considers an array of meteorological variables (wind speed, atmospheric stability, *etc*.) in order to identify the worst-case conditions that lead to the highest concentrations of pollutants.

Modeling parameters for the sources are derived from equipment specifications and source-specific data. The flare is modeled as a flare source with a release height of 40 ft (12.19 m) above the ground. A heat input rate of 267,624 cal/s is estimated from a landfill gas inflow rate of 120 cfm, a 53.1% methane content in the gas, and a heating value for methane of 1000 BTU/ft^3. Based on design plans, the energy recovery engine will have a stack (release) height of 4.17 m (13.67 ft), a gas exit temperature of 954˚F (785 K), a stack exit diameter of 12 in, and a combustion gas flow rate of 180,396 ft^3/hr (3.8 m^3/s). To simulate the aerodynamic effect of the proposed enclosure of the energy recovery engine, the building downwash option was invoked. The height, width, and length of the enclosure were set to 10 ft (3.048 m), 10 ft (3.048 m), and 40 ft (12.196 m), respectively, based on engineering schematics.

Each source was modeled for a nominal emission rate of 1 gram per second (g/s) such that the results could be readily scaled by COPC-specific emission rates. The model output files for the two SCREEN3 model runs are provided in the Attachment. Short-term (1-hr average) model predictions of concentrations for the closest residential location to the facility, at a distance of 350 m, are:

Flare: $\chi/E = 37.60$ µg/m^3 per g/s emission
Engine: $\chi/E = 62.61$ µg/m^3 per g/s emission

where the symbol χ/E is used to denote a predicted concentration in ambient air per unit (nominal) emission rate. COPC-specific predictions of worst-case annual average concentrations in ambient air for the combination of the two sources are calculated as:

$$C_{COPC} = (\chi/E)_{flare} E_{flare} f_{S\rightarrow L} + (\chi/E)_{engine} E_{engine} f_{S\rightarrow L} \qquad \text{Equation 4}$$

where C_{COPC} is expressed in units of µg/m^3, and the additional term $f_{S\rightarrow L}$ is a factor applied to extrapolate the short-term (1-hour average) predictions of the SCREEN3 model to long-term (annual average) time periods appropriate for the risk assessment calculations. The $f_{S\rightarrow L}$ factor accounts for varying wind directions and meteorological conditions, *i.e.*, the fact that the worst-case model predictions at a specific location are typically much smaller (often zero) at the same location during other times and conditions. An $f_{S\rightarrow L}$ of 0.08 is assumed , per U.S. EPA (1992) guidance. In practice, this factor is typically much smaller in applications of refined U.S. EPA dispersion models such as AERMOD that consider hour-by-hour meteorological conditions over multiple years. The U.S. EPA's SCREEN3 algorithms are thus intentionally designed to overestimate actual air quality impacts that will result from source emissions.

Comparison with Acceptable Risk-Based Concentrations

The modeled COPC-specific concentrations due to Alpha Ridge emissions are provided in Table 3 (as predicted using Equation 4). Also compiled in Table 3 are Acceptable Risk-Based Concentrations (ARBCs) derived from toxicological and/or epidemiological data specific to each COPC. Supporting information for the ARBCs is provided in Table 4 (as described below); the values are based on levels of risk deemed acceptable by regulatory authorities such as the Maryland Department of the Environment (MDE). Two types of risk are considered in the derivation of ARBCs: the theoretical incremental risk of getting cancer from exposure to a COPC, and the possibility of experiencing any other adverse effects on health.

As shown in Table 3, for each chemical, the predicted worst-case concentrations in ambient air due to Alpha Ridge source emissions are substantially smaller than ARBCs. Because the ARBCs are set at levels of no significant risks to health, emissions from the flare and energy recovery engine are expected to be harmless.

Derivation of Acceptable Risk-Based Concentrations

For those chemicals known or suspected to cause cancer in humans, incremental cancer risks *via* inhalation exposure are quantified using COPC-specific unit risk factors (UR_{COPC}) that are derived from studies in humans and/or animals that indicate elevated incidence of cancer. The chance of getting cancer depends on both the length and intensity of exposure. The MDE, like many other state agencies, considers an additional risk of 1 in 100,000 (0.00001) due to exposure to a chemical to be an acceptable level. This risk adds to, but is much smaller than, the actuarial risk of getting cancer from all causes, which is currently 1 in 2 for men, and 1 in 3 for women. Standard risk assessment practice considers an exposure period of thirty (30) years, based on a high-end value of the length of time that people reside at the same location. In the case of the Alpha Ridge Landfill, this 30-year timeframe is also longer than the period that the landfill is

expected to produce substantial levels of landfill gas. With the above assumptions, an $ARBC_{cancer}$ is calculated as:

$$ARBC_{cancer} = \frac{0.00001}{UR_{COPC}} \times \frac{70}{30} \qquad \text{Equation 5}$$

where the terms are:

$ARBC_{cancer}$	the acceptable concentration of the COPC in ambient air based on incremental cancer risk;
0.00001	the acceptable level of incremental cancer risk, equal to 1 per 100,000;
UR_{COPC}	the COPC-specific unit risk factor, in units of $m^3/\mu g$ (the unit risk factor is defined as the additional lifetime risk of cancer per continuous inhalation exposure to a COPC concentration of 1 $\mu g/m^3$);
70	the average length of a human lifetime (years) assumed in the derivation of unit risk factors; and
30	the assumed length of exposure (years) to the COPC emissions from the Alpha Ridge Landfill sources.

The analogous *ARBC* for non-cancer health effects is taken directly from toxicological databases as the chronic Reference Concentration (*RfC*), defined in risk assessment practice as the concentration of a COPC in air that can be safely breathed day in and day out over decades without any significant chance of the exposure resulting in adverse effects on health. *RfC* values are derived from toxicological studies in humans and/or animals, and typically incorporate safety factors to ensure that all members of the public are protected — including those known or reasonably expected to be particularly sensitive to air pollutants. Thus, per its definition:

$$ARBC_{non\text{-}cancer} = RfC_{COPC} \qquad \text{Equation 6}$$

Table 4 lists the toxicological data identified for the COPCs. These data were obtained from the Risk Assessment Information System (RAIS, http://rais.ornl.gov/), a database maintained by the Oak Ridge National Laboratory that pools the most trusted and reputable sources of toxicological data, starting with the U.S. EPA's Integrated Risk Information System. The primary sources of each COPC-specific UR_{COPC} and RfC_{COPC} are provided in Table 4. The *ARBC* for each COPC is selected as the lower (that is, the more stringent) of the two values (from Equation 5 and Equation 6, if both available) for cancer and non-cancer health effects. Toxicological data for some COPCs are not available; most of these chemicals are common hydrocarbons that are not associated with toxic effects at typical environmental concentrations.

Additional Consideration of Polychlorinated Dibenzo-*p*-dioxins and Dibenzo-furans

In February 2012, after thorough evaluation of the toxicity of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo-furans (PCDD/Fs), the U.S. EPA established a reference (that is, safe) dose for 2,3,7,8-tetrachlorodibenzo(p)dioxin (2,3,7,8-TCDD), the most potent of this group of chemicals (U.S. EPA, 2012). The reference dose is 0.7 picograms of per kilogram of body weight per day (pg/kg-day), and is applicable to the other PCDD/Fs according to their potencies relative to 2,3,7,8-TCDD (U.S. EPA, 2010). We rely on this reference dose for safety evaluation as follows.

The highest concentration of 2,3,7,8-TCDD toxic equivalents (2,3,7,8-TCDD TEQs) at a residential location due to combined emissions from the Alpha Ridge energy recovery engine and flare is predicted to be 0.0000000004 μg/m^3 = 0.0004 pg/m^3 (Table 3). At this concentration, a 70-kg person breathing air at a typical rate of 20 m^3 per day would receive a dose of:

$$\text{Exposure} = \frac{\frac{0.0004\,\text{pg}}{\text{m}^3} \times \frac{20\,\text{m}^3}{\text{day}}}{70\,\text{kg}} = 0.0001\,\text{pg/kg - day}$$

which is thousands of times smaller than the safe dose of 0.7 pg/kg-day.

References

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U.S. EPA (1995). SCREEN3 Model User's Guide. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-454/B-95-004.

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U.S. EPA (2010). Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds. EPA/100/R-10/005

U.S. EPA (2012). Integrated Risk Information System summary for 2,3,7,8-Tetrachlorodibenzo-p-dioxin. Available at: http://www.epa.gov/iris/subst/1024.htm.

Table 1 Chemicals of Potential Concern identified in Alpha Ridge Landfill sampling

Chemical	Molecular weight (g/mol)	Concentration detected in landfill gas		Highest emission rate measured in flare exhaust (lb/hr)
		Concentration (ppm)	Sample year	
Acetone	58.08	0.12	2012	0.0008
Benzene	78.11	0.14	2012	0.0034
Butane	58.12	1.4	2012	<0.000025
tert-Butyl alcohol	74.12	0.1	2012	NA
Carbon disulfide	76.14	0.0065	2012	0.00066
Carbonyl sulfide	60.08	4.07	2010	NA
Chlorobenzene	112.56	<0.002	2012	0.000059
Chloroethane	64.51	0.12	2012	<0.000042
Chloromethane	50.49	0.0047	2012	0.00025
Cumene (Isopropylbenzene)	120.19	0.013	2012	NA
Cyclohexane	84.16	0.23	2012	0.000047
p-Cymene (1-Methyl-4-lsopropylbenzene)	134.22	0.0025	2012	NA
Decane	142.28	4	2010	NA
1,2-Dichlorobenzene	147	<0.002	2012	0.00017
1,3-Dichlorobenzene	147	<0.002	2012	0.00015
1,4-Dichlorobenzene	147	<0.002	2012	0.00013
1,1-Dichloroethane	98.96	0.028	2012	<0.000043
cis-1,2-Dichloroethene	96.94	0.11	2012	<0.000040
trans-1,2-Dichloroethene	96.94	0.006	2012	<0.000042
1,2-Dichloropropane	112.99	0.0022	2012	<0.000097
2,2-Dimethylbutane	86.18	0.19	2010	NA
1,4-Dioxane	88.11	0.0063	2012	<0.00038
Dodecane	170.33	0.14	2010	NA
Ethanol	46.07	0.16	2012	<0.00023
Ethylbenzene	106.17	0.28	2012	0.00032
Ethyl butyrate	116.16	0.82	2010	NA
Ethylene dibromide (1,2-Dibromoethane)	187.86	<0.002	2012	0.000075
2-Ethyltoluene	120.19	0.29	2010	NA
3-Ethyltoluene	120.19	0.62	2010	NA
Freon 11 (Trichlorofluoromethane)	137.37	0.023	2012	<0.000059
Freon 12 (Dichlorodifluoromethane)	120.91	0.51	2012	0.00015
Freon 113 (1,1,2-Trichloro-1,2,2-Trifluoroethane)	187.37	0.005	2012	<0.000060
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	170.92	0.05	2012	<0.000063
Heptane	100.2	0.33	2012	0.00091
Hexane	86.18	0.55	2012	0.0003

Table 1 Chemicals of Potential Concern identified in Alpha Ridge Landfill sampling

Chemical	Molecular weight (g/mol)	Concentration detected in landfill gas		Highest emission rate measured in flare exhaust (lb/hr)
		Concentration (ppm)	Sample year	
Hydrogen sulfide	34.08	11.02	2010	NA
Isopropyl alcohol (2-Propanol)	60.1	0.023	2012	<0.00039
Limonene	136.23	0.63	2010	NA
2-Methylbutane	72.15	0.36	2010	NA
Methylcyclohexane	98.19	0.72	2010	NA
Methylcyclopentane	84.16	0.35	2010	NA
Methylene chloride (Dichloromethane)	84.93	0.043	2012	0.00058
Methyl ethyl ketone (2-Butanone)	72.11	0.13	2012	<0.00046
2-Methylheptane	114.23	0.7	2010	NA
3-Methylheptane	114.23	0.5	2010	NA
2-Methylhexane	100.2	0.4	2010	NA
3-Methylhexane	100.2	0.57	2010	NA
Methyl isobutyl ketone (4-Methyl-2-pentanone)	100.16	0.01	2012	<0.00069
3-Methyloctane	128.26	1.4	2010	NA
2-Methylpentane	86.18	0.34	2010	NA
3-Methylpentane	86.18	0.48	2010	NA
Methyl tert-butyl ether (MTBE)	88.15	0.013	2012	<0.000037
Nonane	128.26	3.4	2010	NA
Octane	114.23	1.6	2010	NA
Pentane	72.15	0.18	2010	NA
α-Pinene	136.23	5.1	2010	NA
Propene	42.08	4.0	2012	0.00012
n-Propylbenzene	120.19	0.0039	2012	NA
2,3,7,8-Tetrachlorodibenzo(p)dioxin toxic equivalents (2,3,7,8-TCDD TEQs)	321.97	–	–	0.000000000749
1,1,2,2-Tetrachloroethane	167.85	<0.002	2012	0.00025
Tetrachloroethylene	165.83	0.0075	2012	<0.000071
Tetrahydrofuran	72.11	0.67	2012	<0.000062
Toluene	92.14	0.63	2012	0.0011
1,1,1-Trichloroethane	133.4	0.0043	2012	<0.000086
1,2,4-Trimethylbenzene	120.19	0.0025	2012	0.00038
Trichloroethylene	131.39	0.012	2012	<0.000085
1,3,5-Trimethylbenzene	120.19	0.0022	2012	0.00023
1,1,3-Trimethylcyclohexane	126.24	0.55	2010	NA
2,2,4-Trimethylpentane (iso-Octane)	114.23	0.12	2012	0.0067
2,3,4-Trimethylpentane	114.23	0.16	2010	NA
Undecane	156.31	1.09	2010	NA

Table 1 Chemicals of Potential Concern identified in Alpha Ridge Landfill sampling

Chemical	Molecular weight (g/mol)	Concentration detected in landfill gas		Highest emission rate measured in flare exhaust (lb/hr)
		Concentration (ppm)	Sample year	
Vinyl chloride	62.5	0.56	2012	<0.000024
Xylenes (mixed isomers)	106.17	0.31	2012	0.0031

Notes: NA = Not analyzed for sample. Emission rate estimated in Table 2 is based on Equation 2.
< = Not detected; value indicates reporting limit (the level below which cannot be sensed or reliably measured by the laboratory)

Table 2 Emission rates of COPCs

Chemical	Emission rate (g/s) from:	
	Flare	Energy recovery engine
Acetone	2.57E-05	7.51E-05
Benzene	1.09E-04	3.19E-04
Butane	8.04E-07	2.35E-06
tert-Butyl alcohol	2.40E-06	7.01E-06
Carbon disulfide	2.12E-05	6.19E-05
Carbonyl sulfide	7.93E-05	2.31E-04
Chlorobenzene	1.90E-06	5.54E-06
Chloroethane	1.35E-06	3.94E-06
Chloromethane	8.04E-06	2.35E-05
Cumene (Isopropylbenzene)	5.07E-07	1.48E-06
Cyclohexane	1.51E-06	4.41E-06
p-Cymene (1-Methyl-4-lsopropylbenzene)	1.09E-07	3.17E-07
Decane	1.85E-04	5.38E-04
1,2-Dichlorobenzene	5.47E-06	1.60E-05
1,3-Dichlorobenzene	4.83E-06	1.41E-05
1,4-Dichlorobenzene	4.18E-06	1.22E-05
1,1-Dichloroethane	1.38E-06	4.03E-06
cis-1,2-Dichloroethene	1.29E-06	3.75E-06
trans-1,2-Dichloroethene	1.35E-06	3.94E-06
1,2-Dichloropropane	3.12E-06	9.10E-06
2,2-Dimethylbutane	5.31E-06	1.55E-05
1,4-Dioxane	1.22E-05	3.57E-05
Dodecane	7.73E-06	2.26E-05
Ethanol	7.40E-06	2.16E-05
Ethylbenzene	1.03E-05	3.00E-05
Ethyl butyrate	3.09E-05	9.01E-05
Ethylene dibromide (1,2-Dibromoethane)	2.41E-06	7.04E-06
2-Ethyltoluene	1.13E-05	3.30E-05
3-Ethyltoluene	2.42E-05	7.05E-05
Freon 11 (Trichlorofluoromethane)	1.90E-06	5.54E-06
Freon 12 (Dichlorodifluoromethane)	4.83E-06	1.41E-05
Freon 113 (1,1,2-Trichloro-1,2,2-Trifluoroethane)	1.93E-06	5.63E-06
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	2.03E-06	5.91E-06
Heptane	2.93E-05	8.54E-05
Hexane	9.65E-06	2.81E-05

Table 2 Emission rates of COPCs

Chemical	Emission rate (g/s) from:	
	Flare	Energy recovery engine
Hydrogen sulfide	1.22E-04	3.55E-04
Isopropyl alcohol (2-Propanol)	1.25E-05	3.66E-05
Limonene	2.78E-05	8.12E-05
2-Methylbutane	8.42E-06	2.46E-05
Methylcyclohexane	2.29E-05	6.69E-05
Methylcyclopentane	9.55E-06	2.79E-05
Methylene chloride (Dichloromethane)	1.87E-05	5.44E-05
Methyl ethyl ketone (2-Butanone)	1.48E-05	4.32E-05
2-Methylheptane	2.59E-05	7.56E-05
3-Methylheptane	1.85E-05	5.40E-05
2-Methylhexane	1.30E-05	3.79E-05
3-Methylhexane	1.85E-05	5.40E-05
Methyl isobutyl ketone (4-Methyl-2-pentanone)	2.22E-05	6.47E-05
3-Methyloctane	5.82E-05	1.70E-04
2-Methylpentane	9.50E-06	2.77E-05
3-Methylpentane	1.34E-05	3.91E-05
Methyl tert-butyl ether (MTBE)	1.19E-06	3.47E-06
Nonane	1.41E-04	4.12E-04
Octane	5.93E-05	1.73E-04
Pentane	4.21E-06	1.23E-05
α-Pinene	2.25E-04	6.57E-04
Propene	3.86E-06	1.13E-05
n-Propylbenzene	1.52E-07	4.43E-07
2,3,7,8-Tetrachlorodibenzo(p)dioxin toxic equivalents (2,3,7,8-TCDD TEQs)	2.41E-11	7.03E-11
1,1,2,2-Tetrachloroethane	8.04E-06	2.35E-05
Tetrachloroethylene	2.28E-06	6.66E-06
Tetrahydrofuran	1.99E-06	5.82E-06
Toluene	3.54E-05	1.03E-04
1,1,1-Trichloroethane	2.77E-06	8.07E-06
1,2,4-Trimethylbenzene	1.22E-05	3.57E-05
Trichloroethylene	2.73E-06	7.98E-06
1,3,5-Trimethylbenzene	7.40E-06	2.16E-05
1,1,3-Trimethylcyclohexane	2.25E-05	6.57E-05
2,2,4-Trimethylpentane	2.16E-04	6.29E-04
2,3,4-Trimethylpentane	5.93E-06	1.73E-05
Undecane	5.53E-05	1.61E-04

Table 2 Emission rates of COPCs

Chemical	Emission rate (g/s) from:	
	Flare	Energy recovery engine
Vinyl chloride	7.72E-07	2.25E-06
Xylenes (mixed isomers)	9.97E-05	2.91E-04

Table 3 Comparison of Worst-case Predicted COPC Concentrations in Ambient Air at Residential Locations to Acceptable Risk-Based Concentrations

Chemical	Predicted worst-case concentration due to Alpha Ridge Landfill (from Equation 4) ($\mu g/m^3$)	Acceptable risk-based concentration (ARBC) (from Table 4) ($\mu g/m^3$)
Acetone	0.0005	30900
Benzene	0.002	3
Butane	0.00001	#N/A
tert-Butyl alcohol	0.00004	#N/A
Carbon disulfide	0.0004	700
Carbonyl sulfide	0.001	#N/A
Chlorobenzene	0.00003	50
Chloroethane	0.00002	10000
Chloromethane	0.0001	13
Cumene (Isopropylbenzene)	0.000009	400
Cyclohexane	0.00003	6000
p-Cymene (1-Methyl-4-lsopropylbenzene)	0.000002	#N/A
Decane	0.003	3500
1,2-Dichlorobenzene	0.00010	200
1,3-Dichlorobenzene	0.00009	70
1,4-Dichlorobenzene	0.00007	2
1,1-Dichloroethane	0.00002	15
cis-1,2-Dichloroethene	0.00002	7
trans-1,2-Dichloroethene	0.00002	60
1,2-Dichloropropane	0.00005	2
2,2-Dimethylbutane	0.00009	#N/A
1,4-Dioxane	0.0002	3
Dodecane	0.0001	#N/A
Ethanol	0.0001	#N/A
Ethylbenzene	0.0002	9
Ethyl butyrate	0.0005	#N/A
Ethylene dibromide (1,2-Dibromoethane)	0.00004	0.04
2-Ethyltoluene	0.0002	#N/A
3-Ethyltoluene	0.0004	#N/A
Freon 11 (Trichlorofluoromethane)	0.00003	#N/A
Freon 12 (Dichlorodifluoromethane)	0.00009	100
Freon 113 (1,1,2-Trichloro-1,2,2-Trifluoroethane)	0.00003	30000
Freon 114	0.00004	#N/A

Table 3 Comparison of Worst-case Predicted COPC Concentrations in Ambient Air at Residential Locations to Acceptable Risk-Based Concentrations

Chemical	Predicted worst-case concentration due to Alpha Ridge Landfill (from Equation 4) ($\mu g/m^3$)	Acceptable risk-based concentration (ARBC) (from Table 4) ($\mu g/m^3$)
(1,2-Dichloro-1,1,2,2-tetrafluoroethane)		
Heptane	0.0005	#N/A
Hexane	0.0002	700
Hydrogen sulfide	0.002	2
Isopropyl alcohol (2-Propanol)	0.0002	7000
Limonene	0.0005	#N/A
2-Methylbutane	0.0001	#N/A
Methylcyclohexane	0.0004	3000
Methylcyclopentane	0.0002	1400
Methylene chloride (Dichloromethane)	0.0003	600
Methyl ethyl ketone (2-Butanone)	0.0003	5000
2-Methylheptane	0.0005	#N/A
3-Methylheptane	0.0003	#N/A
2-Methylhexane	0.0002	#N/A
3-Methylhexane	0.0003	#N/A
Methyl isobutyl ketone (4-Methyl-2-pentanone)	0.0004	3000
3-Methyloctane	0.001	#N/A
2-Methylpentane	0.0002	#N/A
3-Methylpentane	0.0002	#N/A
Methyl tert-butyl ether (MTBE)	0.00002	90
Nonane	0.002	200
Octane	0.001	#N/A
Pentane	0.00007	1000
α-Pinene	0.004	#N/A
Propene	0.00007	3000
n-Propylbenzene	0.000003	1000
2,3,7,8-Tetrachlorodibenzo(p)dioxin toxic equivalents (2,3,7,8-TCDD TEQs)	0.0000000004	0.0000006
1,1,2,2-Tetrachloroethane	0.0001	0.4
Tetrachloroethylene	0.00004	40
Tetrahydrofuran	0.00004	2000
Toluene	0.0006	5000
1,1,1-Trichloroethane	0.00005	5000
1,2,4-Trimethylbenzene	0.0002	7
Trichloroethylene	0.00005	2

Table 3 Comparison of Worst-case Predicted COPC Concentrations in Ambient Air at Residential Locations to Acceptable Risk-Based Concentrations

Chemical	Predicted worst-case concentration due to Alpha Ridge Landfill (from Equation 4) ($\mu g/m^3$)	Acceptable risk-based concentration (ARBC) (from Table 4) ($\mu g/m^3$)
1,3,5-Trimethylbenzene	0.0001	6
1,1,3-Trimethylcyclohexane	0.0004	#N/A
2,2,4-Trimethylpentane	0.004	#N/A
2,3,4-Trimethylpentane	0.0001	#N/A
Undecane	0.0010	#N/A
Vinyl chloride	0.00001	5
Xylenes (mixed isomers)	0.002	100

Note: #N/A – Number not available. This is because the chemicals so noted — such as butane — are so relatively benign that regulatory toxicologists need not establish upper-limit-guidelines in order to preserve air quality.

Table 4 Toxicological Data Used to Derive Acceptable Risk-Based Concentrations for COPCs (from http://rais.ornl.gov/)

Chemical	Reference Concentration (Non-Cancer risk) ($ARBC_{non\text{-}cancer}$)		Unit risk factor (Cancer risk) (UR_{COPC})		Cancer risk-based concentration (µg/m^3) ($ARBC_{cancer}$) (Equation 5)	Acceptable risk-based concentration (ARBC) (lower of $ARBC_{non\text{-}cancer}$ and $ARBC_{cancer}$)	
	Value (µg/m^3)	Source	Value (m^3/µg)	Source		Basis	Value (µg/m^3)
Acetone	30900	ATSDR[a]	NC			Non-Cancer	30900
Benzene	30	IRIS	7.80E-06	IRIS	3	Cancer	3
Butane							#N/A
tert-Butyl alcohol							#N/A
Carbon disulfide	700	IRIS	NC			Non-Cancer	700
Carbonyl sulfide							#N/A
Chlorobenzene	50	PPRTV[b]	NC			Non-Cancer	50
Chloroethane	10000	IRIS	NC			Non-Cancer	10000
Chloromethane	90	IRIS	1.80E-06	HEAST	13	Cancer	13
Cumene (Isopropylbenzene)	400	IRIS	NC			Non-Cancer	400
Cyclohexane	6000	IRIS	NC			Non-Cancer	6000
p-Cymene (1-Methyl-4-lsopropylbenzene)			NC				#N/A
Decane			NC			Non-Cancer	3500
1,2-Dichlorobenzene	200	HEAST	NC			Non-Cancer	200
1,3-Dichlorobenzene			NC			Non-Cancer	70
1,4-Dichlorobenzene	800	IRIS	1.10E-05	CALEPA	2	Cancer	2
1,1-Dichloroethane	500	HEAST	1.60E-06	CALEPA	15	Cancer	15
cis-1,2-Dichloroethene			NC			Non-Cancer	7

Table 4 Toxicological Data Used to Derive Acceptable Risk-Based Concentrations for COPCs (from http://rais.ornl.gov/)

Chemical	Reference Concentration (Non-Cancer risk) ($ARBC_{non\text{-}cancer}$)		Unit risk factor (Cancer risk) (UR_{COPC})		Cancer risk-based concentration ($\mu g/m^3$) ($ARBC_{cancer}$) (Equation 5)	Acceptable risk-based concentration (ARBC) (lower of $ARBC_{non\text{-}cancer}$ and $ARBC_{cancer}$)	
	Value ($\mu g/m^3$)	Source	Value ($m^3/\mu g$)	Source		Basis	Value ($\mu g/m^3$)
trans-1,2-Dichloroethene	60	PPRTV[b]	NC			Non-Cancer	60
1,2-Dichloropropane	4	IRIS	1.00E-05	CALEPA	2	Cancer	2
2,2-Dimethylbutane							#N/A
1,4-Dioxane	3600	ATSDR[c]	7.70E-06	CALEPA	3	Cancer	3
Dodecane							#N/A
Ethanol			NC				#N/A
Ethylbenzene	1000	IRIS	2.50E-06	CALEPA	9	Cancer	9
Ethyl butyrate							#N/A
Ethylene dibromide (1,2-Dibromoethane)	9	IRIS	6.00E-04	IRIS	0.04	Cancer	0.04
2-Ethyltoluene							#N/A
3-Ethyltoluene							#N/A
Freon 11 (Trichlorofluoromethane)							#N/A
Freon 12 (Dichlorodifluoromethane)	100	PPRTV[b]	NC			Non-Cancer	100
Freon 113 (1,1,2-Trichloro-1,2,2-Trifluoroethane)	30000	HEAST	NC			Non-Cancer	30000
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)							#N/A
Heptane			NC				#N/A
Hexane	700	IRIS	NC			Non-Cancer	700
Hydrogen sulfide	2	IRIS	NC			Non-Cancer	2

Table 4 Toxicological Data Used to Derive Acceptable Risk-Based Concentrations for COPCs (from http://rais.ornl.gov/)

Chemical	Reference Concentration (Non-Cancer risk) ($ARBC_{non\text{-}cancer}$)		Unit risk factor (Cancer risk) (UR_{COPC})		Cancer risk-based concentration ($\mu g/m^3$) ($ARBC_{cancer}$) (Equation 5)	Acceptable risk-based concentration (ARBC) (lower of $ARBC_{non\text{-}cancer}$ and $ARBC_{cancer}$)	
	Value ($\mu g/m^3$)	Source	Value ($m^3/\mu g$)	Source		Basis	Value ($\mu g/m^3$)
Isopropyl alcohol (2-Propanol)	7000	CALEPA	NC			Non-Cancer	7000
Limonene							#N/A
2-Methylbutane							#N/A
Methylcyclohexane	3000	HEAST	NC			Non-Cancer	3000
Methylcyclopentane			NC			Non-Cancer	1400
Methylene chloride (Dichloromethane)	600	IRIS	1.00E-08	IRIS	2333	Non-Cancer	600
Methyl ethyl ketone (2-Butanone)	5000	IRIS	NC			Non-Cancer	5000
2-Methylheptane							#N/A
3-Methylheptane							#N/A
2-Methylhexane							#N/A
3-Methylhexane							#N/A
Methyl isobutyl ketone (4-Methyl-2-pentanone)	3000	IRIS	NC			Non-Cancer	3000
3-Methyloctane							#N/A
2-Methylpentane							#N/A
3-Methylpentane							#N/A
Methyl tert-butyl ether (MTBE)	3000	IRIS	2.60E-07	CALEPA	90	Cancer	90
Nonane	200	PPRTV[b]	NC			Non-Cancer	200
Octane							#N/A
Pentane	1000	PPRTV[b]	NC			Non-Cancer	1000

Table 4 Toxicological Data Used to Derive Acceptable Risk-Based Concentrations for COPCs (from http://rais.ornl.gov/)

Chemical	Reference Concentration (Non-Cancer risk) ($ARBC_{non\text{-}cancer}$)		Unit risk factor (Cancer risk) (UR_{COPC})		Cancer risk-based concentration ($\mu g/m^3$) ($ARBC_{cancer}$) (Equation 5)	Acceptable risk-based concentration (ARBC) (lower of $ARBC_{non\text{-}cancer}$ and $ARBC_{cancer}$)	
	Value ($\mu g/m^3$)	Source	Value ($m^3/\mu g$)	Source		Basis	Value ($\mu g/m^3$)
α-Pinene							#N/A
Propene	3000	CALEPA	NC			Non-Cancer	3000
n-Propylbenzene	1000	PPRTV[b]	NC			Non-Cancer	1000
2,3,7,8-Tetrachlorodibenzo(p)dioxin toxic equivalents (2,3,7,8-TCDD TEQs)	0.00004	CALEPA	3.80E+01	CALEPA	0.0000006	Cancer	0.0000006
1,1,2,2-Tetrachloroethane			5.80E-05	CALEPA	0.4	Cancer	0.4
Tetrachloroethylene	40	IRIS	2.60E-07	IRIS	90	Non-Cancer	40
Tetrahydrofuran	2000	IRIS	NC			Non-Cancer	2000
Toluene	5000	IRIS	NC			Non-Cancer	5000
1,1,1-Trichloroethane	5000	IRIS	NC			Non-Cancer	5000
1,2,4-Trimethylbenzene	7	PPRTV[b]	NC			Non-Cancer	7
Trichloroethylene	2	IRIS	4.10E-06	IRIS	6	Non-Cancer	2
1,3,5-Trimethylbenzene	6	PPRTV[d]	NC			Non-Cancer	6
1,1,3-Trimethylcyclohexane							#N/A
2,2,4-Trimethylpentane			NC				#N/A
2,3,4-Trimethylpentane							#N/A
Undecane							#N/A
Vinyl chloride	100	IRIS	4.40E-06	IRIS	5	Cancer	5
Xylenes (mixed isomers)	100	IRIS	NC			Non-Cancer	100

Table 4 Toxicological Data Used to Derive Acceptable Risk-Based Concentrations for COPCs (from http://rais.ornl.gov/)

Chemical	Reference Concentration (Non-Cancer risk) ($ARBC_{non\text{-}cancer}$)		Unit risk factor (Cancer risk) (UR_{COPC})		Cancer risk-based concentration ($\mu g/m^3$) ($ARBC_{cancer}$) (Equation 5)	Acceptable risk-based concentration (ARBC) (lower of $ARBC_{non\text{-}cancer}$ and $ARBC_{cancer}$)	
	Value ($\mu g/m^3$)	Source	Value ($m^3/\mu g$)	Source		Basis	Value ($\mu g/m^3$)

Notes

#N/A	Number not available. This is because the chemicals so noted — such as butane — are so relatively benign that regulatory toxicologists need not establish upper-limit-guidelines in order to preserve air quality.
a	Final
b	Current
c	Draft
d	Archive
NC	Chemical not known or suspected to cause cancer
IRIS	Integrated Risk Information System (U.S. EPA)
HEAST	Health Effects Assessment Summary Tables (U.S. EPA)
PPTRV	Provisional Peer-Reviewed Toxicity Value (U.S. EPA)
CALEPA	California Environmental Protection Agency
ATSDR	Agency for Toxic Substances and Disease Registry

Attachment

SCREEN3 Model Run for the Flare Emission Source

```
                                                                    12/14/11
                                                                   17:49:37
 ***  SCREEN3 MODEL RUN  ***
 *** VERSION DATED 96043 ***

test

SIMPLE TERRAIN INPUTS:
   SOURCE TYPE            =        FLARE
   EMISSION RATE (G/S)    =      1.00000
   FLARE STACK HEIGHT (M) =      12.1920
   TOT HEAT RLS (CAL/S)   =      267624.
   RECEPTOR HEIGHT (M)    =        .0000
   URBAN/RURAL OPTION     =        RURAL
   EFF RELEASE HEIGHT (M) =      13.9839
   BUILDING HEIGHT (M)    =        .0000
   MIN HORIZ BLDG DIM (M) =        .0000
   MAX HORIZ BLDG DIM (M) =        .0000

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.


BUOY. FLUX =    4.437 M**4/S**3;  MOM. FLUX =    2.706 M**4/S**2.

*** FULL METEOROLOGY ***

**********************************
*** SCREEN AUTOMATED DISTANCES ***
**********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST     CONC              U10M   USTK  MIX HT   PLUME   SIGMA   SIGMA
   (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   Y (M)   Z (M)  DWASH
-------  ----------  ----  -----  -----  ------  ------  ------  ------  -----
     1.   .0000        1     1.0    1.0   320.0   77.97    1.15    1.08    NO
   100.   15.39         2     5.0    5.1  1600.0   26.78   19.52   11.07    NO
   200.   36.17         2     4.0    4.1  1280.0   29.98   36.45   20.74    NO
   300.   38.32         3     4.0    4.1  1280.0   29.82   34.59   20.82    NO
   400.   36.35         3     3.0    3.1   960.0   35.10   45.05   27.13    NO
   500.   33.30         3     2.5    2.6   800.0   39.32   55.25   33.23    NO
   600.   32.08         4     4.0    4.2  1280.0   29.56   42.95   21.67    NO
   700.   30.83         4     3.5    3.7  1120.0   31.78   49.45   24.57    NO
   800.   29.51         4     3.0    3.2   960.0   34.75   55.89   27.43    NO
   900.   28.15         4     2.5    2.6   800.0   38.90   62.29   30.31    NO
  1000.   26.70         4     2.5    2.6   800.0   38.90   68.50   32.87    NO
  1100.   25.29         4     2.0    2.1   640.0   45.13   74.84   35.27    NO
  1200.   24.08         4     2.0    2.1   640.0   45.13   80.93   37.17    NO
  1300.   22.85         4     2.0    2.1   640.0   45.13   86.98   39.03    NO
  1400.   21.65         4     2.0    2.1   640.0   45.13   92.98   40.84    NO
  1500.   20.65         4     1.5    1.6   480.0   55.51   99.25   43.33    NO
  1600.   19.93         4     1.5    1.6   480.0   55.51  105.16   45.03    NO
  1700.   19.20         4     1.5    1.6   480.0   55.51  111.04   46.70    NO
  1800.   19.08         5     1.0    1.1 10000.0   60.95   88.00   34.09    NO
  1900.   19.33         5     1.0    1.1 10000.0   60.95   92.33   35.09    NO
  2000.   19.48         5     1.0    1.1 10000.0   60.95   96.64   36.08    NO
  2100.   19.48         5     1.0    1.1 10000.0   60.95  100.92   36.96    NO
  2200.   19.42         5     1.0    1.1 10000.0   60.95  105.19   37.82    NO
```

```
  2300.   19.32        5     1.0    1.1 10000.0   60.95  109.45   38.68    NO
  2400.   19.18        5     1.0    1.1 10000.0   60.95  113.68   39.51    NO
  2500.   19.01        5     1.0    1.1 10000.0   60.95  117.91   40.34    NO
  2600.   19.12        6     1.0    1.2 10000.0   52.10   81.50   27.22    NO
  2700.   19.34        6     1.0    1.2 10000.0   52.10   84.28   27.70    NO
  2800.   19.52        6     1.0    1.2 10000.0   52.10   87.05   28.17    NO
  2900.   19.67        6     1.0    1.2 10000.0   52.10   89.81   28.63    NO
  3000.   19.78        6     1.0    1.2 10000.0   52.10   92.57   29.09    NO
  3500.   19.54        6     1.0    1.2 10000.0   52.10  106.21   30.96    NO
  4000.   19.02        6     1.0    1.2 10000.0   52.10  119.67   32.70    NO
  4500.   18.35        6     1.0    1.2 10000.0   52.10  132.95   34.34    NO
  5000.   17.61        6     1.0    1.2 10000.0   52.10  146.08   35.90    NO
  5500.   16.85        6     1.0    1.2 10000.0   52.10  159.06   37.38    NO
  6000.   16.11        6     1.0    1.2 10000.0   52.10  171.92   38.79    NO
  6500.   15.38        6     1.0    1.2 10000.0   52.10  184.66   40.15    NO
  7000.   14.69        6     1.0    1.2 10000.0   52.10  197.29   41.46    NO
  7500.   14.02        6     1.0    1.2 10000.0   52.10  209.82   42.58    NO
  8000.   13.39        6     1.0    1.2 10000.0   52.10  222.25   43.66    NO
  8500.   12.80        6     1.0    1.2 10000.0   52.10  234.59   44.70    NO
  9000.   12.25        6     1.0    1.2 10000.0   52.10  246.85   45.72    NO
  9500.   11.74        6     1.0    1.2 10000.0   52.10  259.02   46.69    NO
 10000.   11.27        6     1.0    1.2 10000.0   52.10  271.12   47.65    NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     1. M:
   283.   38.42        3     4.5    4.7  1440.0   28.06   32.86   19.75    NO

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

*********************************
*** SCREEN DISCRETE DISTANCES ***
*********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST     CONC             U10M   USTK  MIX HT   PLUME   SIGMA   SIGMA
   (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   Y (M)   Z (M)  DWASH
-------  ----------  ----  -----  -----  ------  ------  ------  ------  -----
   350.   37.60        3     3.5    3.6  1120.0   32.08   39.84   23.97    NO
   500.   33.30        3     2.5    2.6   800.0   39.32   55.25   33.23    NO
  1000.   26.70        4     2.5    2.6   800.0   38.90   68.50   32.87    NO

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

     ************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ************************************

 CALCULATION        MAX CONC    DIST TO   TERRAIN
  PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
--------------    -----------   -------   -------
SIMPLE TERRAIN      38.42          283.        0.


************************************************
** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
************************************************
```

12/14/11
17:46:52

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 ***  SCREEN3 MODEL RUN  ***
 *** VERSION DATED 96043 ***

test

SIMPLE TERRAIN INPUTS:
   SOURCE TYPE            =        POINT
   EMISSION RATE (G/S)    =      1.00000
   STACK HEIGHT (M)       =       4.1656
   STK INSIDE DIAM (M)    =        .3048
   STK EXIT VELOCITY (M/S)=      52.0997
   STK GAS EXIT TEMP (K)  =     785.4000
   AMBIENT AIR TEMP (K)   =     293.0000
   RECEPTOR HEIGHT (M)    =        .0000
   URBAN/RURAL OPTION     =        RURAL
   BUILDING HEIGHT (M)    =       3.0480
   MIN HORIZ BLDG DIM (M) =       3.0480
   MAX HORIZ BLDG DIM (M) =      12.1960

THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

   STACK EXIT VELOCITY WAS CALCULATED FROM
   VOLUME FLOW RATE =   3.8015000     (M**3/S)

BUOY. FLUX =    7.439 M**4/S**3;  MOM. FLUX =   23.519 M**4/S**2.

*** FULL METEOROLOGY ***

**********************************
*** SCREEN AUTOMATED DISTANCES ***
**********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***
```

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
1.	.0000	1	1.0	1.0	320.0	100.67	2.40	2.37	NO
100.	232.9	4	15.0	15.0	4800.0	6.28	8.20	4.92	SS
200.	101.7	4	15.0	15.0	4800.0	8.09	15.56	8.74	SS
300.	71.99	4	10.0	10.0	3200.0	11.86	22.61	12.09	SS
400.	55.60	4	8.0	8.0	2560.0	14.72	29.45	15.27	SS
500.	46.07	4	5.0	5.0	1600.0	22.21	36.15	18.30	SS
600.	40.61	4	5.0	5.0	1600.0	22.21	42.72	21.21	SS
700.	35.79	4	4.5	4.5	1440.0	24.37	49.19	24.03	SS
800.	31.42	4	4.5	4.5	1440.0	24.37	55.57	26.78	SS
900.	27.81	4	3.5	3.5	1120.0	31.74	62.38	30.50	NO
1000.	25.57	4	3.0	3.0	960.0	36.34	68.74	33.38	NO
1100.	23.64	4	3.0	3.0	960.0	36.34	74.88	35.34	NO
1200.	21.86	4	2.5	2.5	800.0	42.77	81.19	37.74	NO
1300.	20.57	4	2.5	2.5	800.0	42.77	87.22	39.57	NO
1400.	20.16	5	1.0	1.0	10000.0	62.19	71.17	31.46	NO
1500.	20.75	5	1.0	1.0	10000.0	62.19	75.54	32.48	NO
1600.	21.21	5	1.0	1.0	10000.0	62.19	79.89	33.48	NO
1700.	21.54	5	1.0	1.0	10000.0	62.19	84.22	34.47	NO
1800.	22.24	6	1.0	1.0	10000.0	52.31	59.48	24.47	NO
1900.	23.04	6	1.0	1.0	10000.0	52.31	62.32	25.05	NO
2000.	23.75	6	1.0	1.0	10000.0	52.31	65.14	25.63	NO
2100.	24.14	6	1.0	1.0	10000.0	52.31	67.96	26.13	NO

```
  2200.   24.48        6     1.0    1.0 10000.0   52.31   70.77   26.61    NO
  2300.   24.75        6     1.0    1.0 10000.0   52.31   73.58   27.09    NO
  2400.   24.97        6     1.0    1.0 10000.0   52.31   76.37   27.57    NO
  2500.   25.15        6     1.0    1.0 10000.0   52.31   79.15   28.03    NO
  2600.   25.27        6     1.0    1.0 10000.0   52.31   81.93   28.49    NO
  2700.   25.36        6     1.0    1.0 10000.0   52.31   84.69   28.95    NO
  2800.   25.42        6     1.0    1.0 10000.0   52.31   87.45   29.40    NO
  2900.   25.44        6     1.0    1.0 10000.0   52.31   90.20   29.84    NO
  3000.   25.43        6     1.0    1.0 10000.0   52.31   92.95   30.28    NO
  3500.   24.64        6     1.0    1.0 10000.0   52.31  106.54   32.08    NO
  4000.   23.66        6     1.0    1.0 10000.0   52.31  119.96   33.77    NO
  4500.   22.62        6     1.0    1.0 10000.0   52.31  133.21   35.36    NO
  5000.   21.56        6     1.0    1.0 10000.0   52.31  146.32   36.87    NO
  5500.   20.53        6     1.0    1.0 10000.0   52.31  159.29   38.31    NO
  6000.   19.55        6     1.0    1.0 10000.0   52.31  172.13   39.69    NO
  6500.   18.61        6     1.0    1.0 10000.0   52.31  184.85   41.02    NO
  7000.   17.74        6     1.0    1.0 10000.0   52.31  197.47   42.30    NO
  7500.   16.89        6     1.0    1.0 10000.0   52.31  209.99   43.40    NO
  8000.   16.11        6     1.0    1.0 10000.0   52.31  222.41   44.46    NO
  8500.   15.39        6     1.0    1.0 10000.0   52.31  234.74   45.49    NO
  9000.   14.72        6     1.0    1.0 10000.0   52.31  246.99   46.48    NO
  9500.   14.10        6     1.0    1.0 10000.0   52.31  259.16   47.44    NO
 10000.   13.52        6     1.0    1.0 10000.0   52.31  271.25   48.38    NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     1. M:
    40.   437.7        4    20.0   20.0  6400.0    4.38    3.58    2.69    SS

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

*********************************
*** SCREEN DISCRETE DISTANCES ***
*********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST     CONC             U10M   USTK  MIX HT   PLUME   SIGMA   SIGMA
   (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   Y (M)   Z (M)  DWASH
-------  ----------  ----  -----  -----  ------  ------  ------  ------  -----
   350.   62.61        4     8.0    8.0  2560.0   14.72   26.05   13.70    SS
   500.   46.07        4     5.0    5.0  1600.0   22.21   36.15   18.30    SS
  1000.   25.57        4     3.0    3.0   960.0   36.34   68.74   33.38    NO

 DWASH=   MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

**************************************
     *** REGULATORY (Default) ***
    PERFORMING CAVITY CALCULATIONS
  WITH ORIGINAL SCREEN CAVITY MODEL
          (BRODE, 1988)
**************************************


 *** CAVITY CALCULATION - 1 ***       *** CAVITY CALCULATION - 2 ***
  CONC (UG/M**3)     =    .0000        CONC (UG/M**3)     =    .0000
  CRIT WS @10M (M/S) =   99.99        CRIT WS @10M (M/S) =   99.99
  CRIT WS @ HS (M/S) =   99.99        CRIT WS @ HS (M/S) =   99.99
  DILUTION WS (M/S)  =   99.99        DILUTION WS (M/S)  =   99.99
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  CAVITY HT (M)      =     4.38        CAVITY HT (M)      =     3.07
  CAVITY LENGTH (M)  =    12.80        CAVITY LENGTH (M)  =     4.27
  ALONGWIND DIM (M)  =     3.05        ALONGWIND DIM (M)  =    12.20

CAVITY CONC NOT CALCULATED FOR CRIT WS > 20.0 M/S.  CONC SET = 0.0

************************************
      END OF CAVITY CALCULATIONS
************************************


     ************************************
     *** SUMMARY OF SCREEN MODEL RESULTS ***
     ************************************

 CALCULATION        MAX CONC    DIST TO   TERRAIN
  PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
-------------    -----------   -------   -------
SIMPLE TERRAIN      437.7           40.        0.


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** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
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