Section 6

All Calculations

Show all calculations used to determine both the hourly and annual controlled and uncontrolled emission rates. All calculations shall be performed keeping a minimum of three significant figures. Document the source of each emission factor used (if an emission rate is carried forward and not revised, then a statement to that effect is required). If identical units are being permitted and will be subject to the same operating conditions, submit calculations for only one unit and a note specifying what other units to which the calculations apply. All formulas and calculations used to calculate emissions must be submitted. The "Calculations" tab in the UA2 has been provided to allow calculations to be linked to the emissions tables. Add additional "Calc" tabs as needed. If the UA2 or other spread sheets are used, all calculation spread sheet(s) shall be submitted electronically in Microsoft Excel compatible format so that formulas and input values can be checked. Format all spread sheets and calculations such that the reviewer can follow the logic and verify the input values. Define all variables. If calculation spread sheets are not used, provide the original formulas with defined variables. Additionally, provide subsequent formulas showing the input values for each variable in the formula. All calculations, including those calculations are imbedded in the Calc tab of the UA2 portion of the application, the printed Calc tab(s), should be submitted under this section.

Tank Flashing Calculations: The information provided to the AQB shall include a discussion of the method used to estimate tank-flashing emissions, relative thresholds (i.e., NOI, permit, or major source (NSPS, PSD or Title V)), accuracy of the model, the input and output from simulation models and software, all calculations, documentation of any assumptions used, descriptions of sampling methods and conditions, copies of any lab sample analysis. If Hysis is used, all relevant input parameters shall be reported, including separator pressure, gas throughput, and all other relevant parameters necessary for flashing calculation.

SSM Calculations: It is the applicant's responsibility to provide an estimate of SSM emissions or to provide justification for not doing so. In this Section, provide emissions calculations for Startup, Shutdown, and Routine Maintenance (SSM) emissions listed in the Section 2 SSM and/or Section 22 GHG Tables and the rational for why the others are reported as zero (or left blank in the SSM/GHG Tables). Refer to "Guidance for Submittal of Startup, Shutdown, Maintenance Emissions in Permit Applications (http://www.env.nm.gov/aqb/permit/app_form.html) for more detailed instructions on calculating SSM emissions. If SSM emissions are greater than those reported in the Section 2, Requested Allowables Table, modeling may be required to ensure compliance with the standards whether the application is NSR or Title V. Refer to the Modeling Section of this application for more guidance on modeling requirements.

Glycol Dehydrator Calculations: The information provided to the AQB shall include the manufacturer's maximum design recirculation rate for the glycol pump. If GRI-Glycalc is used, the full input summary report shall be included as well as a copy of the gas analysis that was used.

Road Calculations: Calculate fugitive particulate emissions and enter haul road fugitives in Tables 2-A, 2-D and 2-E for:

1. If you transport raw material, process material and/or product into or out of or within the facility and have PER emissions greater than 0.5 tpy.
2. If you transport raw material, process material and/or product into or out of the facility more frequently than one round trip per day.

Significant Figures:
A. All emissions standards are deemed to have at least two significant figures, but not more than three significant figures.
B. At least 5 significant figures shall be retained in all intermediate calculations.
C. In calculating emissions to determine compliance with an emission standard, the following rounding off procedures shall be used:

- **(1)** If the first digit to be discarded is less than the number 5, the last digit retained shall not be changed;
- **(2)** If the first digit discarded is greater than the number 5, or if it is the number 5 followed by at least one digit other than the number zero, the last figure retained shall be increased by one unit; **and**
- **(3)** If the first digit discarded is exactly the number 5, followed only by zeros, the last digit retained shall be rounded upward if it is an odd number, but no adjustment shall be made if it is an even number.
- **(4)** The final result of the calculation shall be expressed in the units of the standard.

Control Devices: In accordance with 20.2.72.203.A(3) and (8) NMAC, 20.2.70.300.D(5)(b) and (e) NMAC, and 20.2.73.200.B(7) NMAC, the permittee shall report all control devices and list each pollutant controlled by the control device regardless if the applicant takes credit for the reduction in emissions. The applicant can indicate in this section of the application if they chose to not take credit for the reduction in emission rates. For notices of intent submitted under 20.2.73 NMAC, only uncontrolled emission rates can be considered to determine applicability unless the state or federal Acts require the control. This information is necessary to determine if federally enforceable conditions are necessary for the control device, and/or if the control device produces its own regulated pollutants or increases emission rates of other pollutants.

Emissions calculations are provided for the following sources and were prepared to conform to the requirements listed above:

- Road Particulate Emissions inclusive of both paved and unpaved routes (Unit Number 1);
- Landfill Earthmoving Particulate Emissions inclusive of bulldozing operations, grading operations, scraper operations, and wind erosion (Unit Number 2);
- Landfill Gas Emissions (Unit Number 3);
- Petroleum Hydrocarbon Landfill (Unit Number 4);
- Landfill Gas Flare inclusive of flare combustion by-products (Unit Number 5); and
- Insignificant Sources inclusive of the 500 and 10,000-gallon diesel fuel storage tanks and two portable light towers.

The emissions calculations themselves are included in the following tables and include appropriate Greenhouse Gas (GHG) emissions as set forth in the calculation methods described in Section 6.a on the next page.

No potential emissions during startup, shutdown, and routine maintenance (SSM) are included in this application. A backup water truck is available for the primary control system water truck for Units 1 and 2 in case of an SSM event. Any potential SSM event for the controls system of Unit 3 (Unit 5 being the control unit) would be covered by the existing emissions reported. No SSM events are expected for Unit 4 as emissions from operations since all emissions are from this unit are from a continual process neither subject to malfunction nor "started up" or "shut down" at will.

For Permit Purposes

DAVID J. MEZZACAPPA 12/5/17

15236

Exp. 12/31/18

Section 6.a

Green House Gas Emissions

(Submitting under 20.2.70, 20.2.72 20.2.74 NMAC)

Title V (20.2.70 NMAC), Minor NSR (20.2.72 NMAC), and PSD (20.2.74 NMAC) applicants must estimate and report greenhouse gas (GHG) emissions to verify the emission rates reported in the public notice, determine applicability to 40 CFR 60 Subparts, and to evaluate Prevention of Significant Deterioration (PSD) applicability. GHG emissions that are subject to air permit regulations consist of the sum of an aggregate group of these six greenhouse gases: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Calculating GHG Emissions:

1. Calculate the ton per year (tpy) GHG mass emissions and GHG CO_2e emissions from your facility.
2. GHG mass emissions are the sum of the total annual tons of greenhouse gases without adjusting with the global warming potentials (GWPs). GHG CO_2e emissions are the sum of the mass emissions of each individual GHG multiplied by its GWP found in Table A-1 in 40 CFR 98 Mandatory Greenhouse Gas Reporting.
3. Emissions from routine or predictable start up, shut down, and maintenance must be included.
4. Report GHG mass and GHG CO_2e emissions in Table 2-P of this application. Emissions are reported in **short** tons per year and represent each emission unit's Potential to Emit (PTE).
5. All Title V major sources, PSD major sources, and all power plants, whether major or not, must calculate and report GHG mass and CO2e emissions for each unit in Table 2-P.
6. For minor source facilities that are not power plants, are not Title V, and are not PSD there are three options for reporting GHGs in Table 2-P: 1) report GHGs for each individual piece of equipment; 2) report all GHGs from a group of unit types, for example report all combustion source GHGs as a single unit and all venting GHGs as a second separate unit; 3) or check the following ☐ By checking this box, the applicant acknowledges the total CO2e emissions are less than 75,000 tons per year.

Sources for Calculating GHG Emissions:

- Manufacturer's Data
- AP-42 Compilation of Air Pollutant Emission Factors at http://www.epa.gov/ttn/chief/ap42/index.html
- EPA's Internet emission factor database WebFIRE at http://cfpub.epa.gov/webfire/
- 40 CFR 98 Mandatory Green House Gas Reporting except that tons should be reported in short tons rather than in metric tons for the purpose of PSD applicability.
- API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. August 2009 or most recent version.
- Sources listed on EPA's NSR Resources for Estimating GHG Emissions at http://www.epa.gov/nsr/clean-air-act-permitting-greenhouse-gases:

Global Warming Potentials (GWP):
Applicants must use the Global Warming Potentials codified in Table A-1 of the most recent version of 40 CFR 98 Mandatory Greenhouse Gas Reporting. The GWP for a particular GHG is the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 over a specified time period.

"Greenhouse gas" for the purpose of air permit regulations is defined as the aggregate group of the following six gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. **(20.2.70.7 NMAC, 20.2.74.7 NMAC).** You may also find GHGs defined in 40 CFR 86.1818-12(a).

Metric to Short Ton Conversion:
Short tons for GHGs and other regulated pollutants are the standard unit of measure for PSD and title V permitting programs. 40 CFR 98 Mandatory Greenhouse Reporting requires metric tons.
1 metric ton = 1.10231 short tons (per Table A-2 to Subpart A of Part 98 – Units of Measure Conversions)

TABLE 6.1
POTENTIAL-TO-EMIT EMISSIONS SUMMARY
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

			Potential-to-Emit Emissions			
			Uncontrolled		Controlled	
Emission Source/Description	**Units**	**Regulated Air Pollutant**	**pounds/hour**	**tons/year**	**pounds/hour**	**tons/year**
Road Particulate Emissions	001	Particulate Matter < 2.5 Microns	11.458	16.483	1.185	1.704
		Particulate Matter < 10 Microns	114.581	164.826	11.849	17.045
		Total Suspended Particulates	424.441	610.564	43.892	63.139
Landfill Earthmoving Particulate Emissions	002	Particulate Matter < 2.5 Microns	1.909	1.392	0.620	0.589
		Particulate Matter < 10 Microns	19.378	14.089	6.482	6.058
		Total Suspended Particulates	69.509	49.351	21.883	20.241
Landfill Gas Emissions[1]	003	Volatile Organic Compounds	15.504	67.909	4.616	20.217
		Hazardous Air Pollutants	3.255	14.256	0.969	4.244
		Hydrogen Sulfide	0.315	1.379	0.09	0.41
		Non-Methane Organic Compounds	39.755	174.126	11.835	51.839
Petroluem Contaminated Soils[2]	004	Volatile Organic Compounds	<4.208	<18.432	<4.208	<18.432
		Hazardous Air Pollutants	<4.208	<18.432	<4.208	<18.432
Landfill Gas Flare	005	Carbon Monoxide	20.92	91.64	20.92	91.64
		Nitrogen Dioxide	4.59	20.10	4.59	20.10
		Sulfur Dioxide	1.04	4.56	1.04	4.56
		Hazardous Air Pollutants[3]	0.53	2.32	0.53	2.32
		Particulate Matter < 2.5 Microns	0.07	0.30	0.07	0.30
		Particulate Matter < 10 Microns	0.07	0.30	0.07	0.30
		Total Suspended Particulates	0.07	0.30	0.07	0.30
Totals	**-**	**Carbon Monoxide**	**20.92**	**91.64**	**20.92**	**91.64**
		Nitrogen Dioxide	**4.59**	**20.10**	**4.59**	**20.10**
		Sulfur Dioxide	**1.04**	**4.56**	**1.04**	**4.56**
		Particulate Matter < 2.5 Microns	**13.44**	**18.18**	**1.87**	**2.59**
		Particulate Matter < 10 Microns	**134.03**	**179.22**	**18.40**	**23.40**
		Total Suspended Particulates	**494.02**	**660.22**	**65.84**	**83.68**
		Volatile Organic Compounds	**<19.71**	**<86.34**	**<8.82**	**<38.65**
		Hazardous Air Pollutants	**<7.99**	**<20.79**	**<5.71**	**<25.00**
		Hydrogen Sulfide	**0.31**	**1.38**	**0.09**	**0.41**

[1] Emissions for this unit includes fugitive landfill emissions.

[2] Emissions from the Petroluem Contaminated Soils will be limited to no more than 18.432 tons of HAPs to keep the site a minor source. VOC emissions are set equal to HAP emissions.

[3] HAPs from the Landfill Gas Flare are inclusive only of the HAPs that are combustion by-products, Mercury and HCL.

TABLE 6.2A
FUGITIVE PARTICULATE MATTER FROM UNIT 1 - PAVED ROADWAYS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Routes				
	Length of road (one-way)		Length of road (round trip)	
Reference number and Route Name	Feet	Miles	Feet	Miles
1 - Paved Disposal Route	164	0.03	328	0.06
2 - Paved Convenience Station Loop	461	0.09	921	0.17
3 - Miscellaneous Vehicles	485	0.09	970	0.18

Vehicle Miles Traveled (VMT)							
				Maximum Length of road (round trip)		VMT	
						(per day)	(per year)
Type of Vehicle	Routes Applicable	Number of Vehicles/Year	Number of Vehicles/Day	Feet	Miles	Actual	Actual
Light/Medium	1	38,563	123.20	328	0.06	7.65	2,396
Large	1	36,481	116.55	328	0.06	7.24	2,266
Roll Off Trucks	1	31,054	99.21	328	0.06	6.16	1,929
Semi-Truck	1	1,107	3.54	328	0.06	0.22	69
Water Wagon	1	3,756	12.00	328	0.06	0.75	233
Public Station Vehicles (Light/Medium)	2	3,440	10.99	921	0.17	1.92	600
Utility Vehicles	3	5,321	17.00	970	0.18	3.12	978
Supervisor Trucks	3	4,695	15.00	970	0.18	2.76	863
Totals	**-**	**124,417**	**397**	**-**	**-**	**29.8**	**9,333**

Actual Days of Operation =	313	days
Actual Closed Days =	52	days
Actual Hours of Operation/Day =	11.00	hrs/day

Assumptions:

Silt content was taken from AP-42, Table 13.2.2-1, for MSW landfills.

Mean number of days of precipitation was taken from AP-42, Figure 13.2.2-1.

Assume aerodynamic particle size is less than 10 microns.

Water truck is utilized as needed for a control efficiency of 95%

Mean vehicle weights were derived by averaging the full and empty vehicle weights.

Mean Vehicle Weight (W)	
Type of Vehicle	W (tons)
Light/Medium	1.5
Large	20
Roll Off Trucks	22.5
Semi-Truck	33.8
Water Wagon	55.5
Public Station Vehicles (Light/Medium)	1.5
Utility Vehicles	1.5
Supervisor Trucks	1.5
Weighted Avg. Vehicle Weight	**11.9**

(weighted based on vehicle miles traveled)

Methodologies:

AP-42, Section 13.2.2 for Unpaved Roads.

Example - Actual Emissions Calculation (PM10):

Calculation of total particulate fugitive emissions for vehicles on unpaved haul roads.

Uncontrolled Long-Term $E_{ext} = [k * (s/12)^a * (W/3)^b] * [(365 - p)/365]$

Uncontrolled Short-Term $E_{ext} = [k * (s/12)^a * (W/3)^b]$

TABLE 6.2A
FUGITIVE PARTICULATE MATTER FROM UNIT 1 - PAVED ROADWAYS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Variables:

Mean Silt content (s)	6.4	%	(from AP-42, Table 13.2.2-1)
# of days w/ >0.01 in. rainfall (p)	60	days/year	(from AP-42, Figure 13.2.2-1)
k factor (dimensionless) for PM2.5 =	0.15	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for PM10 =	1.5	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for TSP =	4.9	lb/VMT	(from AP-42, Table 13.2.2-2.)
a (constant) for PM2.5 and PM10 =	0.9		(from AP-42, Table 13.2.2-2.)
a (constant) for TSP =	0.7		
b (constant) =	0.45		(from AP-42, Table 13.2.2-2.)

Facility	Uncontrolled Long-Term		Uncontrolled Short-Term		
E_{ext} =	0.13	lb/VMT	0.16	lb/VMT	PM2.5
	1.32	lb/VMT	1.58	lb/VMT	PM10
	4.91	lb/VMT	5.87	lb/VMT	TSP

Obtain vehicle miles traveled (VMT) per day as follows:

VMT/day = Number of vehicles * length of roadway (round trip in miles)
= 29.82

Assume:

95% reduction in PM-10 emissions through dust suppression operations with the water truck.

Obtain long-term emissions in pounds per day as follows:

lbs/day = E * VMT / day * (1-reduction rate for dust control measures)
= 1.97

Obtain long-term emissions in pounds per hour as follows:

lbs/hour = lbs per day / operating hours per day
= 0.18

Assume:

Operating days per year = 313

Obtain long-term emissions in tons per year as follows:

tons/year = (lbs per day * operating days per year) / pounds per ton
= 0.31

SUMMARY OF PARTICULATE EMISSIONS FROM PAVED ROADWAYS

	Uncontrolled Long-Term Emissions			Uncontrolled Short-Term Emissions		
Pollutant	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	3.95	0.36	0.62	4.73	0.43	0.74
PM_{10}	39.49	3.59	6.18	47.26	4.30	7.40
TSP	146.29	13.30	22.89	175.07	15.92	27.40
	Controlled Long-Term Emissions [1]			Controlled Short-Term Emissions [1]		
Pollutant	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	0.20	0.02	0.03	0.24	0.02	0.04
PM_{10}	1.97	0.18	0.31	2.36	0.21	0.37
TSP	7.31	0.66	1.14	8.75	0.80	1.37

1 Long-Term Emissions determine the reported tons/year and the Short-Term Emissions determine the reported lbs/hr.

TABLE 6.2B
FUGITIVE PARTICULATE MATTER FROM UNIT 1 - UNPAVED ROADWAYS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Vehicle Miles Traveled (VMT)						
Type of Vehicle	Number of Vehicles/Year	Number of Vehicles/Day	Length of road (round trip)		VMT	
					(per day)	(per year)
			Feet	Miles	Actual	Actual
Light/Medium	38,563	123.20	9,876	1.87	230.45	72,130
Large	36,481	116.55	9,876	1.87	218.01	68,236
Roll Off Trucks	31,054	99.21	9,876	1.87	185.58	58,085
Semi-Truck	1,107	3.54	9,876	1.87	6.62	2,071
Water Wagon	3,756	12.00	9,876	1.87	22.45	7,025
Public Station Vehicles (Light/Medium)	3,440	10.99	0	0	0	0
Utility Vehicles [1]	-	-	-	-	10.20	3,193
Supervisor Trucks [1]	-	-	-	-	15.00	4,695
Totals	**114,401**	**365**	**-**	**-**	**688.3**	**215,435**

1 Vehicle Miles Traveled (VMT) details for utility vehicles and supervisor trucks are based on the maximum usage on-site.

Actual Days of Operation =	313	days
Actual Closed Days =	52	days
Actual Hours of Operation/Day =	11.00	hrs/day

Assumptions:

Silt content was taken from AP-42, Table 13.2.2-1, for MSW landfills.

Mean number of days of precipitation was taken from AP-42, Figure 13.2.2-1.

Assume aerodynamic particle size is less than 10 microns.

Water truck is utilized as needed for a control efficiency of 90% for unpaved disposal roads per the permit application
60% for unpaved access roads per the permit application

Weighted Average control efficiency is calculated as follows:

$$\frac{[(0.9)*[(\text{Route 1 VMT})+(0.5 * \text{Routes 2 \& 3 VMT})]+(0.6)*[(0.5*\text{Routes 2 \& 3 VMT})]]}{\text{Total VMT}}$$

Weighted Average Control Efficiency = ((0.9)*(663.09+0.5*25.2)+(0.6)*(0.5*25.2))/(688.29) = 89%

Mean vehicle weights were derived by averaging the full and empty vehicle weights.

Mean Vehicle Weight (W)	
Type of Vehicle	W (tons)
Light/Medium	1.5
Large	20
Roll Off Trucks	22.5
Semi-Truck	33.8
Water Wagon	55.5
Public Station Vehicles (Light/Medium)	1.5
Utility Vehicles 1	1.5
Supervisor Trucks 1	1.5
Weighted Avg. Vehicle Weight	**15.1**

(weighted based on vehicle miles traveled)

Methodologies:

AP-42, Section 13.2.2 for Unpaved Roads.

Example - Actual Emissions Calculation (PM10):

Calculation of total particulate fugitive emissions for vehicles on unpaved haul roads.

Uncontrolled Long-Term $E_{ext} = [k * (s/12)^a * (W/3)^b] * [(365 - p)/365]$

Uncontrolled Short-Term $E_{ext} = [k * (s/12)^a * (W/3)^b]$

Variables:

Mean Silt content (s)	6.4	%	(from AP-42, Table 13.2.2-1)
# of days w/ >0.01 in. rainfall (p)	60	days/yea	(from AP-42, Figure 13.2.2-1)
k factor (dimensionless) for PM2.5 =	0.15	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for PM10 =	1.5	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for TSP =	4.9	lb/VMT	(from AP-42, Table 13.2.2-2.)
a (constant) for PM2.5 and PM10 =	0.9		(from AP-42, Table 13.2.2-2.)
a (constant) for TSP =	0.7		
b (constant) =	0.45		(from AP-42, Table 13.2.2-2.)

Facility		Uncontrolled Long-Term		Uncontrolled Short-Term		
E_{ext}	=	0.15	lb/VMT	0.18	lb/VMT	PM2.5
		1.47	lb/VMT	1.76	lb/VMT	PM10
		5.46	lb/VMT	6.53	lb/VMT	TSP

Obtain vehicle miles traveled (VMT) per day as follows:

VMT/day = Number of vehicles * length of roadway (round trip in miles)
= 688.29

Assume:
89% reduction in PM10 emissions through dust suppression operations with the water truck.

Obtain long-term emissions in pounds per day as follows:

lbs/day = E * VMT / day
= 106.94

Obtain long-term emissions in pounds per hour as follows:

lbs/hour = lbs per day / operating hours per day
= 9.72

Assume:
Operating days per year = 313

Obtain long-term emissions in tons per year as follows:

tons/year = (lbs per day * operating days per year) / pounds per ton
= 16.74

SUMMARY OF PARTICULATE EMISSIONS FROM UNPAVED ROADWAYS						
	Uncontrolled Long-Term Emissions			Uncontrolled Short-Term Emissions		
Pollutant	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
PM$_{2.5}$	101.37	9.22	15.86	121.31	11.03	18.99
PM$_{10}$	1013.71	92.16	158.65	1213.13	110.28	189.85
TSP	3755.07	341.37	587.67	4493.78	408.53	703.28
	Controlled Long-Term Emissions [1]			Controlled Short-Term Emissions [1]		
Pollutant	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
PM$_{2.5}$	10.69	0.97	1.67	12.80	1.16	2.00
PM$_{10}$	106.94	9.72	16.74	127.98	11.63	20.03
TSP	396.13	36.01	61.99	474.06	43.10	74.19

[1] Per the permit, Long-Term Emissions determine the reported tons/year and the Short-Term Emissions determine the reported lbs/hr.

TABLE 6.3A
PARTICULATE EMISSIONS FROM UNIT 2 - MOTOR GRADER, COMPACTOR, BULLDOZER OPERATIONS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Emission Source:
Earthmoving and Landfilling Operation Emissions
This spreadsheet is divided into two sections for Grading Operations and Dozer/Compactor Operations.
This list of equipment below represents PTE calculations in 2080 and were conservatively based on data provided by site personnel.
All equations taken from AP-42, Table 11.9-1.

Bulldozing Operations (Inclusive of Dozers and Compactors)

The emissions factors this operation in lbs/hr are based on the following

	TSP:	PM10:	PM2.5:
	$\frac{5.7*(s)^{1.2}}{(M)^{1.3}}$	$\frac{0.75*(s)^{1.5}}{(M)^{1.4}}$	$\frac{0.105*(s)^{1.2}}{(M)^{1.3}}$

where s = material silt content (%) and M = material moisture content (%) and assuming s = 0.5% and M = 15%

Therefore the emission factors for this operation are: 0.0734 (TSP), 0.0060 (PM10), and 0.0008 (PM2.5) [lbs/hr]
The equipment is expected to run a maximum of 6,886 hours per year.

Therefore PM2.5 emissions are as follows: 1*0.0008 lbs/hr)*(6,886 hours/yr)*(1 ton/2000 lbs) =	0.003 tons/year	0.001 lbs/hr
Therefore PM10 emissions are as follows: 1*0.0060 lbs/hr)*(6,886 hours/yr)*(1 ton/2000 lbs) =	0.02 tons/year	0.01 lbs/hr
Therefore TSP emissions are as follows: 1*0.0734 lbs/hr)*(6,886 hours/yr)*(1 ton/2000 lbs) =	0.25 tons/year	0.07 lbs/hr

Grading Operations (Inclusive of 1 Grading Dozer)

The emissions factors this operation in lbs/VMT are based on the following equations:

	TSP:	PM10:	PM2.5:
	$0.040*(S)^{2.5}$	$0.60*0.051*(S)^{2.0}$	$0.031*0.051*(S)^{2.5}$

where S = mean vehicle speed (mph) and assuming S = 3.0 mph

Therefore the emission factors for this operation is: 0.6235 (TSP), 0.2754 (PM10), and 0.0142 (PM2.5) [lbs/VMT]
The equipment is expected to run a maximum of 1,252 hours per year at an efficiency of 0.75%.

Therefore PM2.5 emissions are as follows: 1*(0.0142 lbs/VMT)*(1,252 hours/yr)*(0.75%)*(3.0 mph)*(1 ton/2000 lbs) =	0.02 tons/year	0.03 lbs/hr
Therefore PM10 emissions are as follows: 1*(0.2754 lbs/VMT)*(1,252 hours/yr)*(0.75%)*(3.0 mph)*(1 ton/2000 lbs) =	0.39 tons/year	0.62 lbs/hr
Therefore TSP emissions are as follows: 1*(0.6235 lbs/VMT)*(1,252 hours/yr)*(0.75%)*(3.0 mph)*(1 ton/2000 lbs) =	0.88 tons/year	1.40 lbs/hr

Emissions	tons/year	lbs/hr
Total PM2.5 Emissions From Earthmoving =	**0.02**	**0.03**
Total PM10 Emissions From Earthmoving =	**0.41**	**0.63**
Total TSP Emissions From Earthmoving =	**1.13**	**1.48**

TABLE 6.3B
FUGITIVE EMISSIONS FROM UNIT 2 - SCRAPER OPERATIONS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Emission Source:
Scraper Travel

		One-Way Length		Roundtrip Length		VMT	
Route	Trips per day	Feet	Mile	Feet	Mile	Per Day	Per Year
Disposal Area on Disposal Route	30	1185	0.22	2370	0.45	13.47	140
Daily Cover Soil Borrow Area on Access Roads	30	615	0.12	1230	0.23	6.99	73
Total	**30**	**-**	**-**	**-**	**-**	**20.45**	**213**

Days of Operation =	313	days
Closed Days =	52	days
Scraper Hours of Operation/Day =	4.00	hrs/day

Assumptions:

Silt content was taken from AP-42, Table 13.2.2-1, for MSW landfills.

Mean number of days of precipitation was taken from AP-42, Figure 13.2.2-1.

Assume aerodynamic particle size is less than 10 microns.

Water truck is utilized as needed for a control efficiency of 90% for unpaved disposal roads per the permit application
60% for unpaved access roads per the permit application

Weighted Average control efficiency is calculated as follows:

[(0.9)*(Disposal Route VMT)+(0.6)*[Access Roads VMT)
Total VMT 79.75%

Mean vehicle weights were derived by averaging the full and empty vehicle weights.

Mean Vehicle Weight (W)
W (tons) = 52.2

Methodologies:
AP-42, Section 13.2.2 for Unpaved Roads.

Example - Actual Emissions Calculation (PM10):

Calculation of total particulate fugitive emissions for vehicles on unpaved haul roads.

Uncontrolled Long-Term $E_{ext} = [k * (s/12)^a * (W/3)^b] * [(365 - p)/365]$

Uncontrolled Short-Term $E_{ext} = [k * (s/12)^a * (W/3)^b]$

Variables:

Mean Silt content (s)	6.4	%	(from AP-42, Table 13.2.2-1)
# of days w/ >0.01 in. rainfall (p)	60	days/year	(from AP-42, Figure 13.2.2-1)
k factor (dimensionless) for PM2.5 =	0.15	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for PM10 =	1.5	lb/VMT	(from AP-42, Table 13.2.2-2.)
k factor (dimensionless) for TSP =	4.9	lb/VMT	(from AP-42, Table 13.2.2-2.)
a (constant) for PM2.5 and PM10 =	0.9		(from AP-42, Table 13.2.2-2.)
a (constant) for TSP =	0.7		
b (constant) =	0.45		(from AP-42, Table 13.2.2-2.)

Facility		Uncontrolled Long-Term		Uncontrolled Short-Term		
E_{ext}	=	0.26	lb/VMT	0.31	lb/VMT	PM2.5
		2.57	lb/VMT	3.08	lb/VMT	PM10
		9.54	lb/VMT	11.41	lb/VMT	TSP

Obtain vehicle miles traveled (VMT) per day as follows:

VMT/day = Number of vehicles * length of roadway (round trip in miles)
= 20.45

Obtain long-term emissions in pounds per day as follows:

lbs/day = E * VMT / day
= 52.65

Obtain long-term emissions in pounds per hour as follows:

lbs/hour = lbs per day / operating hours per day
= 13.16

Assume:

Operating days per year = 313

TABLE 6.3B
FUGITIVE EMISSIONS FROM UNIT 2 - SCRAPER OPERATIONS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Obtain long-term emissions in tons per year as follows:

tons/year = (lbs per day * operating days per year) / pounds per ton
= 8.24

Summary of particulate emissions from Scraper Travels

Pollutant	Uncontrolled Long-Term Emissions			Uncontrolled Short-Term Emissions		
	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	5.27	1.32	0.82	6.30	1.58	0.99
PM_{10}	52.65	13.16	8.24	63.01	15.75	9.86
TSP	195.05	48.76	30.52	233.42	58.35	36.53
	Controlled Long-Term Emissions			Controlled Short-Term Emissions		
Pollutant	lbs/day	lbs/hr	tons/yr	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	1.07	0.27	0.17	1.28	0.32	0.20
PM_{10}	10.66	2.67	1.67	12.76	3.19	2.00
TSP	39.50	9.87	6.18	47.27	11.82	7.40

Emission Source:
Scraper Loading

The following uncontrolled emissions for scraper loading at the Daily cover Soil Borrow Area was estimated through application of emission factors presented in AP-42, Section 11.9, Western

E_{TSP} = 0.058 lbs/ton of soil loaded (Table 11.9-4)

The emission factors for PM10 and PM2.5 were calculated by applying the ratio of the PM10 and PM2.5 to the TSP particle size multiplier (k) values, obtained from AP-42, Section 13.2.2.2, to the TSP emission factor of 0.058 lbs/ton of soil loaded.

E_{PM10} = (1.5/4.9)*E_{TSP} = 0.31*0.058 = 0.018 lbs/ton of soil loaded
$E_{PM2.5}$ = (0.15/4.9)*E_{TSP} = 0.031*0.058 = 0.0018 lbs/ton of soil loaded

Number of Scraper loads per day =	25	loads/day
Scraper capacity =	15	yd^3/load
Soil density =	1.2	tons/yd^3
Mass of soil loaded per day =	450	tons/day
Operating days in year =	313	days
Mass of soil loaded in year =	140,850	tons
Control Efficiency	0	%

Summary of particulate emissions from Scraper Loading

Pollutant	Emissions		
	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	0.81	0.20	0.13
PM_{10}	8.10	2.03	1.27
TSP	26.10	6.53	4.08

Emission Source:
Scraper Unloading

Stockpile Area or Disposal Area. Equation (1) from Section 13.2.4 is used to calculate TSP and PM_{10} emissions.

$$E = \frac{(k)(0.0032)(U/5)^{1.3}}{(M/2)^{1.4}}$$ (AP-42, 13.2.4.3, equation (1))

E = size-specific emission factor (lbs/ton of material unloaded)
k = particle size multiplier (dimensionless)

k_{TSP} =	0.74	(AP-42, 13.2.4.3)
k_{PM10} =	0.35	(AP-42, 13.2.4.3)
$k_{PM2.5}$ =	0.053	(AP-42, 13.2.4.3)
U = mean wind speed (mph) =	10	(Santa Teresa Airport)
M = soil moisture content (%) =	12	(AP-42, Table 13.2.4-1)

ETSP = 0.000475 lbs/ton of soil unloaded
EPM10 = 0.000224 lbs/ton of soil unloaded
EPM2.5 = 0.000034 lbs/ton of soil unloaded

Mass of soil unloaded in year = 140,850 tons

Summary of particulate emissions from Scraper Unloading

Pollutant	Emissions		
	lbs/day	lbs/hr	tons/yr
$PM_{2.5}$	0.015	0.004	0.002
PM_{10}	0.101	0.025	0.016
TSP	0.214	0.053	0.033

TABLE 6.3C
FUGITIVE EMISSIONS FROM UNIT 2 - WIND EROSION EMISSIONS
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Emission Source:
Wind Erosion

The emission factor for TSP is obtained from AP-42, Section 11.9 (Table 11.9-4) and Section 13.2.2.2:

E_{TSP} = 0.38 tons/acre (Table 11.9-4)

The emission factor for PM10 was calculated by applying the ratio of the PM 10 and TSP particle size multiplier (k) values, obtained from Ap-42, Section 13.2.2.2, to the TSP emission factor of 0.38 ton/acre:

$E_{PM10} = (1.5/4.9)E_{TSP} =$ 0.12 tons/acre
$E_{PM2.5} = (0.15/4.9)E_{TSP} =$ 0.012 tons/acre

Days in Year	365	days
Hours in Year	8,760	hours

Area	Length (feet)	Width (feet)	Area (acre)	TSP		PM_{10}		$PM_{2.5}$		Control Efficiency	TSP		PM_{10}		$PM_{2.5}$	
				lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr		lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
Disposal Route [1]	5,620	32.8	4.2	0.367	1.608	0.112	0.492	0.011	0.049	90%	0.037	0.161	0.011	0.049	0.001	0.005
Access Roads [1]	18,858	20	8.7	0.751	3.290	0.230	1.007	0.023	0.101	60%	0.300	1.316	0.092	0.403	0.009	0.040
Maintenance Compound	-	-	1.4	0.121	0.532	0.037	0.163	0.004	0.016	60%	0.049	0.213	0.015	0.065	0.001	0.007
Landfill Office Parking Area	-	-	4.5	0.390	1.710	0.120	0.523	0.012	0.052	60%	0.156	0.684	0.048	0.209	0.005	0.021
Auxiliary Roads [1]	6,404	20	2.9	0.255	1.117	0.078	0.342	0.008	0.034	0%	0.255	1.117	0.078	0.342	0.008	0.034
Disposal Area	-	-	5	0.434	1.900	0.133	0.582	0.013	0.058	0%	0.434	1.900	0.133	0.582	0.013	0.058
Daily Cover Soil Borrow Area	-	-	9	0.781	3.420	0.239	1.047	0.024	0.105	0%	0.781	3.420	0.239	1.047	0.024	0.105
Total	**-**	**-**	**35.7**	**3.0999**	**13.5776**	**0.9490**	**4.1564**	**0.0949**	**0.4156**	65%	**2.0116**	**8.8110**	**0.6158**	**2.6972**	**0.0616**	**0.2697**

[1] Average width of landfill roads are 32.8 ft (10 m) and the conversion from ft^2 to acre is 43,560 ft^2/acre.

TABLE 6.4
EMISSIONS FROM UNITS 3 & 5 - LANDFILL & FLARE STACK
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

A	B	C	D	E	F	G	H	I
			EMISSIONS ESTIMATES					
Pollutant	Molecular Weight (g/Mol)	Average Concentration Found In LFG (ppmv) (2)	LFG Generation (tons/yr) (3)	LFG to Open Flare (tons/yr) (4)	Open Flare Control Efficiency (5)	LFG Emissions from Open Flare (tons/yr) (6)	Total Landfill Emissions (No Flaring in 2018) (tons/yr) (12)	Total Landfill Emissions (No Flaring in 2018) (lb/hr)
Hazardous Air Pollutants (HAPs) (1)								
1,1,1-Trichloroethane (methyl chloroform)	133.41	0.168	0.045	0.034	98.0%	0.0007	0.013	0.003
1,1,2,2-Tetrachloroethane	167.85	0.070	0.024	0.018	98.0%	0.0004	0.007	0.002
1,1-Dichloroethane (ethylidene dichloride)	98.97	0.741	0.148	0.111	98.0%	0.0022	0.044	0.010
1,1-Dichloroethene (vinylidene chloride)	96.94	0.092	0.018	0.014	98.0%	0.0003	0.005	0.001
1,2-Dichloroethane (ethylene dichloride)	98.96	0.120	0.024	0.018	98.0%	0.0004	0.007	0.002
1,2-Dichloropropane (propylene dichloride)	112.99	0.023	0.005	0.004	98.0%	0.0001	0.002	0.000
Acrylonitrile	53.06	0.036	0.004	0.003	99.7%	0.00001	0.001	0.000
Benzene	78.11	0.972	0.154	0.115	99.7%	0.00035	0.046	0.010
Carbon disulfide	76.13	0.320	0.049	0.037	99.7%	0.0001	0.015	0.003
Carbon tetrachloride	153.84	0.007	0.002	0.002	98.0%	0.00003	0.001	0.000
Carbonyl sulfide	60.07	0.183	0.022	0.017	99.7%	0.0001	0.007	0.002
Chlorobenzene	112.56	0.227	0.052	0.039	98.0%	0.0008	0.015	0.004
Chloroethane (ethyl chloride)	64.52	0.239	0.031	0.023	98.0%	0.0005	0.009	0.002
Chloroform	119.39	0.021	0.005	0.004	98.0%	0.0001	0.002	0.000
Chloromethane (methyl chloride)	50.49	0.249	0.025	0.019	98.0%	0.0004	0.008	0.002
Dichlorobenzene (1,4-Dichlorobenzene)	147.00	1.607	0.478	0.358	98.0%	0.0072	0.142	0.032
Dichloromethane (Methylene Chloride)	84.94	3.395	0.583	0.438	98.0%	0.0088	0.174	0.040
Ethylbenzene	106.16	6.789	1.458	1.094	99.7%	0.0033	0.434	0.099
Ethylene dibromide (1,2-Dibromoethane)	187.88	0.046	0.017	0.013	98.0%	0.0003	0.005	0.001
Hexane	86.18	2.324	0.405	0.304	99.7%	0.0009	0.121	0.028
Mercury*	200.61	2.92E-04	-	-	-	0.00009	-	-
Methyl ethyl ketone	72.11	10.557	1.540	1.155	99.7%	0.0035	0.459	0.105
Methyl isobutyl ketone	100.16	0.750	0.152	0.114	99.7%	0.0003	0.045	0.010
Perchloroethylene (tetrachloroethylene)	165.83	1.193	0.400	0.300	98.0%	0.0060	0.119	0.027
Toluene	92.13	25.400	4.734	3.551	99.7%	0.0107	1.409	0.322
Trichloroethylene (trichloroethene)	131.40	0.681	0.181	0.136	98.0%	0.0027	0.054	0.012
Vinyl chloride	62.50	1.077	0.136	0.102	98.0%	0.0020	0.041	0.009
Xylenes	106.16	16.582	3.561	2.671	99.7%	0.0080	1.060	0.242
Hydrochloric Acid (HCl) (7)	36.45	42.000	-	-	-	2.3229	-	-
Total HAPs	**-**	**-**	**14.256**	**10.692**	**-**	**2.383**	**4.244**	**0.969**
Criteria Air Pollutants								
Total VOCs (8)	86.18	389.5	67.909	50.932	99.2%	0.407	20.22	4.62
Sulfur Dioxide (SO_2) (7)	64.1	46.9	-	-	-	4.559	-	-
Carbon Monoxide (CO) (10)	-	-	-	-	-	91.643	-	-
Nitrogen Oxides (NO_x) (10)	-	-	-	-	-	20.102	-	-
Particulates (PM_{10}) (10)	-	-	-	-	-	0.301	-	-
Other Regulated Air Pollutants								
Ethane	30.07	889	54.081	40.561	99.7%	0.122	16.10	3.68
Hydrogen sulfide (13)	34.08	20.0	1.379	-	-	-	0.41	0.09
NMOCs as Hexane (9)	86.18	999	174.126	130.594	99.2%	1.045	51.84	11.84

NOTES TO TABLE 6.4:

(1) Listed Hazardous Air Pollutants (HAPs) are among compounds commonly found in landfill gas (LFG), as presented in AP-42, Tables 2.4-1and 2.4-2.

(2) Average concentrations of pollutants in LFG are based on Waste Industry Air Coalition Values, except Mercury (marked with an *), which use a value listed on AP-42, Table 2.4-1.

(3) Based on average concentrations of compounds found in LFG and an estimated LFG generation of 2,964 scfm (2082), based on EPA's LandGEM 3.02 and calibrated on-site recovery using the site-specific k value from the 1999 Tier 3 Testing (0.007 1/year) and Lo value recommended in AP-42 (100 m3/Mg).

(4) The percentage of LFG generated that is assumed collected and routed to the flare.

(5) Typical control efficiency for flares, as found in AP-42, Table 2.4-3.

(6) (LFG to flare) * (1-control efficiency) = LFG emissions from flare.

(7) Concentrations of HCl and SO2 are from AP-42, Section 2.4.4.

(8) According to AP-42, Table 2.4-2, Note C, VOC content at MSW sites with no co-disposal equals 39% by weight of total NMOC concentration.

(9) Based on site-specific NMOC concentration from 2016 Tier 2 sampling (SCS Engineers).

(10) Open Flare Emission factors for PM10 (in lb/hr/dscfm CH4) are from AP-42, Table 2.4-5. Emission factors for CO and NOx (in lb/mmBtu) are from AP-42 section on industrial flares.

(11) Fugitive Landfill Emissions represent the 25% of generation that cannot be reasonably collected per EPA guidance and AP-42 collection efficiency guidance.

(12) Maximum landfill emissions are based on the scenario of no GCCS operation through 2018 prior to the landfill being subject to the control requirements of NSPS, Subpart WWW. Based on the estimated LFG generation of 882.5 (2018), based on EPA's LandGEM 3.02 and calibrated on-site recover using the site-specific k value from the 1999 Tier 3 Testing (0.007 1/year) and Lo value recommended in AP-42 (100 m3/Mg).

(13) Concentration of Hydrogen Sulfide based on the latest site-specific gas component analysis is 1.3 ppmv. However the concentration is set to 20 ppmv for conservativeness.

TABLE 6.4
EMISSIONS FROM UNITS 3 & 5 - LANDFILL & FLARE STACK
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

MODEL INPUT VARIABLES:

Methane Content of LFG assumed to be	50.0%	based on a 1,012 Btu/scf heating value of methane
Collection Efficiency (4)	75.0%	
Maximum Landfill Gas Generation Rate in 2082 (3)	2,964	scfm
Landfill Gas Generation Rate in 2018 (12)	882	scfm
Landfill Gas To Open Flare	2,223	scfm

OPEN FLARE EMISSIONS FACTORS:

Pollutant	Emissions factor (10)	
CO	0.3100	lb/MMBtu
NO_x	0.0680	lb/MMBtu
PM	0.0010	lb/hr/dscfm

EXAMPLE CALCULATIONS

(HAPs, VOCs, NMOCs)

LFG Generation [tons/year] = (Molecular Weight of Compound[g/mol])*(Concentration of Compound[ppm]/1,000,000)*(LFG Generation Rate [cfm])
(525,600 min/yr)(1ton/2,000lb)*(1lb/453.6g)*(1mol/24.04L @ STP)*(28.32L/1cf)

LFG To Flare = (Molecular Weight of Compound[g/mol])*(Concentration of Compound[ppm]/1,000,000)*(LFG to Flare [cfm])
(525,600 min/yr)(1ton/2,000lb)*(1lb/453.6g)*(1mol/24.04L @ STP)*(28.32L/1cf)

LFG Emissions From Flare = (LFG To Flare [tons/yr])*(1 - Control Efficiency)

Emissions From Landfill = (LFG Generation [tons/year])

(SO_2, HCl)

LFG Emissions from Flare = (Molecular Weight of Compound[g/mol])*(Concentration of Compound[ppm]/1,000,000)*(LFG to Flare [cfm])
(525,600 min/yr)(1ton/2,000lb)*(1lb/453.6g)*(1mol/24.04L @ STP)*(28.32L/1cf)

(CO, NO_x)

LFG Emissions from Flare = (Methane Flow Rate to Flare [cfm])*(Emission Factor)*(1,012 Btu / cubic ft of methane)

(PM)

LFG Emissions from Flare = (Methane Flow Rate to Flare [cfm])*(Emission Factor)

TABLE 6.5
GHG EMISSIONS FROM UNITS 3 & 5 - LANDFILL & FLARE STACK
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Estimated Uncontrolled Landfill Gas GHG Emissions
Camino Real Landfill - Emissions Unit 3

A	Total CH4 Generation (2018 prior to NSPS Controls)	4,381	Mg/yr
B	Percent of Fugitive Landfill Gas	25%	
C	Tons/Mg	1.102	tons/Mg
D	Total Fugitive CH4 Generation	1,207	tons/yr
E	Total Non-Fugitive CH4 Generation	3,622	tons/yr
F	Oxidation Factor	10%	
G	Non-Fugitive CH4 Oxidized Through Cover	362	tons/yr
H	Total Non-Fugitive CH4 Emissions	3,260	tons/yr
I	CO2e Conversion	25	ton CO2/ton CH4
J	Total Non-Fugitive Anthropogenic CH4 Emissions	**81,495**	**tons/yr CO2e**
K	Total CO2 Generation (2018 prior to NSPS Controls)	12,021	Mg/yr
L	Total Fugitive CO2 Generation	3,313	tons/yr
M	Total Non-Fugitive CO2 Generation	9,938	tons/yr
N	Oxidized CH4 to CO2 Conversion Factor	2.75	
O	Non-Fugitive CO2 Emitted Through Cover (Oxidized CH4)	996	tons/yr
P	Total Non-Fugitive Biogenic CO2 Emissions	**10,934**	**tons/yr**

Estimated Controlled Landfill Gas GHG Emissions
Camino Real Landfill - Emissions Unit 5

A	Flare Throughput =	2,223	cfm
B	Flare Throughput =	1168.473508	mmscf
C	Flare Methane Throughput =	584.2367542	mmscf
D	Flare Carbon Dioxide Throughput =	584.2367542	mmscf
E	Heat Rate =	67.49	MMBTU/hr
F	Combustion CO2 =	30,786	metric tpy
G	Passthrough CO2 =	30,739	metric tpy
H	Total Biogenic CO2 =	61,526	metric tpy
I	Total Biogenic CO2 =	**67,820**	**tons/yr**
J	Total Anthropogenic N2O =	0.372	metric tpy
K	Total Anthropogenic N2O =	0.411	tons/yr
L	Total Anthropogenic CH4 =	1.892	metric tpy
M	Total Anthropogenic CH4 =	2.086	tons/yr
N	Global Warming Potential of N2O =	298	
O	Global Warming Potential of CH4 =	25	
P	Total Anthropogenic Emissions =	**174.50**	**tpy CO2e**

TABLE 6.6
INSIGNIFICANT ACTIVITIES
CAMINO REAL LANDFILL
SUNLAND PARK, NEW MEXICO

Diesel Fuel Storage Tank

Tank Contents	Capacity (gallons)	Maximum Annual Throughput (gallons/year) [1]	Emissions	
			lb/yr	tpy
Diesel	500	1,000,000	24.95	0.012
Diesel	10,000	1,000,000	31.62	0.016

The VOC emissions from the storage tanks were estimated using the TANKS 4.0.9d model. The output files from the TANKS models are included in Appendix 7-7.

Light Plants

Regulated Pollutants for each 8-HP Diesel Engine	Engine Rating (hp)	Actual Hours of Operation (hrs/yr)	Emissions Factor (lb/hp-hr)	Actual Emissions (tons/yr)
NO_x	8	624	0.031	0.077

Emissions factorfor NOx is from AP-42, Table 3.3-1. Emissions are below the 25 tons/year NOx threshold for 200-hp engines.

Section 7

Information Used To Determine Emissions

<u>Information Used to Determine Emissions</u> shall include the following:

☐ If manufacturer data are used, include specifications for emissions units <u>and</u> control equipment, including control efficiencies specifications and sufficient engineering data for verification of control equipment operation, including design drawings, test reports, and design parameters that affect normal operation.
☐ If test data are used, include a copy of the complete test report. If the test data are for an emissions unit other than the one being permitted, the emission units must be identical. Test data may not be used if any difference in operating conditions of the unit being permitted and the unit represented in the test report significantly effect emission rates.
☑ If the most current copy of AP-42 is used, reference the section and date located at the bottom of the page. Include a copy of the page containing the emissions factors, and clearly mark the factors used in the calculations.
☐ If an older version of AP-42 is used, include a complete copy of the section.
☐ If an EPA document or other material is referenced, include a complete copy.
☐ Fuel specifications sheet.
☑ If computer models are used to estimate emissions, include an input summary (if available) and a detailed report, and a disk containing the input file(s) used to run the model. For tank-flashing emissions, include a discussion of the method used to estimate tank-flashing emissions, relative thresholds (i.e., permit or major source (NSPS, PSD or Title V)), accuracy of the model, the input and output from simulation models and software, all calculations, documentation of any assumptions used, descriptions of sampling methods and conditions, copies of any lab sample analysis.

Multiple sources of equipment and activity-specific data, equations and emissions factors were used in determining potential emissions produced by activities at CRLF. Information used to determine emissions is included in the following attachments:

- Attachment 7.1 – AP-42, Section 13.2.2 Unpaved Roads;
- Attachment 7.2 – AP-42, Section 11.9 Western Surface Coal Mining;
- Attachment 7.3 – AP-42, Section 13.2.4 Aggregate Handling and Storage Piles;
- Attachment 7.4 – AP-42, Section 2.4 Municipal Solid Waste Landfills;
- Attachment 7.5 – Waste Industry Air Coalition Values;
- Attachment 7.6 – LandGEM Model Output for Landfill Gas Generation (done in two parts due to site life since each model can only process 80 years);
- Attachment 7.7 – TANKs 4.09D Model Outputs for Diesel Tanks;
- Attachment 7.8 – AP-42, Section 3.3 Gasoline and Diesel Industrial Engines;
- Attachment 7.9 – Heavy Equipment Manufacturer's Specification Sheets;
- Attachment 7.10 – AP-42, Section 13.5 Industrial Flares;
- Attachment 7.11 – Dust Control Plan; and
- Attachment 7.12 – Site-Specific Hydrogen Sulfide Analysis.

ATTACHMENT 7.1

AP-42, SECTION 13.2.2 UNPAVED ROADS

13.2.2 Unpaved Roads

13.2.2.1 General

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

The particulate emission factors presented in the previous draft version of this section of AP-42, dated October 2001, implicitly included the emissions from vehicles in the form of exhaust, brake wear, and tire wear as well as resuspended road surface material[25]. EPA included these sources in the emission factor equation for unpaved public roads (equation 1b in this section) since the field testing data used to develop the equation included both the direct emissions from vehicles and emissions from resuspension of road dust.

This version of the unpaved public road emission factor equation only estimates particulate emissions from resuspended road surface material [23, 26]. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2 [24]. This approach eliminates the possibility of double counting emissions. Double counting results when employing the previous version of the emission factor equation in this section and MOBILE6.2 to estimate particulate emissions from vehicle traffic on unpaved public roads. It also incorporates the decrease in exhaust emissions that has occurred since the unpaved public road emission factor equation was developed. The previous version of the unpaved public road emission factor equation includes estimates of emissions from exhaust, brake wear, and tire wear based on emission rates for vehicles in the 1980 calendar year fleet. The amount of PM released from vehicle exhaust has decreased since 1980 due to lower new vehicle emission standards and changes in fuel characteristics.

13.2.2.2 Emissions Calculation And Correction Parameters[1-6]

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on source parameters that characterize the condition of a particular road and the associated vehicle traffic. Characterization of these source parameters allow for "correction" of emission estimates to specific road and traffic conditions present on public and industrial roadways.

Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 micrometers [µm] in diameter) in the road surface materials.[1] The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200-mesh screen, using the ASTM-C-136 method. A summary of this method is contained in Appendix C of AP-42. Table 13.2.2-1 summarizes measured silt values for industrial unpaved roads. Table 13.2.2-2 summarizes measured silt values for public unpaved roads. It should be noted that the ranges of silt content vary over two orders of magnitude. Therefore, the use of data from this table can potentially introduce considerable error. Use of this data is strongly discouraged when it is feasible to obtain locally gathered data.

Since the silt content of a rural dirt road will vary with geographic location, it should be measured for use in projecting emissions. As a conservative approximation, the silt content of the parent soil in the area can be used. Tests, however, show that road silt content is normally lower than in the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles.

Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight. On the other hand, there is far less variability in the weights of cars and pickup trucks that commonly travel publicly accessible unpaved roads throughout the United States. For those roads, the moisture content of the road surface material may be more dominant in determining differences in emission levels between, for example a hot, desert environment and a cool, moist location.

The PM-10 and TSP emission factors presented below are the outcomes from stepwise linear regressions of field emission test results of vehicles traveling over unpaved surfaces. Due to a limited amount of information available for PM-2.5, the expression for that particle size range has been scaled against the result for PM-10. Consequently, the quality rating for the PM-2.5 factor is lower than that for the PM-10 expression.

Table 13.2.2-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIAL ON INDUSTRIAL UNPAVED ROADS[a]

Industry	Road Use Or Surface Material	Plant Sites	No. Of Samples	Silt Content (%)	
				Range	Mean
Copper smelting	Plant road	1	3	16 - 19	17
Iron and steel production	Plant road	19	135	0.2 - 19	6.0
Sand and gravel processing	Plant road	1	3	4.1 - 6.0	4.8
	Material storage area	1	1	-	7.1
Stone quarrying and processing	Plant road	2	10	2.4 - 16	10
	Haul road to/from pit	4	20	5.0-15	8.3
Taconite mining and processing	Service road	1	8	2.4 - 7.1	4.3
	Haul road to/from pit	1	12	3.9 - 9.7	5.8
Western surface coal mining	Haul road to/from pit	3	21	2.8 - 18	8.4
	Plant road	2	2	4.9 - 5.3	5.1
	Scraper route	3	10	7.2 - 25	17
	Haul road (freshly graded)	2	5	18 - 29	24
Construction sites	Scraper routes	7	20	0.56-23	8.5
Lumber sawmills	Log yards	2	2	4.8-12	8.4
Municipal solid waste landfills	Disposal routes	4	20	2.2 - 21	6.4

[a] References 1,5-15.

The following empirical expressions may be used to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT):

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$E = k\ (s/12)^a (W/3)^b \tag{1a}$$

and, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions may be estimated from the following:

$$E = \frac{k\ (s/12)^a (S/30)^d}{(M/0.5)^c} - C \tag{1b}$$

where k, a, b, c and d are empirical constants (Reference 6) given below and

E = size-specific emission factor (lb/VMT)
s = surface material silt content (%)
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The source characteristics s, W and M are referred to as correction parameters for adjusting the emission estimates to local conditions. The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows:

1 lb/VMT = 281.9 g/VKT

The constants for Equations 1a and 1b based on the stated aerodynamic particle sizes are shown in Tables 13.2.2-2 and 13.2.2-4. The PM-2.5 particle size multipliers (k-factors) are taken from Reference 27.

Table 13.2.2-2. CONSTANTS FOR EQUATIONS 1a AND 1b

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 13.2.2-2 also contains the quality ratings for the various size-specific versions of Equation 1a and 1b. The equation retains the assigned quality rating, if applied within the ranges of source conditions, shown in Table 13.2.2-3, that were tested in developing the equation:

Table 13.2.2-3. RANGE OF SOURCE CONDITIONS USED IN DEVELOPING EQUATION 1a AND 1b

Emission Factor	Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
		Mg	ton	km/hr	mph		
Industrial Roads (Equation 1a)	1.8-25.2	1.8-260	2-290	8-69	5-43	4-17[a]	0.03-13
Public Roads (Equation 1b)	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

[a] See discussion in text.

As noted earlier, the models presented as Equations 1a and 1b were developed from tests of traffic on unpaved surfaces. Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering, because of traffic-enhanced natural evaporation. (Factors influencing how fast a road dries are discussed in Section 13.2.2.3, below.) The quality ratings given above pertain to the mid-range of the measured source conditions for the equation. A higher mean vehicle weight and a higher than normal traffic rate may be justified when performing a worst-case analysis of emissions from unpaved roads.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [23]. The emission factor also varies with aerodynamic size range as shown in Table 13.2.2-4

Table 13.2.2-4. EMISSION FACTOR FOR 1980'S VEHICLE FLEET EXHAUST, BRAKE WEAR AND TIRE WEAR

Particle Size Range[a]	*C*, Emission Factor for Exhaust, Brake Wear and Tire Wear[b] lb/VMT
$PM_{2.5}$	0.00036
PM_{10}	0.00047
PM_{30}[c]	0.00047

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are pounds per vehicle mile traveled (lb/VMT).

[c] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

It is important to note that the vehicle-related source conditions refer to the average weight, speed, and number of wheels for all vehicles traveling the road. For example, if 98 percent of traffic on the road are 2-ton cars and trucks while the remaining 2 percent consists of 20-ton trucks, then the mean weight is 2.4 tons. More specifically, Equations 1a and 1b are *not* intended to be used to calculate a separate emission factor for each vehicle class within a mix of traffic on a given unpaved road. That is, in the example, one should *not* determine one factor for the 2-ton vehicles and a second factor for the 20-ton trucks. Instead, only one emission factor should be calculated that represents the "fleet" average of 2.4 tons for all vehicles traveling the road.

Moreover, to retain the quality ratings when addressing a group of unpaved roads, it is necessary that reliable correction parameter values be determined for the road in question. The field and laboratory procedures for determining road surface silt and moisture contents are given in AP-42 Appendices C.1 and C.2. Vehicle-related parameters should be developed by recording visual observations of traffic. In some cases, vehicle parameters for industrial unpaved roads can be determined by reviewing maintenance records or other information sources at the facility.

In the event that site-specific values for correction parameters cannot be obtained, then default values may be used.In the absence of site-specific silt content information, an appropriate mean value from Table 13.2.2-1 may be used as a default value, but the quality rating of the equation is reduced by two letters. Because of significant differences found between different types of road surfaces and between different areas of the country, use of the default moisture content value of 0.5 percent in Equation 1b is discouraged. The quality rating should be downgraded two letters when the default moisture content value is used. (It is assumed that readers addressing industrial roads have access to the information needed to develop average vehicle information in Equation 1a for their facility.)

The effect of routine watering to control emissions from unpaved roads is discussed below in Section 13.2.2.3, “Controls”. However, all roads are subject to some natural mitigation because of rainfall and other precipitation. The Equation 1a and 1b emission factors can be extrapolated to annual average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm [0.01 inch]) precipitation:

$$E_{ext} = E\ [(365 - P)/365] \tag{2}$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor from Equation 1a or 1b

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation (see below)

Figure 13.2.2-1 gives the geographical distribution for the mean annual number of "wet" days for the United States.

Equation 2 provides an estimate that accounts for precipitation on an annual average basis for the purpose of inventorying emissions. It should be noted that Equation 2 does not account for differences in the temporal distributions of the rain events, the quantity of rain during any event, or the potential for the rain to evaporate from the road surface. In the event that a finer temporal and spatial resolution is desired for inventories of public unpaved roads, estimates can be based on a more complex set of assumptions. These assumptions include:

1. The moisture content of the road surface material is increased in proportion to the quantity of water added;
2. The moisture content of the road surface material is reduced in proportion to the Class A pan evaporation rate;
3. The moisture content of the road surface material is reduced in proportion to the traffic volume; and
4. The moisture content of the road surface material varies between the extremes observed in the area. The CHIEF Web site (http://www.epa.gov/ttn/chief/ap42/ch13/related/c13s02-2.html) has a file which contains a spreadsheet program for calculating emission factors which are temporally and spatially resolved. Information required for use of the spreadsheet program includes monthly Class A pan evaporation values, hourly meteorological data for precipitation, humidity and snow cover, vehicle traffic information, and road surface material information.

It is emphasized that <u>the simple assumption underlying Equation 2 and the more complex set of assumptions underlying the use of the procedure which produces a finer temporal and spatial resolution</u> have not been verified in any rigorous manner. For this reason, the quality ratings for either approach should be downgraded one letter from the rating that would be applied to Equation 1.

13.2.2.3 Controls[18-22]

A wide variety of options exist to control emissions from unpaved roads. Options fall into the following three groupings:

1. <u>Vehicle restrictions</u> that limit the speed, weight or number of vehicles on the road;

2. Surface improvement, by measures such as (a) paving or (b) adding gravel or slag to a dirt road; and
3. Surface treatment, such as watering or treatment with chemical dust suppressants.

Available control options span broad ranges in terms of cost, efficiency, and applicability. For example, traffic controls provide moderate emission reductions (often at little cost) but are difficult to enforce. Although paving is highly effective, its high initial cost is often prohibitive. Furthermore, paving is not feasible for industrial roads subject to very heavy vehicles and/or spillage of material in transport. Watering and chemical suppressants, on the other hand, are potentially applicable to most industrial roads at moderate to low costs. However, these require frequent reapplication to maintain an acceptable level of control. Chemical suppressants are generally more cost-effective than water but not in cases of temporary roads (which are common at mines, landfills, and construction sites). In summary, then, one needs to consider not only the type and volume of traffic on the road but also how long the road will be in service when developing control plans.

Vehicle restrictions. These measures seek to limit the amount and type of traffic present on the road or to lower the mean vehicle speed. For example, many industrial plants have restricted employees from driving on plant property and have instead instituted bussing programs. This eliminates emissions due to employees traveling to/from their worksites. Although the heavier average vehicle weight of the busses increases the base emission factor, the decrease in vehicle-miles-traveled results in a lower overall emission rate.

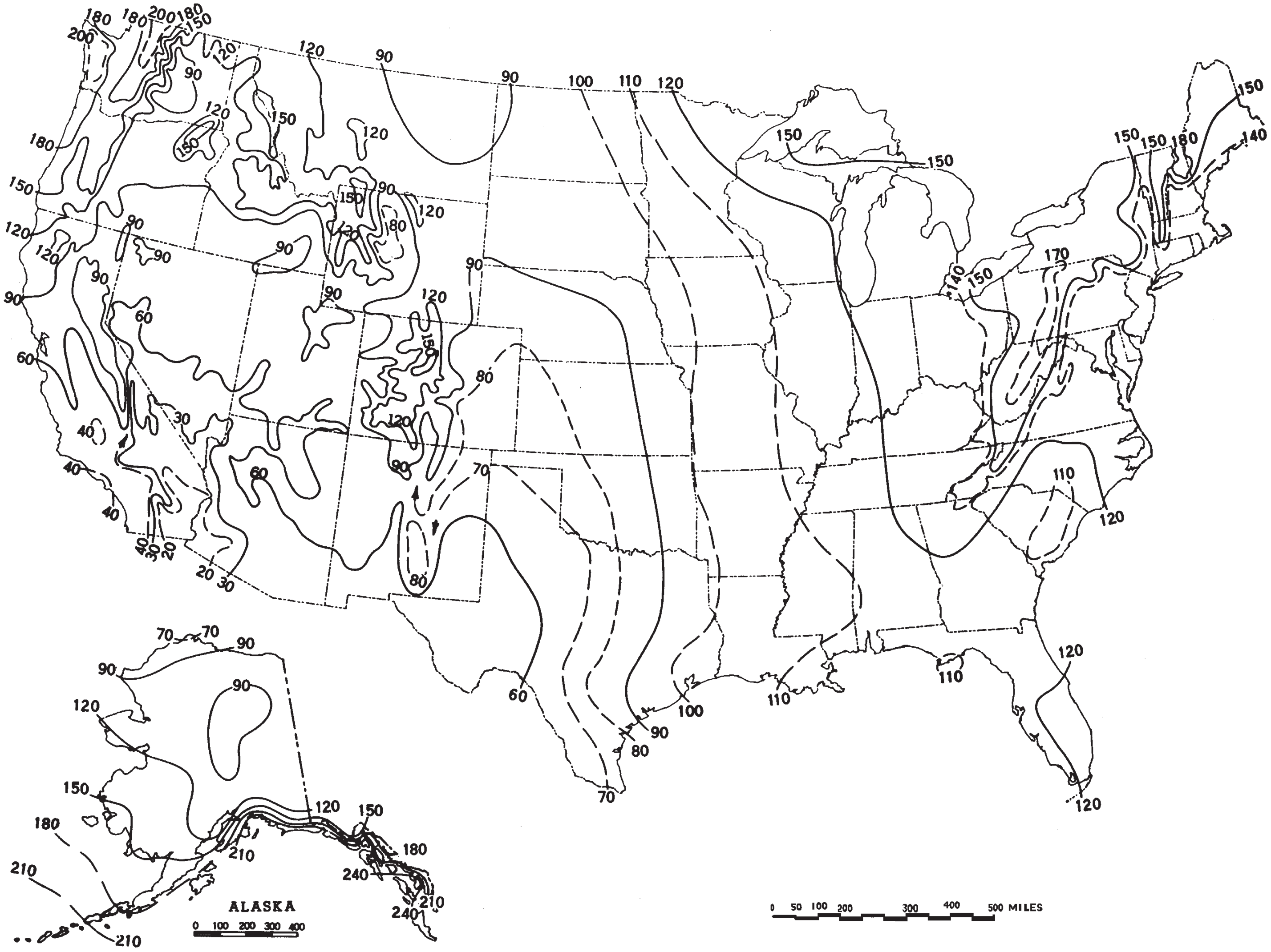


Figure 13.2.2-1. Mean number of days with 0.01 inch or more of precipitation in United States.

Surface improvements. Control options in this category alter the road surface. As opposed to the "surface treatments" discussed below, improvements are relatively "permanent" and do not require periodic retreatment.

The most obvious surface improvement is paving an unpaved road. This option is quite expensive and is probably most applicable to relatively short stretches of unpaved road with at least several hundred vehicle passes per day. Furthermore, if the newly paved road is located near unpaved areas or is used to transport material, it is essential that the control plan address routine cleaning of the newly paved road surface.

The control efficiencies achievable by paving can be estimated by comparing emission factors for unpaved and paved road conditions. The predictive emission factor equation for paved roads, given in Section 13.2.1, requires estimation of the silt loading on the traveled portion of the paved surface, which in turn depends on whether the pavement is periodically cleaned. Unless curbing is to be installed, the effects of vehicle excursion onto unpaved shoulders (berms) also must be taken into account in estimating the control efficiency of paving.

Other improvement methods cover the road surface with another material that has a lower silt content. Examples include placing gravel or slag on a dirt road. Control efficiency can be estimated by comparing the emission factors obtained using the silt contents before and after improvement. The silt content of the road surface should be determined after 3 to 6 months rather than immediately following placement. Control plans should address regular maintenance practices, such as grading, to retain larger aggregate on the traveled portion of the road.

Surface treatments refer to control options which require periodic reapplication. Treatments fall into the two main categories of (a) "wet suppression" (i. e., watering, possibly with surfactants or other additives), which keeps the road surface wet to control emissions and (b) "chemical stabilization/ treatment", which attempts to change the physical characteristics of the surface. The necessary reapplication frequency varies from several minutes for plain water under summertime conditions to several weeks or months for chemical dust suppressants.

Watering increases the moisture content, which conglomerates particles and reduces their likelihood to become suspended when vehicles pass over the surface. The control efficiency depends on how fast the road dries after water is added. This in turn depends on (a) the amount (per unit road surface area) of water added during each application; (b) the period of time between applications; (c) the weight, speed and number of vehicles traveling over the watered road during the period between applications; and (d) meteorological conditions (temperature, wind speed, cloud cover, etc.) that affect evaporation during the period.

Figure 13.2.2-2 presents a simple bilinear relationship between the instantaneous control efficiency due to watering and the resulting increase in surface moisture. The moisture ratio "M" (i.e., the x-axis in Figure 13.2.2-2) is found by dividing the surface moisture content of the watered road by the surface moisture content of the uncontrolled road. As the watered road surface dries, both the ratio M and the predicted instantaneous control efficiency (i.e., the y-axis in the figure) decrease. The figure shows that between the uncontrolled moisture content and a value twice as large, a small increase in moisture content results in a large increase in control efficiency. Beyond that, control efficiency grows slowly with increased moisture content.

Given the complicated nature of how the road dries, characterization of emissions from watered roadways is best done by collecting road surface material samples at various times between water truck passes. (Appendices C.1 and C.2 present the sampling and analysis procedures.) The moisture content measured can then be associated with a control efficiency by use of Figure 13.2.2-2. Samples that reflect average conditions during the watering cycle can take the form of either a series of samples between water applications or a single sample at the midpoint. It is essential that samples be collected during periods with active traffic on the road. Finally, because of different evaporation rates, it is recommended that samples be collected at various times during the year. If only one set of samples is to be collected, these must be collected during hot, summertime conditions.

When developing watering control plans for roads that do not yet exist, it is strongly recommended that the moisture cycle be established by sampling similar roads in the same geographic area. If the moisture cycle cannot be established by similar roads using established watering control plans, the more complex methodology used to estimate the mitigation of rainfall and other precipitation can be used to estimate the control provided by routine watering. An estimate of the maximum daytime Class A pan evaporation (based upon daily evaporation data published in the monthly Climatological Data for the state by the National Climatic Data Center) should be used to insure that adequate watering capability is available during periods of highest evaporation. The hourly precipitation values in the spreadsheet should be replaced with the equivalent inches of precipitation (where the equivalent of 1 inch of precipitation is provided by an application of 5.6 gallons of water per square yard of road). Information on the long term average annual evaporation and on the percentage that occurs between May and October was published in the Climatic Atlas (Reference 16). Figure 13.2.2-3 presents the geographical distribution for "Class A pan evaporation" throughout the United States. Figure 13.2.2-4 presents the geographical distribution of the percentage of this evaporation that occurs between May and October. The U. S. Weather Bureau Class A evaporation pan is a cylindrical metal container with a depth of 10 inches and a diameter of 48 inches. Periodic measurements are made of the changes of the water level.

The above methodology should be used <u>only for prospective analyses</u> and for designing watering programs for existing roadways. The quality rating of an emission factor for a watered road that is based on this methodology should be downgraded two letters. Periodic road surface samples should be collected and analyzed to verify the efficiency of the watering program.

As opposed to watering, chemical dust suppressants have much less frequent reapplication requirements. These materials suppress emissions by changing the physical characteristics of the existing road surface material. Many chemical unpaved road dust suppressants form a hardened surface that binds particles together. After several applications, a treated road often resembles a paved road except that the surface is not uniformly flat. Because the improved surface results in more grinding of small particles, the silt content of loose material on a highly controlled surface may be substantially higher than when the surface was uncontrolled. For this reason, the models presented as Equations 1a and 1b cannot be used to estimate emissions from chemically stabilized roads. Should the road be allowed to return to an uncontrolled state with no visible signs of large-scale cementing of material, the Equation 1a and 1b emission factors could then be used to obtain conservatively high emission estimates.

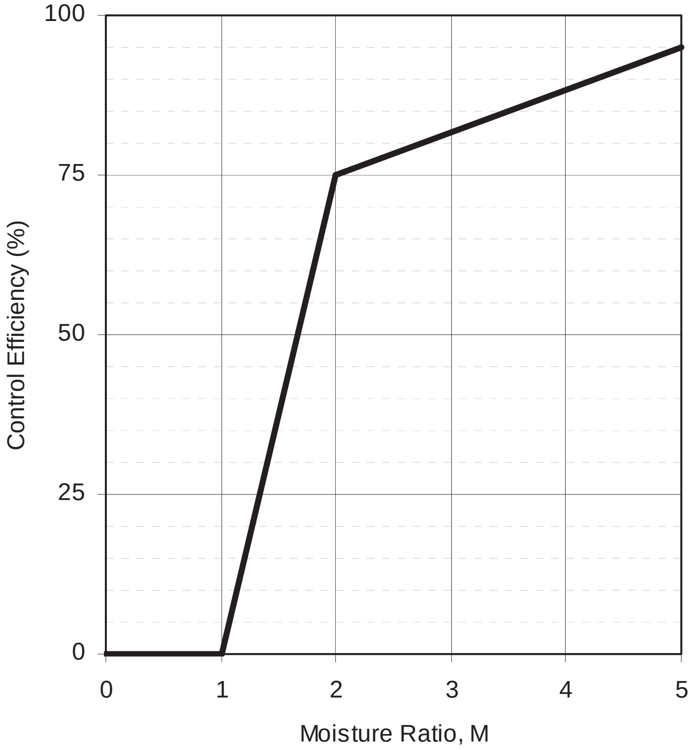


Figure 13.2.2-2. Watering control effectiveness for unpaved travel surfaces

The control effectiveness of chemical dust suppressants appears to depend on (a) the dilution rate used in the mixture; (b) the application rate (volume of solution per unit road surface area); (c) the time between applications; (d) the size, speed and amount of traffic during the period between applications; and (e) meteorological conditions (rainfall, freeze/thaw cycles, etc.) during the period. Other factors that affect the performance of dust suppressants include other traffic characteristics (e. g., cornering, track-on from unpaved areas) and road characteristics (e. g., bearing strength, grade). The variabilities in the above factors and differences between individual dust control products make the control efficiencies of chemical dust suppressants difficult to estimate. Past field testing of emissions from controlled unpaved roads has shown that chemical dust suppressants provide a PM-10 control efficiency of about 80 percent when applied at regular intervals of 2 weeks to 1 month.

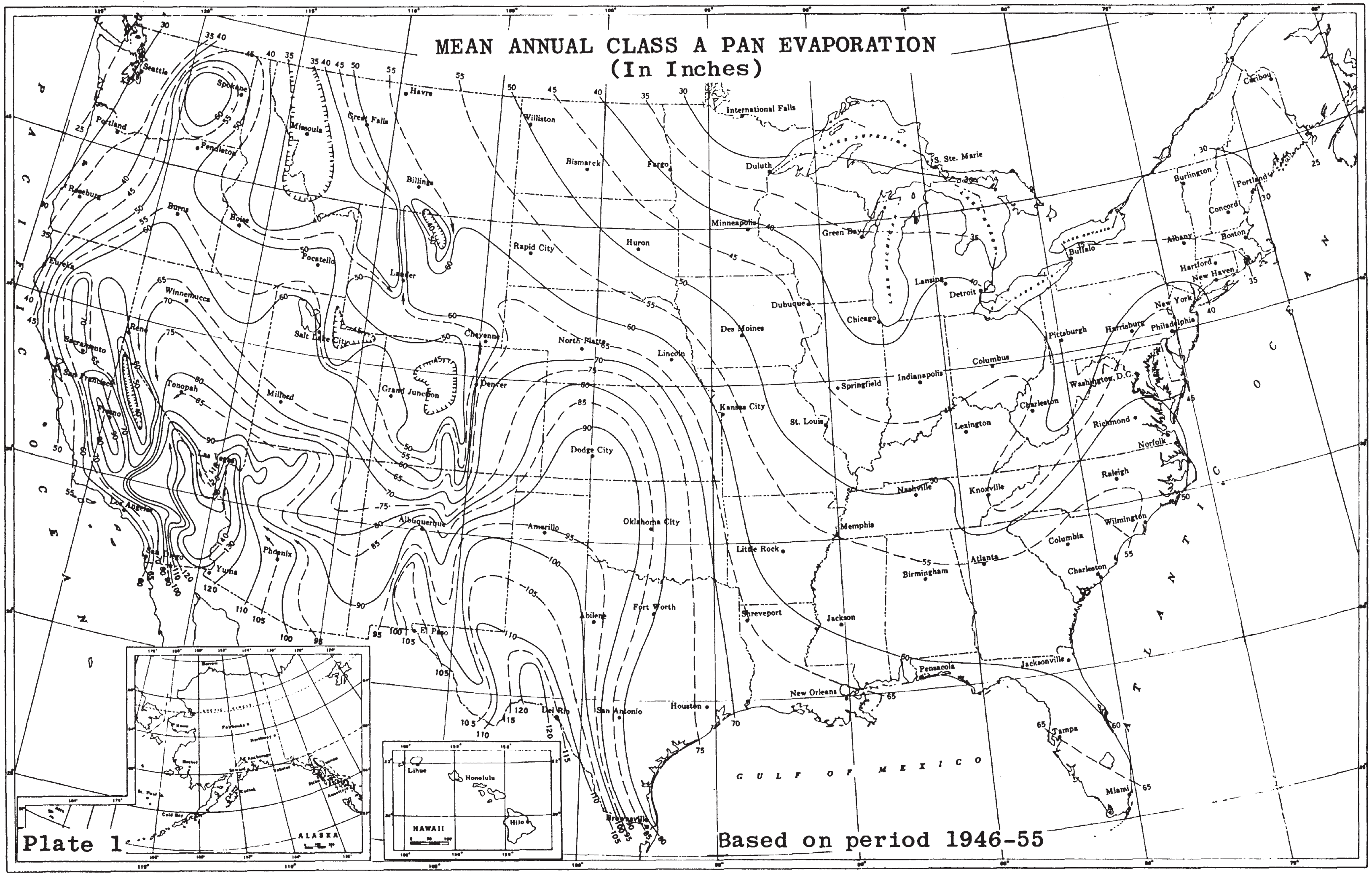
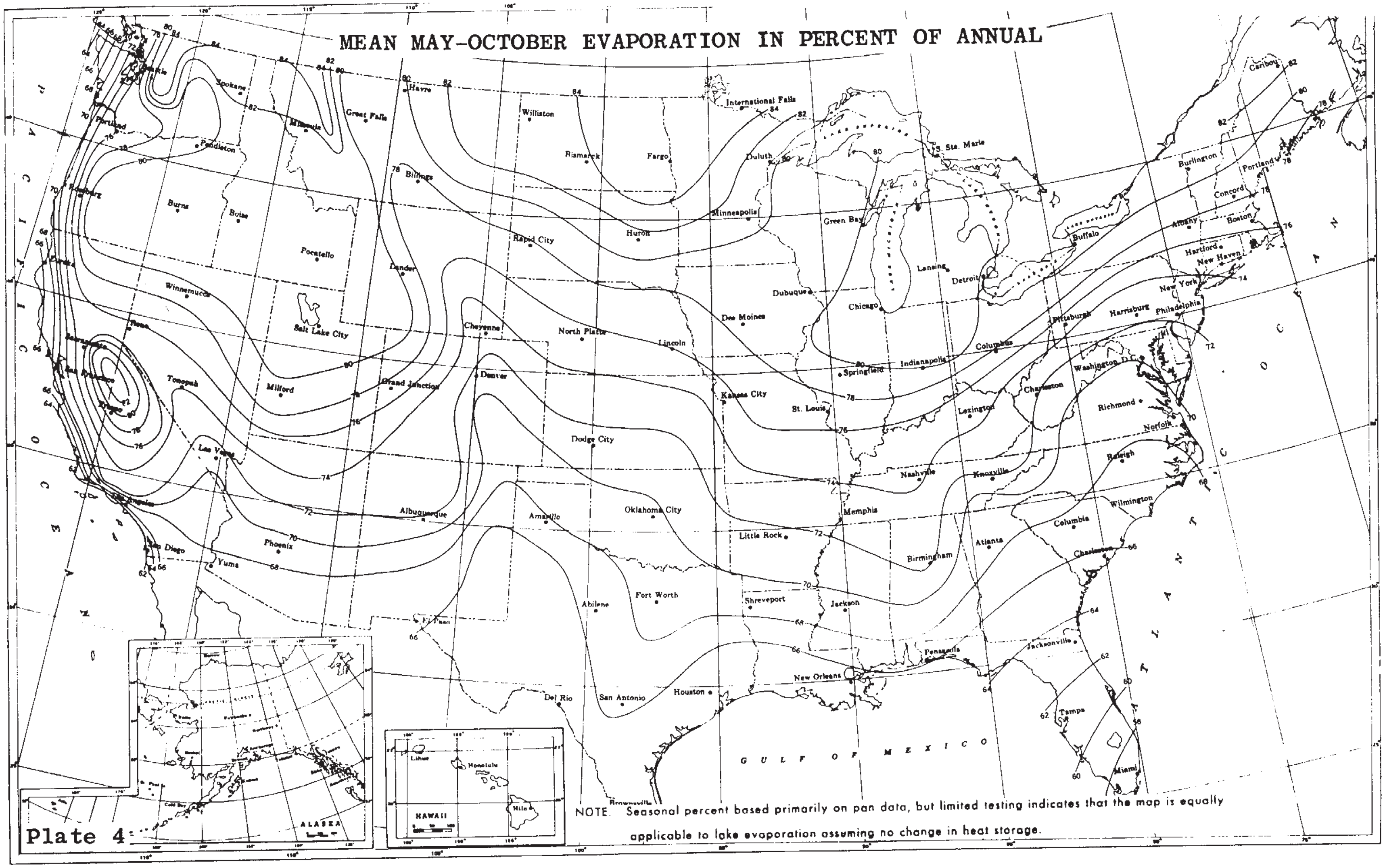


Figure 13.2.2-3. Annual evaporation data.



MEAN MAY-OCTOBER EVAPORATION IN PERCENT OF ANNUAL

NOTE. Seasonal percent based primarily on pan data, but limited testing indicates that the map is equally applicable to lake evaporation assuming no change in heat storage.

Figure 13.2.2-4. Geographical distribution of the percentage of evaporation occurring between May and October.

Petroleum resin products historically have been the dust suppressants (besides water) most widely used on industrial unpaved roads. Figure 13.2.2-5 presents a method to estimate average control efficiencies associated with petroleum resins applied to unpaved roads.[20] Several items should be noted:

1. The term "ground inventory" represents the total volume (per unit area) of petroleum resin concentrate (*not solution*) applied since the start of the dust control season.

2. Because petroleum resin products must be periodically reapplied to unpaved roads, the use of a time-averaged control efficiency value is appropriate. Figure 13.2.2-5 presents control efficiency values averaged over two common application intervals, 2 weeks and 1 month. Other application intervals will require interpolation.

3. Note that zero efficiency is assigned until the ground inventory reaches 0.05 gallon per square yard (gal/yd^2). Requiring a minimum ground inventory ensures that one must apply a reasonable amount of chemical dust suppressant to a road before claiming credit for emission control. Recall that the ground inventory refers to the amount of petroleum resin concentrate rather than the total solution.

As an example of the application of Figure 13.2.2-5, suppose that Equation 1a was used to estimate an emission factor of 7.1 lb/VMT for PM-10 from a particular road. Also, suppose that, starting on May 1, the road is treated with 0.221 gal/yd^2 of a solution (1 part petroleum resin to 5 parts water) on the first of each month through September. Then, the average controlled emission factors, shown in Table 13.2.2-5, are found.

Table 13.2-2-5. EXAMPLE OF AVERAGE CONTROLLED EMISSION FACTORS FOR SPECIFIC CONDITIONS

Period	Ground Inventory, gal/yd^2	Average Control Efficiency, %[a]	Average Controlled Emission Factor, lb/VMT
May	0.037	0	7.1
June	0.073	62	2.7
July	0.11	68	2.3
August	0.15	74	1.8
September	0.18	80	1.4

[a] From Figure 13.2.2-5, ≤10 µm. Zero efficiency assigned if ground inventory is less than 0.05 gal/yd^2.
1 lb/VMT = 281.9 g/VKT. 1 gal/yd^2 = 4.531 L/m^2.

Besides petroleum resins, other newer dust suppressants have also been successful in controlling emissions from unpaved roads. Specific test results for those chemicals, as well as for petroleum resins and watering, are provided in References 18 through 21.

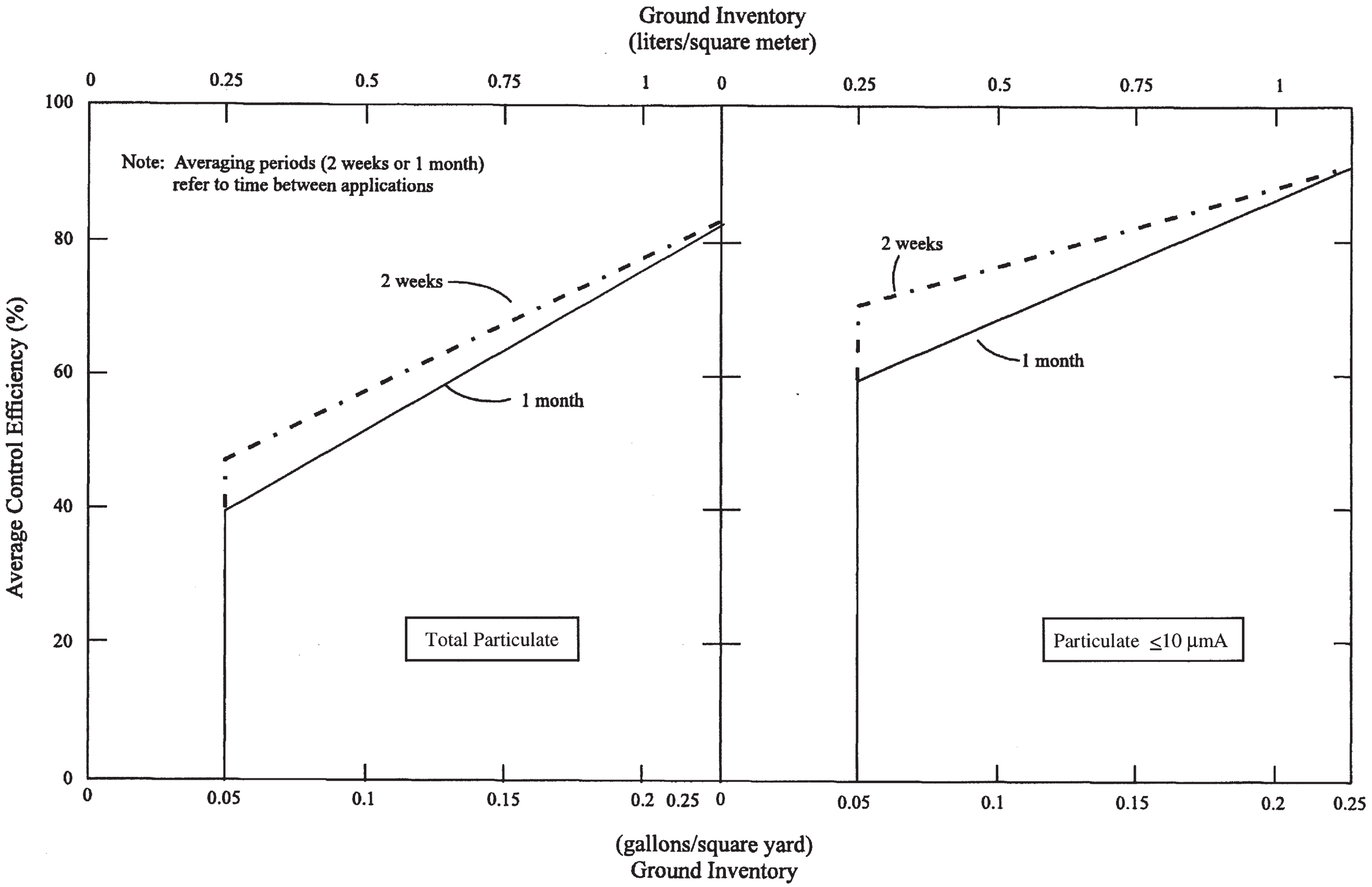


Figure 13.2.2-5. Average control efficiencies over common application intervals.

13.2.2.4 Updates Since The Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the background report for this section (Reference 6).

October 1998 (Supplement E)– This was a major revision of this section. Significant changes to the text and the emission factor equations were made.

October 2001 – Separate emission factors for unpaved surfaces at industrial sites and publicly accessible roads were introduced. Figure 13.2.2-2 was included to provide control effectiveness estimates for watered roads.

December 2003 – The public road emission factor equation (equation 1b) was adjusted to remove the component of particulate emissions from exhaust, brake wear, and tire wear. The parameter C in the new equation varies with aerodynamic size range of the particulate matter. Table 13.2.2-4 was added to present the new coefficients.

January 2006 – The PM-2.5 particle size multipliers (i.e., factors) in Table 13.2.2-2 were modified and the quality ratings were upgraded from C to B based on the wind tunnel studies of a variety of dust emitting surface materials.

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ATTACHMENT 7.2

AP-42, SECTION 11.9 WESTERN SURFACE COAL MINING

11.9 Western Surface Coal Mining

11.9.1 General[1]

There are 12 major coal fields in the western states (excluding the Pacific Coast and Alaskan fields), as shown in Figure 11.9-1. Together, they account for more than 64 percent of the surface minable coal reserves in the United States.[2] The 12 coal fields have varying characteristics that may influence fugitive dust emission rates from mining operations including overburden and coal seam thicknesses and structure, mining equipment, operating procedures, terrain, vegetation, precipitation and surface moisture, wind speeds, and temperatures. The operations at a typical western surface mine are shown in Figure 11.9-2. All operations that involve movement of soil or coal, or exposure of erodible surfaces, generate some amount of fugitive dust.

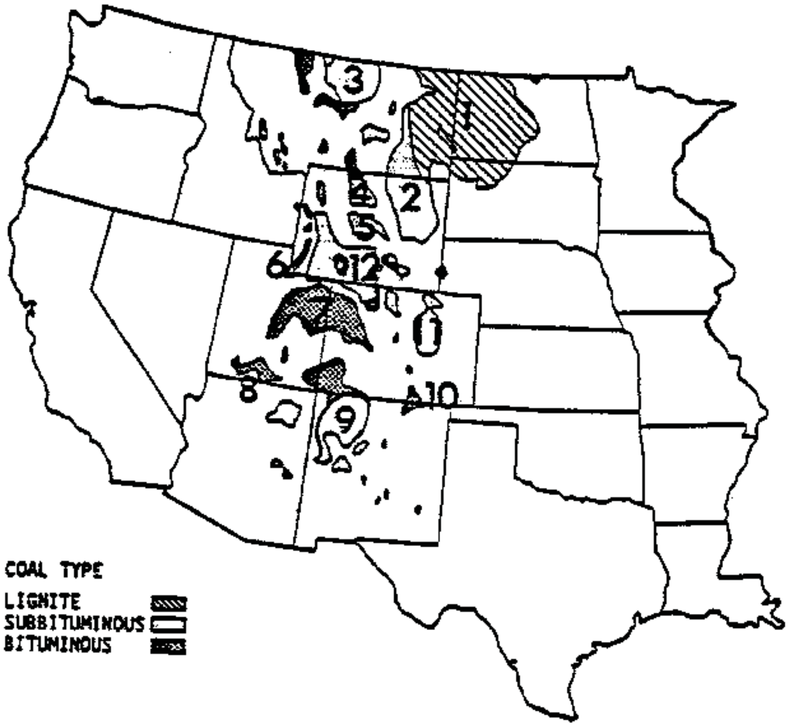
The initial operation is removal of topsoil and subsoil with large scrapers. The topsoil is carried by the scrapers to cover a previously mined and regraded area as part of the reclamation process or is placed in temporary stockpiles. The exposed overburden, the earth that is between the topsoil and the coal seam, is leveled, drilled, and blasted. Then the overburden material is removed down to the coal seam, usually by a dragline or a shovel and truck operation. It is placed in the adjacent mined cut, forming a spoils pile. The uncovered coal seam is then drilled and blasted. A shovel or front end loader loads the broken coal into haul trucks, and it is taken out of the pit along graded haul roads to the tipple, or truck dump. Raw coal sometimes may be dumped onto a temporary storage pile and later rehandled by a front end loader or bulldozer.

At the tipple, the coal is dumped into a hopper that feeds the primary crusher, then is conveyed through additional coal preparation equipment such as secondary crushers and screens to the storage area. If the mine has open storage piles, the crushed coal passes through a coal stacker onto the pile. The piles, usually worked by bulldozers, are subject to wind erosion. From the storage area, the coal is conveyed to a train loading facility and is put into rail cars. At a captive mine, coal will go from the storage pile to the power plant.

During mine reclamation, which proceeds continuously throughout the life of the mine, overburden spoils piles are smoothed and contoured by bulldozers. Topsoil is placed on the graded spoils, and the land is prepared for revegetation by furrowing, mulching, etc. From the time an area is disturbed until the new vegetation emerges, all disturbed areas are subject to wind erosion.

11.9.2 Emissions

Predictive emission factor equations for open dust sources at western surface coal mines are presented in Tables 11.9-1 and 11.9-2. Each equation applies to a single dust-generating activity, such as vehicle traffic on haul roads. The predictive equation explains much of the observed variance in emission factors by relating emissions to three sets of source parameters: (1) measures of source activity or energy expended (e. g., speed and weight of a vehicle traveling on an unpaved road); (2) properties of the material being disturbed (e. g., suspendable fines in the surface material of an unpaved road); and (3) climate (in this case, mean wind speed).



	Coal field	Strippable reserves (10^6 tons)
1	Fort Union	23,529
2	Powder River	56,727
3	North Central	All underground
4	Bighorn Basin	All underground
5	Wind River	3
6	Hams Fork	1,000
7	Uinta	308
8	Southwestern Utah	224
9	San Juan River	2,318
10	Raton Mesa	All underground
11	Denver	All underground
12	Green River	2,120

Figure 11.9-1. Coal fields of the western United States.[3]

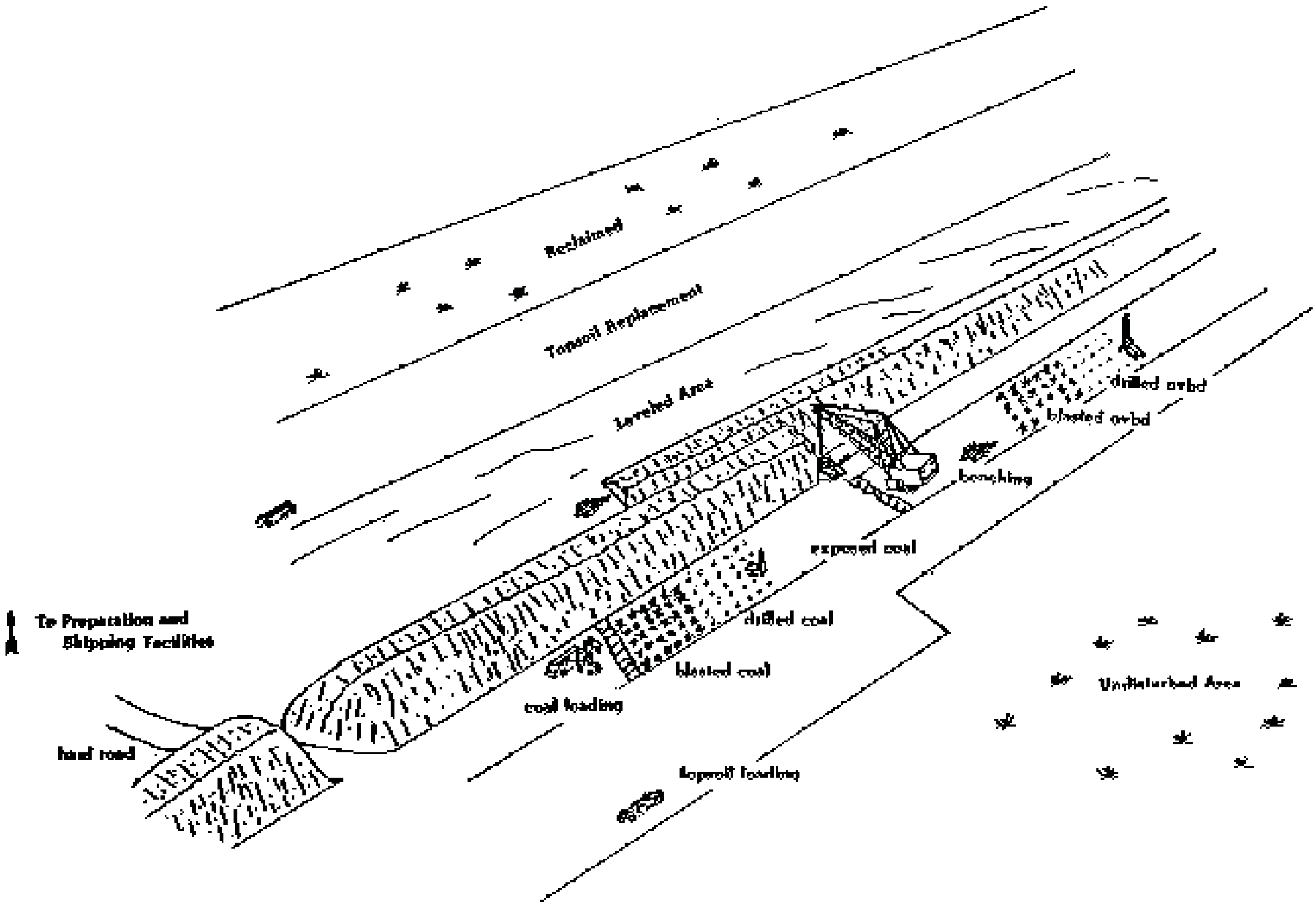


Figure 11.9-2. Operations at typical western surface coal mines.

The equations may be used to estimate particulate emissions generated per unit of source extent or activity (e. g., distance traveled by a haul truck or mass of material transferred). The equations were developed through field sampling of various western surface mine types and are thus applicable to any of the surface coal mines located in the western United States.

In Tables 11.9-1 and 11.9-2, the assigned quality ratings apply within the ranges of source conditions that were tested in developing the equations given in Table 11.9-3. However, the equations should be derated 1 letter value (e. g., A to B) if applied to eastern surface coal mines.

In using the equations to estimate emissions from sources found in a specific western surface mine, it is necessary that reliable values for correction parameters be determined for the specific sources of interest if the assigned quality ratings of the equations are to be applicable. For example, actual silt content of coal or overburden measured at a facility should be used instead of estimated values. In the event that site-specific values for correction parameters cannot be obtained, the appropriate geometric mean values from Table 11.9-3 may be used, but the assigned quality rating of each emission factor equation should be reduced by 1 level (e. g., A to B).

Emission factors for open dust sources not covered in Table 11.9-3 are in Table 11.9-4. These factors were determined through source testing at various western coal mines.

The factors in Table 11.9-4 for mine locations I through V were developed for specific geographical areas. Tables 11.9-5 and 11.9-6 present characteristics of each of these mines (areas). A “mine-specific” emission factor should be used only if the characteristics of the mine for which an emissions estimate is needed are very similar to those of the mine for which the emission factor was developed. The other (nonspecific) emission factors were developed at a variety of mine types and thus are applicable to any western surface coal mine.

As an alternative to the single valued emission factors given in Table 11.9-4 for train or truck loading and for truck or scraper unloading, two empirically derived emission factor equations are presented in Section 13.2.4 of this document. Each equation was developed for a source operation (i. e., batch drop and continuous drop, respectively) comprising a single dust-generating mechanism that crosses industry lines.

Because the predictive equations allow emission factor adjustment to specific source conditions, the equations should be used in place of the single-valued factors in Table 11.9-4 for the sources identified above, if emission estimates for a specific western surface coal mine are needed. However, the generally higher quality ratings assigned to the equations are applicable only if: (1) reliable values of correction parameters have been determined for the specific sources of interest, and (2) the correction parameter values lie within the ranges tested in developing the equations. Caution must be exercised so that only the unbound (sorbed) moisture (i. e., not any bound moisture) is used in determining the moisture content for input to the Chapter 13 equations.

Table 11.9-1 (English Units). EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES[a]

Operation	Material	Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				Units	EMISSION FACTOR RATING
		Emission Factor Equations		Scaling Factors			
		TSP ≤30 µm	≤15 µm	≤10 µm[d]	≤2.5 µm/TSP[e]		
Blasting[f]	Coal or overburden	$0.000014(A)^{1.5}$	ND	0.52[e]	0.03	lb/blast	C_DD
Truck loading	Coal	$\frac{1.16}{(M)^{1.2}}$	$\frac{0.119}{(M)^{0.9}}$	0.75	0.019	lb/ton	BBCC
Bulldozing	Coal	$\frac{78.4\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{18.6\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.022	lb/hr	CCDD
	Overburden	$\frac{5.7\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{1.0\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.105	lb/hr	BCDD
Dragline	Overburden	$\frac{0.0021\ (d)^{1.1}}{(M)^{0.3}}$	$\frac{0.0021\ (d)^{0.7}}{(M)^{0.3}}$	0.75	0.017	lb/yd^3	BCDD
Vehicle traffic[g]							
Grading		$0.040\ (S)^{2.5}$	$0.051\ (S)^{2.0}$	0.60	0.031	lb/VMT	CCDD
Active storage pile[h] (wind erosion and maintenance)	Coal	0.72 u	ND	ND	ND	$\frac{lb}{(acre)(hr)}$	C[i]_ _ _

[a] Reference 1, except as noted. VMT = vehicle miles traveled. ND = no data. Quality ratings coded where "Q, X, Y, Z" are ratings for ≤30 µm, ≤15 µm, ≤10 µm, and ≤2.5 µm, respectively. See also note below.

[b] Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Symbols for equations:

A = horizontal area (ft^2), with blasting depth ≤ 70 ft. Not for vertical face of a bench.
M = material moisture content (%)
s = material silt content (%)
u = wind speed (mph)
d = drop height (ft)
W = mean vehicle weight (tons)
S = mean vehicle speed (mph)
w = mean number of wheels

Table 11.9-1 (cont.).

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[d] Multiply the □15-µm equation by this fraction to determine emissions, except as noted.

[e] Multiply the TSP predictive equation by this fraction to determine emissions.

[f] Blasting factor taken from a reexamination of field test data reported in Reference 1. See Reference 4.

[g] To estimate emissions from traffic on unpaved surfaces by vehicles such as haul trucks, light-to-medium duty vehicles, or scrapers in the travel mode, see the unpaved road emission factor equation in AP-42 Section 13.2.2.

[h] Coal storage pile factor taken from Reference 5. To estimate emissions on a shorter time scale (e. g., worst-case day), see the procedure presented in Section 13.2.5.

[i] Rating applicable to mine types I, II, and IV (see Tables 11.9-5 and 11.9-6).

Note: Section 234 of the Clean Air Act of 1990 required EPA to review and revise the emission factors in this Section (and models used to evaluate ambient air quality impact), to ensure that they did not overestimate emissions from western surface coal mines. Due to resource and technical limitations, the haul road emission factors were isolated to receive the most attention during these studies, as the largest contributor to emissions. Resultant model evaluation with revised emission factors have improved model prediction for total suspended particulate (TSP); however, there is still a tendency for overprediction of particulate matter impact for PM-10, for as yet undetermined causes, prompting the Agency to make a policy decision not to use them for regulatory applications to these sources. However, the technical consideration exists that no better alternative data are currently available and the information should be made known. Users should accordingly use these factors with caution and awareness of their likely limitations.

Table 11.9-2 (Metric Units). EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES[a]

Operation	Material	Emissions By Particle Size Range (Aerodynamic Diameter)[b,c]				Units	EMISSION FACTOR RATING
		Emission Factor Equations		Scaling Factors			
		TSP ≤30 µm	≤15 µm	≤10 µm[d]	≤2.5 µm/TSP[e]		
Blasting[f]	Coal or overburden	$0.00022(A)^{1.5}$	ND	0.52[e]	0.03	kg/blast	C_DD
Truck loading	Coal	$\frac{0.580}{(M)^{1.2}}$	$\frac{0.0596}{(M)^{0.9}}$	0.75	0.019	kg/Mg	BBCC
Bulldozing	Coal	$\frac{35.6\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{8.44\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.022	kg/hr	CCDD
	Overburden	$\frac{2.6\ (s)^{1.2}}{(M)^{1.3}}$	$\frac{0.45\ (s)^{1.5}}{(M)^{1.4}}$	0.75	0.105	kg/hr	BCDD
Dragline	Overburden	$\frac{0.0046\ (d)^{1.1}}{(M)^{0.3}}$	$\frac{0.0029\ (d)^{0.7}}{(M)^{0.3}}$	0.75	0.017	kg/m^3	BCDD
Vehicle traffic[g]							
Grading		$0.0034\ (S)^{2.5}$	$0.0056\ (S)^{2.0}$	0.60	0.031	kg/VKT	CCDD
Active storage pile[h] (wind erosion and maintenance)	Coal	1.8 u	ND	ND	ND	$\frac{kg}{(hectare)(hr)}$	C[i]_ _ _

[a] Reference 1, except as noted. VKT = vehicle kilometers traveled. ND = no data. Quality ratings coded as "QXYZ", where Q, X, Y, and Z are quality ratings for ≤30 µm, ≤15 µm, ≤10 µm, and ≤2.5 µm, respectively. See also note below.

[b] Particulate matter less than or equal to 30 µm in aerodynamic diameter is sometimes termed "suspendable particulate" and is often used as a surrogate for TSP (total suspended particulate). TSP denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Symbols for equations:

A = horizontal area (m^2), with blasting depth ≤ 21 m. Not for vertical face of a bench.
M = material moisture content (%)
s = material silt content (%)
u = wind speed (m/sec)
d = drop height (m)
W = mean vehicle weight (Mg)
S = mean vehicle speed (kph)
w = mean number of wheels

Table 11.9-2 (cont.).

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[d] Multiply the □ 15-µm equation by this fraction to determine emissions, except as noted.

[e] Multiply the TSP predictive equation by this fraction to determine emissions.

[f] Blasting factor taken from a reexamination of field test data reported in Reference 1. See Reference 4.

[g] To estimate emissions from traffic on unpaved surfaces by vehicles such as haul trucks, light-to-medium duty vehicles, or scrapers in the travel mode, see the unpaved road emission factor equation in AP-42 Section 13.2.2

[h] Coal storage pile factor taken from Reference 5. To estimate emissions on a shorter time scale (e. g., worst-case day), see the procedure presented in Section 13.2.5.

[i] Rating applicable to mine types I, II, and IV (see Tables 11.9-5 and 11.9-6).

Note: Section 234 of the Clean Air Act of 1990 required EPA to review and revise the emission factors in this Section (and models used to evaluate ambient air quality impact), to ensure that they did not overestimate emissions from western surface coal mines. Due to resource and technical limitations, the haul road emission factors were isolated to receive the most attention during these studies, as the largest contributor to emissions. Resultant model evaluation with revised emission factors have improved model prediction for total suspended particulate (TSP); however, there is still a tendency for overprediction of particulate matter impact for PM-10, for as yet undetermined causes, prompting the Agency to make a policy decision not to use them for regulatory applications to these sources. However, the technical consideration exists that no better alternative data are currently available and the information should be made known. Users should accordingly use these factors with caution and awareness of their likely limitations.

Table 11.9-3 (Metric And English Units). TYPICAL VALUES FOR CORRECTION FACTORS APPLICABLE TO THE PREDICTIVE EMISSION FACTOR EQUATIONS[a]

Source	Correction Factor	Number Of Test Samples	Range	Geometric Mean	Units
Blasting	Area blasted	17	100 ▫ 6,800	1,590	m^2
	Area blasted	17	1100 ▫ 73,000	17,000	ft^2
Coal loading	Moisture	7	6.6 - 38	17.8	%
Bulldozers					
Coal	Moisture	3	4.0 - 22.0	10.4	%
	Silt	3	6.0 - 11.3	8.6	%
Overburden	Moisture	8	2.2 - 16.8	7.9	%
	Silt	8	3.8 - 15.1	6.9	%
Dragline	Drop distance	19	1.5 - 30	8.6	m
	Drop distance	19	5 - 100	28.1	ft
	Moisture	7	0.2 - 16.3	3.2	%
Scraper	Silt	10	7.2 - 25.2	16.4	%
	Weight	15	33 - 64	48.8	Mg
	Weight	15	36 - 70	53.8	ton
Grader	Speed	7	8.0 - 19.0	11.4	kph
	Speed		5.0 - 11.8	7.1	mph
Haul truck	Silt content	61	1.2 ▫ 19.2	4.3	%
	Moisture	60	0.3 ▫ 20.1	2.4	%
	Weight	61	20.9 ▫ 260	110	mg
	Weight	61	23.0 ▫ 290	120	ton

[a] Reference 1,6.

Table 11.9-4 (English And Metric Units). UNCONTROLLED PARTICULATE EMISSION FACTORS FOR OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES

Source	Material	Mine Location[a]	TSP Emission Factor[b]	Units	EMISSION FACTOR RATING
Drilling	Overburden	Any	1.3 0.59	lb/hole kg/hole	C C
	Coal	V	0.22 0.10	lb/hole kg/hole	E E
Topsoil removal by scraper	Topsoil	Any	0.058 0.029	lb/ton kg/Mg	E E
		IV	0.44 0.22	lb/ton kg/Mg	E E
Overburden replacement	Overburden	Any	0.012 0.0060	lb/ton kg/Mg	C C
Truck loading by power shovel (batch drop)[c]	Overburden	V	0.037 0.018	lb/ton kg/Mg	E E
Train loading (batch or continuous drop)[c]	Coal	Any	0.028 0.014	lb/ton kg/Mg	E E
		III	0.0002 0.0001	lb/ton kg/Mg	E E
Bottom dump truck unloading (batch drop)[c]	Overburden	V	0.002 0.001	lb/ton kg/Mg	E E
	Coal	IV	0.027 0.014	lb/ton kg/Mg	E E
		III	0.005 0.002	lb/ton kg/Mg	E E
		II	0.020 0.010	lb/ton kg/Mg	E E
		I	0.014 0.0070	lb/T kg/Mg	E E
		Any	0.066 0.033	lb/T kg/Mg	D D

Table 11.9-4 (cont.).

Source	Material	Mine Location[a]	TSP Emission Factor[b]	Units	EMISSION FACTOR RATING
End dump truck unloading (batch drop)[c]	Coal	V	0.007 0.004	lb/T kg/Mg	E E
Scraper unloading (batch drop)[c]	Topsoil	IV	0.04 0.02	lb/T kg/Mg	E E
Wind erosion of exposed areas[d]	Seeded land, stripped overburden, graded overburden	Any	0.38	$\frac{T}{(acre)(yr)}$	C
			0.85	$\frac{Mg}{(hectare)(yr)}$	C

[a] Roman numerals I through V refer to specific mine locations for which the corresponding emission factors were developed (Reference 5). Tables 11.9-4 and 11.9-5 present characteristics of each of these mines. See text for correct use of these “mine-specific” emission factors. The other factors (from Reference 7, except for overburden drilling from Reference 1) can be applied to any western surface coal mine.

[b] Total suspended particulate (TSP) denotes what is measured by a standard high volume sampler (see Section 13.2).

[c] Predictive emission factor equations, which generally provide more accurate estimates of emissions, are presented in Chapter 13.

[d] To estimate wind erosion on a shorter time scale (e. g., worst-case day), see Section 13.2.5.

Table 11.9-5 (Metric And English Units). GENERAL CHARACTERISTICS OF SURFACE COAL MINES REFERRED TO IN TABLE 11.9-4[a]

Mine	Location	Type Of Coal Mined	Terrain	Vegetative Cover	Surface Soil Type And Erodibility Index	Mean Wind Speed		Mean Annual Precipitation	
						m/s	mph	cm	in.
I	N.W. Colorado	Subbitum.	Moderately steep	Moderate, sagebrush	Clayey loamy (71)	2.3	5.1	38	15
II	S.W. Wyoming	Subbitum.	Semirugged	Sparse, sagebrush	Arid soil with clay and alkali or carbonate accumulation (86)	6.0	13.4	36	14
III	S.E. Montana	Subbitum.	Gently rolling to semirugged	Sparse, moderate, prairie grassland	Shallow clay loamy deposits on bedrock (47)	4.8	10.7	28 - 41	11 - 16
IV	Central North Dakota	Lignite	Gently rolling	Moderate, prairie grassland	Loamy, loamy to sandy (71)	5.0	11.2	43	17
V	N.E. Wyoming	Subbitum.	Flat to gently rolling	Sparse, sagebrush	Loamy, sandy, clayey, and clay loamy (102)	6.0	13.4	36	14

[a] Reference 4.

Table 11.9-6 (English Units). OPERATING CHARACTERISTICS OF THE COAL MINES REFERRED TO IN TABLE 11.9-4[a]

Parameter	Required Information	Units	Mine				
			I	II	III	IV	V
Production rate	Coal mined	10^6 ton/yr	1.13	5.0	9.5	3.8	12.0[b]
Coal transport	Avg. unit train frequency	per day	NA	NA	2	NA	2
Stratigraphic data	Overburden thickness	ft	21	80	90	65	35
	Overburden density	lb/yd^3	4000	3705	3000	ND	ND
	Coal seam thicknesses	ft	9,35	15,9	27	2,4,8	70
	Parting thicknesses	ft	50	15	NA	32,16	NA
	Spoils bulking factor	%	22	24	25	20	ND
	Active pit depth	ft	52	100	114	80	105
Coal analysis data	Moisture	%	10	18	24	38	30
	Ash	%, wet	8	10	8	7	6
	Sulfur	%, wet	0.46	0.59	0.75	0.65	0.48
	Heat content	Btu/lb	11000	9632	8628	8500	8020
Surface disposition	Total disturbed land	acre	168	1030	2112	1975	217
	Active pit	acre	34	202	87	ND	71
	Spoils	acre	57	326	144	ND	100
	Reclaimed	acre	100	221	950	ND	100
	Barren land	acre	ND	30	455	ND	ND
	Associated disturbances	acre	12	186	476	ND	46
Storage	Capacity	ton	NA	NA	ND	NA	48000
Blasting	Frequency, total	per week	4	4	3	7	7[b]
	Frequency, overburden	per week	3	0.5	3	NA	7[b]
	Area blasted, coal	ft^2	16000	40000	ND	30000	ND
	Area blasted, overburden	ft^2	20000	ND	ND	NA	ND

[a] Reference 5. NA = not applicable. ND = no data.

[b] Estimate.

11.9.3 Updates Since the Fifth Edition

The Fifth Edition which was released in January 1995 reformatted the section that was dated September 1988. Revisions to this section since these dates are summarized below. For further detail, consult the memoranda describing each supplement or the background report for this section. These and other documents can be found on the CHIEF WEB site (home page http://www.epa.gov/ttn/chief/).

Supplement E

- The predictive equations for emission factors for haul trucks and light/medium duty vehicles were removed and replaced with a footnote refering users to the recently revised unpaved road section in the Miscellaneous Sources chapter.
- The emission factor quality ratings were revised based upon a revised predictive equation and single value criteria.
- The typographical errors for the TSP equation and the omission of the PM-2.5 scaling factor for blasting were corrected.

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ATTACHMENT 7.3

AP-42, SECTION 13.2.4 AGGREGATE HANDLING AND STORAGE PILES

13.2.4 Aggregate Handling And Storage Piles

13.2.4.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

13.2.4.2 Emissions And Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on 3 parameters of the condition of a particular storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and then the drying process is very slow.

Silt (particles equal to or less than 75 micrometers [µm] in diameter) content is determined by measuring the portion of dry aggregate material that passes through a 200-mesh screen, using ASTM-C-136 method.[1] Table 13.2.4-1 summarizes measured silt and moisture values for industrial aggregate materials.

Table 13.2.4-1. TYPICAL SILT AND MOISTURE CONTENTS OF MATERIALS AT VARIOUS INDUSTRIES[a]

Industry	No. Of Facilities	Material	Silt Content (%)			Moisture Content (%)		
			No. Of Samples	Range	Mean	No. Of Samples	Range	Mean
Iron and steel production	9	Pellet ore	13	1.3 - 13	4.3	11	0.64 - 4.0	2.2
		Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.0	5.4
		Coal	12	2.0 - 7.7	4.6	11	2.8 - 11	4.8
		Slag	3	3.0 - 7.3	5.3	3	0.25 - 2.0	0.92
		Flue dust	3	2.7 - 23	13	1	—	7
		Coke breeze	2	4.4 - 5.4	4.9	2	6.4 - 9.2	7.8
		Blended ore	1	—	15	1	—	6.6
		Sinter	1	—	0.7	0	—	—
		Limestone	3	0.4 - 2.3	1.0	2	ND	0.2
Stone quarrying and processing	2	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
		Various limestone products	8	0.8 - 14	3.9	8	0.46 - 5.0	2.1
Taconite mining and processing	1	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.0	0.9
		Tailings	2	ND	11	1	—	0.4
Western surface coal mining	4	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
		Overburden	15	3.8 - 15	7.5	0	—	—
		Exposed ground	3	5.1 - 21	15	3	0.8 - 6.4	3.4
Coal-fired power plant	1	Coal (as received)	60	0.6 - 4.8	2.2	59	2.7 - 7.4	4.5
Municipal solid waste landfills	4	Sand	1	—	2.6	1	—	7.4
		Slag	2	3.0 - 4.7	3.8	2	2.3 - 4.9	3.6
		Cover	5	5.0 - 16	9.0	5	8.9 - 16	12
		Clay/dirt mix	1	—	9.2	1	—	14
		Clay	2	4.5 - 7.4	6.0	2	8.9 - 11	10
		Fly ash	4	78 - 81	80	4	26 - 29	27
		Misc. fill materials	1	—	12	1	—	11

[a] References 1-10. ND = no data.

13.2.4.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by either type of drop operation, per kilogram (kg) (ton) of material transferred, may be estimated, with a rating of A, using the following empirical expression:[11]

$$E = k(0.0016)\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(kg/megagram [Mg])}$$

$$\boxed{E = k(0.0032)\ \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \text{(pound [lb]/ton)}} \qquad (1)$$

where:

E = emission factor
k = particle size multiplier (dimensionless)
U = mean wind speed, meters per second (m/s) (miles per hour [mph])
M = material moisture content (%)

The particle size multiplier in the equation, k, varies with aerodynamic particle size range, as follows:

Aerodynamic Particle Size Multiplier (k) For Equation 1				
< 30 μm	< 15 μm	< 10 μm	< 5 μm	< 2.5 μm
0.74	0.48	0.35	0.20	0.053[a]

[a] Multiplier for < 2.5 μm taken from Reference 14.

The equation retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows. Note that silt content is included, even though silt content does not appear as a correction parameter in the equation. While it is reasonable to expect that silt content and emission factors are interrelated, no significant correlation between the 2 was found during the derivation of the equation, probably because most tests with high silt contents were conducted under lower winds, and vice versa. It is recommended that estimates from the equation be reduced 1 quality rating level if the silt content used in a particular application falls outside the range given:

Ranges Of Source Conditions For Equation 1			
Silt Content (%)	Moisture Content (%)	Wind Speed	
		m/s	mph
0.44 - 19	0.25 - 4.8	0.6 - 6.7	1.3 - 15

To retain the quality rating of the equation when it is applied to a specific facility, reliable correction parameters must be determined for specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site-specific values for correction parameters cannot be obtained, the appropriate mean from Table 13.2.4-1 may be used, but the quality rating of the equation is reduced by 1 letter.

For emissions from equipment traffic (trucks, front-end loaders, dozers, etc.) traveling between or on piles, it is recommended that the equations for vehicle traffic on unpaved surfaces be used (see Section 13.2.2). For vehicle travel between storage piles, the silt value(s) for the areas among the piles (which may differ from the silt values for the stored materials) should be used.

Worst-case emissions from storage pile areas occur under dry, windy conditions. Worst-case emissions from materials-handling operations may be calculated by substituting into the equation appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for Section 13.2.2, vehicle traffic, "Unpaved Roads", follows the methodology described in that section centering on parameter p. A separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity also may be justified for the worst-case averaging period.

13.2.4.4 Controls[12-13]

Watering and the use of chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical agents (such as surfactants) that permit more extensive wetting. Continuous chemical treating of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.[12]

References For Section 13.2.4

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ATTACHMENT 7.4

AP-42, SECTION 2.4 MUNICIPAL SOLID WASTE LANDFILLS

2.4 MUNICIPAL SOLID WASTE LANDFILLS

2.4.1 General[1-4]

A municipal solid waste (MSW) landfill unit is a discrete area of land or an excavation that receives household waste, and that is not a land application unit, surface impoundment, injection well, or waste pile. An MSW landfill unit may also receive other types of wastes, such as commercial solid waste, nonhazardous sludge, and industrial solid waste. The municipal solid waste types potentially accepted by MSW landfills include (most landfills accept only a few of the following categories):

- MSW,
- Household hazardous waste,
- Municipal sludge,
- Municipal waste combustion ash,
- Infectious waste,
- Waste tires,
- Industrial non-hazardous waste,
- Conditionally exempt small quantity generator (CESQG) hazardous waste,
- Construction and demolition waste,
- Agricultural wastes,
- Oil and gas wastes, and
- Mining wastes.

In the United States, approximately 57 percent of solid waste is landfilled, 16 percent is incinerated, and 27 percent is recycled or composted. There were an estimated 2,500 active MSW landfills in the United States in 1995. These landfills were estimated to receive 189 million megagrams (Mg) (208 million tons) of waste annually, with 55 to 60 percent reported as household waste, and 35 to 45 percent reported as commercial waste.

2.4.2 Process Description[2,5]

There are three major designs for municipal landfills. These are the area, trench, and ramp methods. All of these methods utilize a three step process, which includes spreading the waste, compacting the waste, and covering the waste with soil. The trench and ramp methods are not commonly used, and are not the preferred methods when liners and leachate collection systems are utilized or required by law. The area fill method involves placing waste on the ground surface or landfill liner, spreading it in layers, and compacting with heavy equipment. A daily soil cover is spread over the compacted waste. The trench method entails excavating trenches designed to receive a day's worth of waste. The soil from the excavation is often used for cover material and wind breaks. The ramp method is typically employed on sloping land, where waste is spread and compacted similar to the area method, however, the cover material obtained is generally from the front of the working face of the filling operation.

Modern landfill design often incorporates liners constructed of soil (i.e., recompacted clay), or synthetics (i.e., high density polyethylene), or both to provide an impermeable barrier to leachate (i.e., water that has passed through the landfill) and gas migration from the landfill.

2.4.3 Control Technology[1,2,6]

The Resource Conservation and Recovery Act (RCRA) Subtitle D regulations promulgated on October 9, 1991 require that the concentration of methane generated by MSW landfills not exceed 25 percent of the lower explosive limit (LEL) in on-site structures, such as scale houses, or the LEL at the facility property boundary.

The New Source Performance Standards (NSPS) and Emission Guidelines for air emissions from MSW landfills for certain new and existing landfills were published in the Federal Register on March 1, 1996. The regulation requires that Best Demonstrated Technology (BDT) be used to reduce MSW landfill emissions from affected new and existing MSW landfills emitting greater than or equal to 50 Mg/yr (55 tons/yr) of non-methane organic compounds (NMOCs). The MSW landfills that are affected by the NSPS/Emission Guidelines are each new MSW landfill, and each existing MSW landfill that has accepted waste since November 8, 1987, or that has capacity available for future use. The NSPS/Emission Guidelines affect landfills with a design capacity of 2.5 million Mg (2.75 million tons) or more. Control systems require: (1) a well-designed and well-operated gas collection system, and (2) a control device capable of reducing NMOCs in the collected gas by 98 weight-percent.

Landfill gas (LFG) collection systems are either active or passive systems. Active collection systems provide a pressure gradient in order to extract LFG by use of mechanical blowers or compressors. Passive systems allow the natural pressure gradient created by the increase in pressure created by LFG generation within the landfill to mobilize the gas for collection.

LFG control and treatment options include (1) combustion of the LFG, and (2) purification of the LFG. Combustion techniques include techniques that do not recover energy (i.e., flares and thermal incinerators), and techniques that recover energy (i.e., gas turbines and internal combustion engines) and generate electricity from the combustion of the LFG. Boilers can also be employed to recover energy from LFG in the form of steam. Flares involve an open combustion process that requires oxygen for combustion, and can be open or enclosed. Thermal incinerators heat an organic chemical to a high enough temperature in the presence of sufficient oxygen to oxidize the chemical to carbon dioxide (CO_2) and water. Purification techniques can also be used to process raw landfill gas to pipeline quality natural gas by using adsorption, absorption, and membranes.

2.4.4 Emissions[2,7]

Methane (CH_4) and CO_2 are the primary constituents of landfill gas, and are produced by microorganisms within the landfill under anaerobic conditions. Transformations of CH_4 and CO_2 are mediated by microbial populations that are adapted to the cycling of materials in anaerobic environments. Landfill gas generation, including rate and composition, proceeds through four phases. The first phase is aerobic [i.e., with oxygen (O_2) available] and the primary gas produced is CO_2. The second phase is characterized by O_2 depletion, resulting in an anaerobic environment, where large amounts of CO_2 and some hydrogen (H_2) are produced. In the third phase, CH_4 production begins, with an accompanying reduction in the amount of CO_2 produced. Nitrogen (N_2) content is initially high in landfill gas in the first phase, and declines sharply as the landfill proceeds through the second and third phases. In the fourth phase, gas production of CH_4, CO_2, and N_2 becomes fairly steady. The total time and phase duration of gas generation varies with landfill conditions (i.e., waste composition, design management, and anaerobic state).

Typically, LFG also contains a small amount of non-methane organic compounds (NMOC). This NMOC fraction often contains various organic hazardous air pollutants (HAP), greenhouse gases (GHG), and compounds associated with stratospheric ozone depletion. The NMOC fraction also contains volatile organic compounds (VOC). The weight fraction of VOC can be determined by subtracting the weight fractions of individual compounds that are non-photochemically reactive (i.e., negligibly-reactive organic compounds as defined in 40 CFR 51.100).

Other emissions associated with MSW landfills include combustion products from LFG control and utilization equipment (i.e., flares, engines, turbines, and boilers). These include carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), hydrogen chloride (HCl), particulate matter (PM) and other combustion products (including HAPs). PM emissions can also be generated in the form of fugitive dust created by mobile sources (i.e., garbage trucks) traveling along paved and unpaved surfaces. The reader should consult AP-42 Volume I Sections 13.2.1 and 13.2.2 for information on estimating fugitive dust emissions from paved and unpaved roads.

The rate of emissions from a landfill is governed by gas production and transport mechanisms. Production mechanisms involve the production of the emission constituent in its vapor phase through vaporization, biological decomposition, or chemical reaction. Transport mechanisms involve the transportation of a volatile constituent in its vapor phase to the surface of the landfill, through the air boundary layer above the landfill, and into the atmosphere. The three major transport mechanisms that enable transport of a volatile constituent in its vapor phase are diffusion, convection, and displacement.

2.4.4.1 Uncontrolled Emissions — To estimate uncontrolled emissions of the various compounds present in landfill gas, total landfill gas emissions must first be estimated. Uncontrolled CH_4 emissions may be estimated for individual landfills by using a theoretical first-order kinetic model of methane production developed by the EPA.[8] This model is known as the Landfill Air Emissions Estimation model, and can be accessed from the Office of Air Quality Planning and Standards Technology Transfer Network Website (OAQPS TTN Web) in the Clearinghouse for Inventories and Emission Factors (CHIEF) technical area (URL http://www.epa.gov/ttn/chief). The Landfill Air Emissions Estimation model equation is as follows:

$$Q_{CH_4} = L_o \; R \; (e^{-kc} - e^{-kt}) \tag{1}$$

where:

Q_{CH_4} = Methane generation rate at time t, m^3/yr;
L_o = Methane generation potential, m^3 CH_4/Mg refuse;
R = Average annual refuse acceptance rate during active life, Mg/yr;
e = Base log, unitless;
k = Methane generation rate constant, yr^{-1};
c = Time since landfill closure, yrs (c = 0 for active landfills); and
t = Time since the initial refuse placement, yrs.

It should be noted that the model above was designed to estimate LFG generation and not LFG emissions to the atmosphere. Other fates may exist for the gas generated in a landfill, including capture and subsequent microbial degradation within the landfill’s surface layer. Currently, there are no data that adequately address this fate. It is generally accepted that the bulk of the gas generated will be emitted through cracks or other openings in the landfill surface.

Site-specific landfill information is generally available for variables R, c, and t. When refuse acceptance rate information is scant or unknown, R can be determined by dividing the refuse in place by the age of the landfill. If a facility has documentation that a certain segment (cell) of a landfill received *only* nondegradable refuse, then the waste from this segment of the landfill can be excluded from the calculation of R. Nondegradable refuse includes concrete, brick, stone, glass, plaster, wallboard, piping, plastics, and metal objects. The average annual acceptance rate should only be estimated by this method when there is inadequate information available on the actual average acceptance rate. The time variable, t, includes the total number of years that the refuse has been in place (including the number of years that the landfill has accepted waste and, if applicable, has been closed).

Values for variables L_o and k must be estimated. Estimation of the potential CH_4 generation capacity of refuse (L_o) is generally treated as a function of the moisture and organic content of the refuse. Estimation of the CH_4 generation constant (k) is a function of a variety of factors, including moisture, pH, temperature, and other environmental factors, and landfill operating conditions. Specific CH_4 generation constants can be computed by the use of EPA Method 2E (40 CFR Part 60 Appendix A).

The Landfill Air Emission Estimation model includes both regulatory default values and recommended AP-42 default values for L_o and k. The regulatory defaults were developed for compliance purposes (NSPS/Emission Guideline). As a result, the model contains conservative L_o and k default values in order to protect human health, to encompass a wide range of landfills, and to encourage the use of site-specific data. Therefore, different L_o and k values may be appropriate in estimating landfill emissions for particular landfills and for use in an emissions inventory.

Recommended AP-42 defaults include a k value of 0.04/yr for areas recieving 25 inches or more of rain per year. A default k of 0.02/yr should be used in drier areas (<25 inches/yr). An L_o value of 100 m^3/Mg (3,530 ft^3/ton) refuse is appropriate for most landfills. Although the recommended default k and L_o are based upon the best fit to 21 different landfills, the predicted methane emissions ranged from 38 to 492% of actual, and had a relative standard deviation of 0.85. It should be emphasized that in order to comply with the NSPS/Emission Guideline, the regulatory defaults for k and L_o must be applied as specified in the final rule.

When gas generation reaches steady state conditions, LFG consists of approximately 40 percent by volume CO_2, 55 percent CH_4, 5 percent N_2 (and other gases), and trace amounts of NMOCs. Therefore, the estimate derived for CH_4 generation using the Landfill Air Emissions Estimation model can also be used to represent CO_2 generation. Addition of the CH_4 and CO_2 emissions will yield an estimate of total landfill gas emissions. If site-specific information is available to suggest that the CH_4 content of landfill gas is not 55 percent, then the site-specific information should be used, and the CO_2 emission estimate should be adjusted accordingly.

Most of the NMOC emissions result from the volatilization of organic compounds contained in the landfilled waste. Small amounts may be created by biological processes and chemical reactions within the landfill. The current version of the Landfill Air Emissions Estimation model contains a proposed regulatory default value for total NMOC of 4,000 ppmv, expressed as hexane. However, available data show that there is a range of over 4,400 ppmv for total NMOC values from landfills. The proposed regulatory default value for NMOC concentration was developed for regulatory compliance purposes and to provide the most cost-effective default values on a national basis. For emissions inventory purposes, site-specific information should be taken into account when determining the total NMOC concentration. In the absence of site-specific information, a value of 2,420 ppmv as hexane is suggested for landfills known to have co-disposal of MSW and non-residential waste. If the landfill is known to contain only MSW or have very little organic commercial/industrial wastes, then a total NMOC value of 595 ppmv as hexane should be used. In addition, as with the landfill model defaults, the regulatory default value for NMOC content must be used in order to comply with the NSPS/Emission Guideline.

If a site-specific total pollutant concentration is available (i.e., as measured by EPA Reference Method 25C), it must be corrected for air infiltration which can occur by two different mechanisms: LFG sample dilution, and air intrusion into the landfill. These corrections require site-specific data for the LFG CH_4,

CO_2, nitrogen (N_2), and oxygen (O_2) content. If the ratio of N_2 to O_2 is less than or equal to 4.0 (as found in ambient air), then the total pollutant concentration is adjusted for sample dilution by assuming that CO_2 and CH_4 are the primary (100 percent) constituents of landfill gas, and the following equation is used:

$$C_P \text{ (ppmv) (corrected for air infiltration)} = \frac{C_P \text{ (ppmv) } (1 \text{ x } 10^6)}{C_{CO_2} \text{ (ppmv)} + C_{CH_4} \text{ (ppmv)}} \tag{2}$$

where:

C_P = Concentration of pollutant P in landfill gas (i.e., NMOC as hexane), ppmv;

C_{CO_2} = CO_2 concentration in landfill gas, ppmv;

C_{CH_4} = CH_4 Concentration in landfill gas, ppmv; and

$1 \text{ x } 10^6$ = Constant used to correct concentration of P to units of ppmv.

If the ratio of N_2 to O_2 concentrations (i.e., C_{N_2}, C_{O_2}) is greater than 4.0, then the total pollutant concentration should be adjusted for air intrusion into the landfill by using equation 2 and adding the concentration of N_2 (i.e., C_{N_2}) to the denominator. Values for C_{CO_2}, C_{CH_4}, C_{N_2}, C_{O_2}, can usually be found in the source test report for the particular landfill along with the total pollutant concentration data.

To estimate emissions of NMOC or other landfill gas constituents, the following equation should be used:

$$Q_P = 1.82 \; Q_{CH_4} * \frac{C_P}{(1 \text{ x } 10^6)} \tag{3}$$

where:

Q_P = Emission rate of pollutant P (i.e. NMOC), m^3/yr;

Q_{CH_4} = CH_4 generation rate, m^3/yr (from the Landfill Air Emissions Estimation model);

C_P = Concentration of P in landfill gas, ppmv; and

1.82 = Multiplication factor (assumes that approximately 55 percent of landfill gas is CH_4 and 45 percent is CO_2, N_2, and other constituents).

Uncontrolled mass emissions per year of total NMOC (as hexane), CO_2, CH_4, and speciated organic and inorganic compounds can be estimated by the following equation:

$$UM_P = Q_P * \left[\frac{MW_P * 1 \text{ atm}}{(8.205\text{x}10^{-5} \text{ m}^3\text{-atm/gmol-}^\circ\text{K})(1000\text{g/kg})(273 + T\,^\circ\text{K})} \right] \tag{4}$$

where:

UM_P = Uncontrolled mass emissions of pollutant P (i.e., NMOC), kg/yr;

MW_P = Molecular weight of P, g/gmol (i.e., 86.18 for NMOC as hexane);

Q_P = NMOC emission rate of P, m^3/yr; and

T = Temperature of landfill gas, ^oC.

This equation assumes that the operating pressure of the system is approximately 1 atmosphere. If the temperature of the landfill gas is not known, a temperature of 25°C (77°F) is recommended.

Uncontrolled default concentrations of speciated organics along with some inorganic compounds are presented in Table 2.4-1. These default concentrations have already been corrected for air infiltration and can be used as input parameters to equation 3 or the Landfill Air Emission Estimation model for estimating speciated emissions from landfills when site-specific data are not available. An analysis of the data, based on the co-disposal history (with non-residential wastes) of the individual landfills from which the concentration data were derived, indicates that for benzene, NMOC, and toluene, there is a difference in the uncontrolled concentrations. Table 2.4-2 presents the corrected concentrations for benzene, NMOC, and toluene to use based on the site's co-disposal history.

It is important to note that the compounds listed in Tables 2.4-1 and 2.4-2 are not the only compounds likely to be present in LFG. The listed compounds are those that were identified through a review of the available literature. The reader should be aware that additional compounds are likely present, such as those associated with consumer or industrial products. Given this information, extreme caution should be exercised in the use of the default VOC weight fractions and concentrations given at the bottom of Table 2.4-2. These default VOC values are heavily influenced by the ethane content of the LFG. Available data have shown that there is a range of over 1,500 ppmv in LFG ethane content among landfills.

2.4.4.2 Controlled Emissions — Emissions from landfills are typically controlled by installing a gas collection system, and combusting the collected gas through the use of internal combustion engines, flares, or turbines. Gas collection systems are not 100 percent efficient in collecting landfill gas, so emissions of CH_4 and NMOC at a landfill with a gas recovery system still occur. To estimate controlled emissions of CH_4, NMOC, and other constituents in landfill gas, the collection efficiency of the system must first be estimated. Reported collection efficiencies typically range from 60 to 85 percent, with an average of 75 percent most commonly assumed. Higher collection efficiencies may be achieved at some sites (i.e., those engineered to control gas emissions). If site-specific collection efficiencies are available (i.e., through a comprehensive surface sampling program), then they should be used instead of the 75 percent average.

Controlled emission estimates also need to take into account the control efficiency of the control device. Control efficiencies based on test data for the combustion of CH_4, NMOC, and some speciated organics with differing control devices are presented in Table 2.4-3. Emissions from the control devices need to be added to the uncollected emissions to estimate total controlled emissions.

Controlled CH_4, NMOC, and speciated emissions can be calculated with equation 5. It is assumed that the landfill gas collection and control system operates 100 percent of the time. Minor durations of system downtime associated with routine maintenance and repair (i.e., 5 to 7 percent) will not appreciably effect emission estimates. The first term in equation 5 accounts for emissions from uncollected landfill gas, while the second term accounts for emissions of the pollutant that were collected but not combusted in the control or utilization device:

$$CM_P = \left[UM_P * \left(1 - \frac{\eta_{col}}{100}\right)\right] + \left[UM_P * \frac{\eta_{col}}{100} * \left(1 - \frac{\eta_{cnt}}{100}\right)\right] \qquad (5)$$

where:

CM_P = Controlled mass emissions of pollutant P, kg/yr;

UM_P = Uncontrolled mass emissions of P, kg/yr (from equation 4 or the Landfill Air Emissions Estimation Model);

η_{col} = Collection efficiency of the landfill gas collection system, percent; and

η_{cnt} = Control efficiency of the landfill gas control or utilization device, percent.

Emission factors for the secondary compounds, CO and NO_x, exiting the control device are presented in Tables 2.4-4 and 2.4-5. These emission factors should be used when equipment vendor guarantees are not available.

Controlled emissions of CO_2 and sulfur dioxide (SO_2) are best estimated using site-specific landfill gas constituent concentrations and mass balance methods.[68] If site-specific data are not available, the data in tables 2.4-1 through 2.4-3 can be used with the mass balance methods that follow.

Controlled CO_2 emissions include emissions from the CO_2 component of landfill gas (equivalent to uncontrolled emissions) and additional CO_2 formed during the combustion of landfill gas. The bulk of the CO_2 formed during landfill gas combustion comes from the combustion of the CH_4 fraction. Small quantities will be formed during the combustion of the NMOC fraction, however, this typically amounts to less than 1 percent of total CO_2 emissions by weight. Also, the formation of CO through incomplete combustion of landfill gas will result in small quantities of CO_2 not being formed. This contribution to the overall mass balance picture is also very small and does not have a significant impact on overall CO_2 emissions.[68]

The following equation which assumes a 100 percent combustion efficiency for CH_4 can be used to estimate CO_2 emissions from controlled landfills:

$$CM_{CO_2} = UM_{CO_2} + \left[UM_{CH_4} * \frac{\eta_{col}}{100} * 2.75 \right] \qquad (6)$$

where:

CM_{CO_2} = Controlled mass emissions of CO_2, kg/yr;
UM_{CO_2} = Uncontrolled mass emissions of CO_2, kg/yr (from equation 4 or the Landfill Air Emission Estimation Model);
UM_{CH_4} = Uncontrolled mass emissions of CH_4, kg/yr (from equation 4 on the Landfill Air Emission Estimation Model);
η_{col} = Efficiency of the landfill gas collection system, percent; and
2.75 = Ratio of the molecular weight of CO_2 to the molecular weight of CH_4.

To prepare estimates of SO_2 emissions, data on the concentration of reduced sulfur compounds within the landfill gas are needed. The best way to prepare this estimate is with site-specific information on the total reduced sulfur content of the landfill gas. Often these data are expressed in ppmv as sulfur (S). Equations 3 and 4 should be used first to determine the uncontrolled mass emission rate of reduced sulfur compounds as sulfur. Then, the following equation can be used to estimate SO_2 emissions:

$$CM_{SO_2} = UM_S * \frac{\eta_{col}}{100} * 2.0 \qquad (7)$$

where:

CM_{SO_2} = Controlled mass emissions of SO_2, kg/yr;
UM_S = Uncontrolled mass emissions of reduced sulfur compounds as sulfur, kg/yr (from equations 3 and 4);
η_{col} = Efficiency of the landfill gas collection system, percent; and
2.0 = Ratio of the molecular weight of SO_2 to the molecular weight of S.

The next best method to estimate SO_2 concentrations, if site-specific data for total reduced sulfur compounds as sulfur are not available, is to use site-specific data for speciated reduced sulfur compound concentrations. These data can be converted to ppmv as S with equation 8. After the total reduced sulfur as S has been obtained from equation 8, then equations 3, 4, and 7 can be used to derive SO_2 emissions.

$$C_S = \sum_{i=1}^{n} C_P * S_P \qquad (8)$$

where:

C_S = Concentration of total reduced sulfur compounds, ppmv as S (for use in equation 3);
C_P = Concentration of each reduced sulfur compound, ppmv;
S_P = Number of moles of S produced from the combustion of each reduced sulfur compound (i.e., 1 for sulfides, 2 for disulfides); and
n = Number of reduced sulfur compounds available for summation.

If no site-specific data are available, a value of 46.9 ppmv can be assumed for C_S (for use in equation 3). This value was obtained by using the default concentrations presented in Table 2.4-1 for reduced sulfur compounds and equation 8.

Hydrochloric acid [Hydrogen Chloride (HCl)] emissions are formed when chlorinated compounds in LFG are combusted in control equipment. The best methods to estimate emissions are mass balance methods that are analogous to those presented above for estimating SO_2 emissions. Hence, the best source of data to estimate HCl emissions is site-specific LFG data on total chloride [expressed in ppmv as the chloride ion (Cl^-)]. If these data are not available, then total chloride can be estimated from data on individual chlorinated species using equation 9 below. However, emission estimates may be underestimated, since not every chlorinated compound in the LFG will be represented in the laboratory report (i.e., only those that the analytical method specifies).

$$C_{Cl} = \sum_{i=1}^{n} C_P * Cl_P \qquad (9)$$

where:

C_{Cl} = Concentration of total chloride, ppmv as Cl^- (for use in equation 3);
C_P = Concentration of each chlorinated compound, ppmv;
Cl_P = Number of moles of Cl^- produced from the combustion of each chlorinated compound (i.e., 3 for 1,1,1-trichloroethane); and
n = Number of chlorinated compounds available for summation.

After the total chloride concentration (C_{Cl}) has been estimated, equations 3 and 4 should be used to determine the total uncontrolled mass emission rate of chlorinated compounds as chloride ion (UM_{Cl}). This value is then used in equation 10 below to derive HCl emission estimates:

$$CM_{HCl} = UM_{Cl} * \frac{\eta_{col}}{100} * 1.03 * \left(\frac{\eta_{cnt}}{100}\right) \qquad (10)$$

where:

CM_{HCl} = Controlled mass emissions of HCl, kg/yr;
UM_{Cl} = Uncontrolled mass emissions of chlorinated compounds as chloride, kg/yr (from equations 3 and 4);
η_{col} = Efficiency of the landfill gas collection system, percent;
1.03 = Ratio of the molecular weight of HCl to the molecular weight of Cl^-; and
η_{cnt} = Control efficiency of the landfill gas control or utilization device, percent.

In estimating HCl emissions, it is assumed that all of the chloride ion from the combustion of chlorinated LFG constituents is converted to HCl. If an estimate of the control efficiency, η_{cnt}, is not available, then the high end of the control efficiency range for the equipment listed in Table 9 should be used. This assumption is recommended to assume that HCl emissions are not under-estimated.

If site-specific data on total chloride or speciated chlorinated compounds are not available, then a default value of 42.0 ppmv can be used for C_{Cl}. This value was derived from the default LFG constituent concentrations presented in Table 2.4-1. As mentioned above, use of this default may produce underestimates of HCl emissions since it is based only on those compounds for which analyses have been performed. The constituents listed in Table 2.4-1are likely not all of the chlorinated compounds present in LFG.

The reader is referred to Sections 11.2-1 (Unpaved Roads, SCC 50100401), and 11-2.4 (Heavy Construction Operations) of Volume I, and Section II-7 (Construction Equipment) of Volume II, of the AP-42 document for determination of associated fugitive dust and exhaust emissions from these emission sources at MSW landfills.

2.4.5 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Supplemnt D (8/98) is a major revision of the text and recommended emission factors conained in the section. The most significant revisions to this section since publication in the Fifth Edition are summarized below.

- The equations to calculate the CH_4, CO_2 and other constituents were simplified.
- The default L_0 and k were revised based upon an expanded base of gas generation data.
- The default ratio of CO_2 to CH_4 was revised based upon averages observed in available source test reports.
- The default concentrations of LFG constituents were revised based upon additional data.
- Additional control efficiencies were included and existing efficiencies were revised based upon additional emission test data.
- Revised and expanded the recommended emission factors for secondary compounds emitted from typical control devices.

Supplement E (11/98) includes correction in equation 10 and a very minor change in the molecular weights for 1,1,1-Trichloroethane (methyl chloroform), 1,1-Dichloroethane, 1,2-Dichloropropane and Trichloroethylene (trichloroethene) presented in Table 2.4-1 to agree with values presented in Perry’s Handbook.

Table 2.4-1. DEFAULT CONCENTRATIONS FOR LFG CONSTITUENTS[a]

(SCC 50100402, 50300603)

Compound	Molecular Weight	Default Concentration (ppmv)	Emission Factor Rating
1,1,1-Trichloroethane (methyl chloroform)[a]	133.41	0.48	B
1,1,2,2-Tetrachloroethane[a]	167.85	1.11	C
1,1-Dichloroethane (ethylidene dichloride)[a]	98.97	2.35	B
1,1-Dichloroethene (vinylidene chloride)[a]	96.94	0.20	B
1,2-Dichloroethane (ethylene dichloride)[a]	98.96	0.41	B
1,2-Dichloropropane (propylene dichloride)[a]	112.99	0.18	D
2-Propanol (isopropyl alcohol)	60.11	50.1	E
Acetone	58.08	7.01	B
Acrylonitrile[a]	53.06	6.33	D
Bromodichloromethane	163.83	3.13	C
Butane	58.12	5.03	C
Carbon disulfide[a]	76.13	0.58	C
Carbon monoxide[b]	28.01	141	E
Carbon tetrachloride[a]	153.84	0.004	B
Carbonyl sulfide[a]	60.07	0.49	D
Chlorobenzene[a]	112.56	0.25	C
Chlorodifluoromethane	86.47	1.30	C
Chloroethane (ethyl chloride)[a]	64.52	1.25	B
Chloroform[a]	119.39	0.03	B
Chloromethane	50.49	1.21	B
Dichlorobenzene[c]	147	0.21	E
Dichlorodifluoromethane	120.91	15.7	A
Dichlorofluoromethane	102.92	2.62	D
Dichloromethane (methylene chloride)[a]	84.94	14.3	A
Dimethyl sulfide (methyl sulfide)	62.13	7.82	C
Ethane	30.07	889	C
Ethanol	46.08	27.2	E
Ethyl mercaptan (ethanethiol)	62.13	2.28	D
Ethylbenzene[a]	106.16	4.61	B
Ethylene dibromide	187.88	0.001	E
Fluorotrichloromethane	137.38	0.76	B
Hexane[a]	86.18	6.57	B
Hydrogen sulfide	34.08	35.5	B
Mercury (total)[a,d]	200.61	2.92×10^{-4}	E

Table 2.4-1. (Concluded)

Compound	Molecular Weight	Default Concentration (ppmv)	Emission Factor Rating
Methyl ethyl ketone[a]	72.11	7.09	A
Methyl isobutyl ketone[a]	100.16	1.87	B
Methyl mercaptan	48.11	2.49	C
Pentane	72.15	3.29	C
Perchloroethylene (tetrachloroethylene)[a]	165.83	3.73	B
Propane	44.09	11.1	B
t-1,2-dichloroethene	96.94	2.84	B
Trichloroethylene (trichloroethene)[a]	131.40	2.82	B
Vinyl chloride[a]	62.50	7.34	B
Xylenes[a]	106.16	12.1	B

NOTE: This is not an all-inclusive list of potential LFG constituents, only those for which test data were available at multiple sites. References 10-67. Source Classification Codes in parentheses.

[a] Hazardous Air Pollutants listed in Title III of the 1990 Clean Air Act Amendments.

[b] Carbon monoxide is not a typical constituent of LFG, but does exist in instances involving landfill (underground) combustion. Therefore, this default value should be used with caution. Of 18 sites where CO was measured, only 2 showed detectable levels of CO.

[c] Source tests did not indicate whether this compound was the para- or ortho- isomer. The para isomer is a Title III-listed HAP.

[d] No data were available to speciate total Hg into the elemental and organic forms.

Table 2.4-2. DEFAULT CONCENTRATIONS OF BENZENE, NMOC, AND TOLUENE BASED ON WASTE DISPOSAL HISTORY[a]

(SCC 50100402, 50300603)

Pollutant	Molecular Weight	Default Concentration (ppmv)	Emission Factor Rating
Benzene[b]	78.11		
Co-disposal		11.1	D
No or Unknown co-disposal		1.91	B
NMOC (as hexane)[c]	86.18		
Co-disposal		2420	D
No or Unknown co-disposal		595	B
Toluene[b]	92.13		
Co-disposal		165	D
No or Unknown co-disposal		39.3	A

[a] References 10-54. Source Classification Codes in parentheses.

[b] Hazardous Air Pollutants listed in Title III of the 1990 Clean Air Act Amendments.

[c] For NSPS/Emission Guideline compliance purposes, the default concentration for NMOC as specified in the final rule must be used. For purposes not associated with NSPS/Emission Guideline compliance, the default VOC content at co-disposal sites = 85 percent by weight (2,060 ppmv as hexane); at No or Unknown sites = 39 percent by weight 235 ppmv as hexane).

Table 2.4-3. CONTROL EFFICIENCIES FOR LFG CONSTITUENTS[a]

Control Device	Constituent[b]	Control Efficiency (%) Typical	Range	Rating
Boiler/Steam Turbine (50100423)	NMOC	98.0	96-99+	D
	Halogenated Species	99.6	87-99+	D
	Non-Halogenated Species	99.8	67-99+	D
Flare[c] (50100410) (50300601)	NMOC	99.2	90-99+	B
	Halogenated Species	98.0	91-99+	C
	Non-Halogenated Species	99.7	38-99+	C
Gas Turbine (50100420)	NMOC	94.4	90-99+	E
	Halogenated Species	99.7	98-99+	E
	Non-Halogenated Species	98.2	97-99+	E
IC Engine (50100421)	NMOC	97.2	94-99+	E
	Halogenated Species	93.0	90-99+	E
	Non-Halogenated Species	86.1	25-99+	E

[a] References 10-67. Source Classification Codes in parentheses.

[b] Halogenated species are those containing atoms of chlorine, bromine, fluorine, or iodine. For any equipment, the control efficiency for mercury should be assumed to be 0. See section 2.4.4.2 for methods to estimate emissions of SO_2, CO_2, and HCl.

[c] Where information on equipment was given in the reference, test data were taken from enclosed flares. Control efficiencies are assumed to be equally representative of open flares.

Table 2.4-4. (Metric Units) EMISSION FACTORS FOR SECONDARY COMPOUNDS EXITING CONTROL DEVICES[a]

Control Device	Pollutant[b]	$kg/10^6$ dscm Methane	Emission Factor Rating
Flare[c] (50100410) (50300601)	Nitrogen dioxide	650	C
	Carbon monoxide	12,000	C
	Particulate matter	270	D
IC Engine (50100421)	Nitrogen dioxide	4,000	D
	Carbon monoxide	7,500	C
	Particulate matter	770	E
Boiler/Steam Turbine[d] (50100423)	Nitrogen dioxide	530	D
	Carbon monoxide	90	E
	Particulate matter	130	D
Gas Turbine (50100420)	Nitrogen dioxide	1,400	D
	Carbon monoxide	3,600	E
	Particulate matter	350	E

[a] Source Classification Codes in parentheses. Divide $kg/10^6$ dscm by 16,700 to obtain kg/hr/dscmm.
[b] No data on PM size distributions were available, however for other gas-fired combustion sources, most of the particulate matter is less than 2.5 microns in diameter. Hence, this emission factor can be used to provide estimates of PM-10 or PM-2.5 emissions. See section 2.4.4.2 for methods to estimate CO_2, SO_2, and HCl.
[c] Where information on equipment was given in the reference, test data were taken from enclosed flares. Control efficiencies are assumed to be equally representative of open flares.
[d] All source tests were conducted on boilers, however emission factors should also be representative of steam turbines. Emission factors are representative of boilers equipped with low-NO_x burners and flue gas recirculation. No data were available for uncontrolled NO_x emissions.

Table 2.4-5. (English Units) EMISSION RATES FOR SECONDARY COMPOUNDS EXITING CONTROL DEVICES[a]

Control Device	Pollutant[b]	$lb/10^6$ dscf Methane	Emission Factor Rating
Flare[c] (50100410) (50300601)	Nitrogen dioxide	40	C
	Carbon monoxide	750	C
	Particulate matter	17	D
IC Engine (50100421)	Nitrogen dioxide	250	D
	Carbon monoxide	470	C
	Particulate matter	48	E
Boiler/Steam Turbine[d] (50100423)	Nitrogen dioxide	33	E
	Carbon monoxide	5.7	E
	Particulate matter	8.2	E
Gas Turbine (50100420)	Nitrogen dioxide	87	D
	Carbon monoxide	230	D
	Particulate matter	22	E

[a] Source Classification Codes in parentheses. Divide $lb/10^6$ dscf by 16,700 to obtain lb/hr/dscfm.
[b] Based on data for other combustion sources, most of the particulate matter will be less than 2.5 microns in diameter. Hence, this emission rate can be used to provide estimates of PM-10 or PM-2.5 emissions. See section 2.4.4.2 for methods to estimate CO_2, SO_2, and HCl.
[c] Where information on equipment was given in the reference, test data were taken from enclosed flares. Control efficiencies are assumed to be equally representative of open flares.
[d] All source tests were conducted on boilers, however emission factors should also be representative of steam turbines. Emission factors are representative of boilers equipped with low-NO_x burners and flue gas recirculation. No data were available for uncontrolled NO_x emissions.

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75. Normandeau Associates, Inc., *Emissions Testing of a Landfill Gas Flare at Contra Costa Landfill, Antioch, California, March 22, 1994 and April 22, 1994*, May 17, 1994.

76. Roe, S.M., et. al., *Methodologies for Quantifying Pollution Prevention Benefits from Landfill Gas Control and Utilization*, Prepared for U.S. EPA, Office of Air and Radiation, Air and Energy Engineering Laboratory, EPA-600/R-95-089, July 1995.

ATTACHMENT 7.5

WASTE INDUSTRY AIR COALITION VALUES

Waste Industry Air Coalition
Comparison of Recent Landfill Gas Analyses with Historic AP-42 Values

by

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Summary

The Waste Industry Air Coalition (WIAC) is comprised of the Solid Waste Association of North America (SWANA) and the National Solid Wastes Management Association. Members of these associations have reported that the AP-42 landfill gas (LFG) defaults, derived from analyses made on average 13 years ago, overestimate the current trace LFG constituent levels.

The WIAC previously submitted three reports addressing LFG trace constituents. An initial report submitted in August 1999[1] showed a continuous long term hazardous air pollutants (HAP) decline at six California landfills (see LFG Constituent Declines below). HAP levels typically declined five fold or more over a ten year period. A second WIAC report was submitted November 1999[2] showing that Hydrogen Chloride levels in recent source tests are more than four times less that the AP-42 default. A third WIAC report was submitted in May 2000[3] showing that the average of recent non-methane organic compound (NMOC) analyses at 144 landfills was 30% less than the current AP-42 defaults.

This fourth report presents a nationwide WIAC survey of recent trace LFG constituent analyses. The WIAC obtained test results from 75 landfills that were made on average within the last two years. The WIAC survey found that the current trace constituent levels are two to four times less than the AP-42 defaults. For the compounds associated with greater health risk at high concentrations, the differences were yet larger. These findings support those from the previous three reports that the AP-42 defaults substantially overstate current LFG constituent levels.

The decline in LFG constituent levels over time may be due to a variety of factors including:

- improvement of analytical methodologies that better identify and quantify trace constituents;
- federal introduction of waste management regulations that strictly regulate hazardous waste disposal;
- federal introduction of municipal solid waste landfill regulations that detect and prevent disposal of unacceptable hazardous wastes; and
- industry transition to processes and products requiring less or no hazardous materials.

In view of the detected decline, it is strongly recommended that the AP-42 defaults be revised to reflect the current LFG constituent levels. From the California landfill results, showing a continuous long term declining trend in the LFG constituents, it can be reasonably anticipated that additional declines will occur. As a result, two further recommendations are offered. First, older AP-42 data should be purged, to eliminate unrepresentative results, and replaced with current data. The most recent AP-42 revision in 1995 only added new but did not purge older values. Second, U.S. EPA should recognize landfills as a unique source for which its AP-42 defaults will need to change over time. U.S. EPA should consider additional future updates of the AP-42 to address the anticipated declines.

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[1] "Documentation of Large MSW Landfill Gas Constituent Declines From US EPA AP-42 Default Values", Ray Huitric, County Sanitation Districts of Los Angeles County, and submitted by John Skinner, Executive Director and CEO, SWANA, on August 30, 1999.

[2] Correspondence titled "Submission of Hydrogen Chloride Test Data from Landfill Gas Fired Combustion Devices" dated November 1999 from Edwin P. Valis, Jr., Project Manager, EMCON to Roy Huntley, Emission Factor and Inventory Group, OAQPS, U.S. Environmental Protection Agency.

[3] Correspondence titled "Preliminary Data on Non-Methane Organic Compound (NMOC) Concentrations in Landfill Gas" dated May 9, 2000 from Edward W. Repa, Director of Environmental Programs, NSWMA to Roy Huntley, Emission Factor and Inventory Group, OAQPS, U.S. Environmental Protection Agency.

The WIAC will provide the analyses it collected to U.S. EPA for use in developing new AP-42 values. Since it is recognized that this process will require time, it is recommended that the U.S. EPA make the results contained in this report available on its Internet site as an interim reference.

Report Objectives

This report documents actual landfill gas concentrations for compounds of concern using a national database derived from laboratory analyses employing U.S. EPA standard methods. Herein we establish that differences between the data presented in this report and the current AP-42 default values warrant their full-scale review by U.S. EPA. WIAC believes that the data presented here far better represent current conditions for many compounds and that such a review is well warranted.

Procedures and Results

AP-42 data management procedures were applied to the portion of the WIAC data set having AP-42 default values. The data management procedures address, for example, data screening, air dilution, and data averaging methods. The results of these procedures follow.

Data Collection and Screening

WIAC collected LFG analyses from 75 landfills in sixteen states. This information was processed using U.S. EPA's AP-42 data management procedures. U.S. EPA uses a screening process to remove analytically unacceptable, poorly documented or questionable results.[4] A review of the collected data indicated that the sample analyses would likely pass the AP-42 data screening process. The reported samples were normal, untreated LFG derived from typical gas collection systems. The analytical methodologies appeared to be consistent with those accepted by U.S. EPA.

The analytical results were corrected for air dilution using fixed gas analyses (specifically, methane and carbon dioxide). Several samples lacked either or both methane and carbon dioxide and were excluded. Additionally, some results appeared to be default values (e.g., 50% methane and 50% carbon dioxide) or were unusually high; these were excluded as well. In all, analyses from 27 landfills were omitted from subsequent evaluations.

Data Rating

The data for compounds from the remaining 48 landfills were rated from "A" (strongest) to "E" (weakest) using U.S. EPA's rating system. This process largely depends on the number of 'good' results (A for 20 and up, B for 10 to 19, C for 6 to 9, D for 3 to 5, E for 1 to 2). U.S. EPA also adjusts the rating for a compound's variability. If the arithmetic standard deviation is twice or greater than EPA's default value, then the rating is decreased by one letter. Table 1 summarizes the WIAC rating results and compares these with U.S. EPA's AP-42 data set for 43 compounds.

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[4] "EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 2.4 MUNICIPAL SOLID WASTE LANDFILLS REVISED" Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, August 1997; see Table 4-1

Table 1. Count of AP-42 compounds at each rating level (A is strongest; total of 43 compounds).

	Count	
Rating	WIAC	AP-42
A	12	4
B	14	21
C	2	8
D	6	6
E	9	4

The overall rating of the WIAC database is essentially the same as that for U.S. EPA's. For example when the letter grade is expressed as a numeric value (e.g., A = 1, B =2, etc.), the average ratings for the WIAC and U.S. EPA data sets are identical.

Nondetects

AP-42 directs that in general nondetect values should be halved then treated as "real" data. However if a nondetect exceeds by two times the maximum of the detects for a compound, then it should be discarded. It appears that the AP-42 guidance directs that this should be done on a facility-by-facility basis as well as on an emission category basis. However the guidance is unclear. A conservative approach was taken by eliminating only nondetects that were more than double the maximum detection among all facilities.

AP-42 also directs that if all values are nondetects then the result should be clearly indicated as such. U.S. EPA does not indicate which values reported within the LFG portion of AP-42 are nondetects.

Data Averaging

AP-42 specifies that data from a single landfill are to be arithmetically averaged. The result from each landfill is then further averaged using an arithmetic average, geometric mean, or median depending on whether the landfill data are normally distributed, lognormally distributed, or neither, respectively. The distribution type was determined for each compound using the probability plot correlation coefficient method.[5] Where fewer than four landfills reported a compound, the distribution type could not be determined. Instead, the distribution type originally used by U.S. EPA in AP-42 was employed. The distribution type was found to differ from U.S. EPA's for sixteen compounds.

The WIAC data set was averaged using both U.S. EPA's original and the newer WIAC's distribution types (see Table 2). The original distribution types were applied so that an "apples to apples" comparison was possible. Doing otherwise could either create or obscure differences between the data sets. The averages calculated based on U.S. EPA's and WIAC's averaging types are shown in the WIAC column labeled "1" and "2", respectively. Values in WIAC column 2 having a different distribution type are highlighted in gray. The results using the two data averaging methods are discussed in Data Summary below.

Codisposal Landfills

Because of detected statistical differences, EPA developed separate codisposal and municipal solid waste (MSW) only default AP-42 levels for toluene and benzene. All other default values

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[5] This test was developed by J.J. Filliben in 1975 as reported in "Statistical Training Course for Ground-Water Monitoring Data Analysis", sponsored by the U.S. Environmental Protection Agency Office of Solid Waste, 1992.

were developed from the combined data sets. WIAC surveyed five codisposal sites and 70 MSW-only sites. The WIAC toluene and benzene data were separately analyzed by disposal site type. No significant differences were found between types of disposal sites for other compounds with one exception. Carbon tetrachloride was detected at one codisposal site but at none of the MSW-only disposal sites. The WIAC value for carbon tetrachloride includes the codisposal sites as these had only a slight effect on the calculated value. The value is reported in Table 2 as a 'nondetect' with a footnote indicating that it was found at one codisposal site.

Data Summary

The WIAC results are compared with AP-42 default concentrations in Table 2. WIAC 1 and 2 show the data prepared using past AP-42 and WIAC updated averaging methods, respectively (see Data Averaging above). The WIAC 1 and 2 concentrations are similarly reduced from AP-42 values by 76% and 80%, respectively. However simple alkane and alcohol compounds for which relatively few analyses were available disproportionately skewed the results. Omitting these compounds shows identical 56% overall reductions. Nearly identical reductions are also noted for aromatic (58%) and chlorinated (79%) compounds. Even though the AP-42 and WIAC averaging methods do not have any large overall effect, the two methods did lead to very significant differences for individual compounds (e.g., note those for 1,1,2,2-Tetrachloroethane).

Discussion

AP-42 and WIAC Differences

The differences between the AP-42 default values and the WIAC survey results may be traced to various factors. It was noted above that there are differences in the age of analyses between the AP-42 and WIAC data sets. Trends in LFG constituents have been well documented and are addressed in the next section. Apart from differences in the age of analyses, it was found that procedures used in U.S. EPA's preparation of the AP-42 defaults departed from the AP-42 guidance[6] in its use of nondetects and the minimum number of sources used for developing default values.

The guidance specifies that nondetects should be used in the development of default values. However all nondetects were discarded in at least one AP-42 update.[7] Nondetects may be discarded under certain circumstances specified by the guidance where these are much greater in magnitude than detects (doing otherwise would bias the default values high). However, the AP-42 documentation does not identify which values are detects or nondetects making it impossible to implement this procedure. Finally, the guidance states that default values developed entirely from nondetects should be clearly identified as such. Since nondetects are not documented, this procedure cannot be carried out.

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[6] "Procedures for Preparing Emission Factor Documents" Office of Air quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1997 (EPA-454/R-95-015 REVISED).

[7] Phone communication (June 2000) with Stephen Roe, U.S. EPA contractor for past AP-42 revisions.

Table 2. WIAC results compared with AP-42 defaults. WIAC-1 values use AP-42 averaging methods. Some WIAC-2 values, grayed in column 2, use different methods (see text).

	WIAC	Concentration, ppmv		
Compound	**Sites**	**AP-42**	**WIAC-1**	**WIAC-2**
1,1,1-Trichloroethane (methyl chloroform)	46	0.48	0.168	0.168
1,1,2,2-Tetrachloroethane	19	1.11	0.070	0.005
1,1-Dichloroethane (ethylidene dichloride)	45	2.35	0.741	0.741
1,1-Dichloroethene (vinylidene chloride)	45	0.2	0.092	0.092
1,2-Dichloroethane (ethylene dichloride)	47	0.41	0.120	0.120
1,2-Dichloropropane (propylene dichloride)	17	0.18	0.023	0.023
2-Propanol (isopropyl alcohol)	3	50.1	7.908	7.908
Acetone	8	7.01	6.126	7.075
Acrylonitrile	3	6.33	<0.036	<0.036
Benzene (Co-Disposal)	3	11.1	10.376	10.376
Benzene (No Co-Disposal)	44	1.91	0.972	0.972
Bromodichloromethane	7	3.13	<0.311	<0.264
Carbon disulfide	31	0.58	0.320	0.221
Carbon tetrachloride	37	0.004	<0.007*	<0.007*
Carbonyl sulfide	29	0.49	0.183	0.183
Chlorobenzene	46	0.25	0.227	0.227
Chlorodifluoromethane (Freon 22)	1	1.3	0.355	0.355
Chloroethane (ethyl chloride)	21	1.25	0.239	0.448
Chloroform	45	0.03	0.021	0.010
Chloromethane	8	1.21	0.249	0.136
Dichlorobenzene	34	0.21	1.607	1.448
Dichlorodifluoromethane (Freon 12)	19	15.7	1.751	0.964
Dichloromethane (Methylene Chloride)	47	14.3	3.395	3.395
Dimethyl sulfide (methyl sulfide)	34	7.82	6.809	6.809
Ethane	1	889	7.943	7.943
Ethanol	4	27.2	118.618	64.425
Ethyl mercaptan (Ethanethiol)	36	2.28	1.356	0.226
Ethylbenzene	26	4.61	6.789	6.789
Ethylene dibromide	30	0.001	<0.046	<0.005
Fluorotrichloromethane (Freon 11)	25	0.76	0.327	0.327
Hexane	4	6.57	2.324	2.063
Hydrogen sulfide	40	35.5	23.578	23.578
Methyl ethyl ketone	8	7.09	10.557	12.694
Methyl isobutyl ketone	7	1.87	0.750	0.750
Methyl mercaptan	36	2.49	1.292	1.266
Perchloroethylene (tetrachloroethylene)	48	3.73	1.193	1.193
Propane	1	11.1	14.757	19.858
Toluene (Co-Disposal)	3	165	37.456	37.456
Toluene (No Co-Disposal)	43	39.3	25.405	25.405
trans-1,2 Dichlorethene	1	2.84	0.051	0.051
Trichloroethylene (trichloroethene)	48	2.82	0.681	0.681
Vinyl Chloride	46	7.34	1.077	1.077
Xylenes	45	12.1	16.582	16.582

Note: “<” indicates that the compound was detected at none of the WIAC sites.

[*] Carbon Tetrachloride was detected at one codisposal site but at none of 35 MSW-only disposal sites.

The guidance also states that a minimum of ten sources should be used in developing a default value (use of fewer sources results in unreliable values). However several of the AP-42 defaults were developed from many fewer samples and sometimes just one sample. In view of the high variability observed between landfill test results, it is recommended that U.S. EPA carefully review its practices in developing AP-42 defaults with fewer than ten samples. At a minimum, defaults derived from limited data should be clearly identified and users cautioned as to their questionable reliability.

LFG Constituent Declines

Large, long term declines in LFG HAP values were documented in the August 1999 WIAC report. This report focused on four active and two closed landfills in Southern California. The decline at the active landfills was concurrent with implementation of waste-screening programs that prevented the disposal of incidental amounts of hazardous wastes present in the municipal solid waste stream starting in the early 1980’s. U.S. EPA’s Resource Conservation and Recovery Act (RCRA) rules for MSW landfills, implemented starting October 9, 1991 (40 CFR 258.20) also began requiring such exclusion programs on a nationwide basis. Additionally, the U.S. EPA established Subtitle C requirements per the 1984 RCRA amendments that set minimum treatment standards for listed wastes. This program ensured that the treatment residuals were placed in Subtitle C landfills. The combination of these programs likely reduced or eliminated incidental hazardous waste disposal in active MSW landfills.

An attempt was made to determine whether a similar long term decline could be detected at other active landfills represented in the AP-42 database. A comparison was made of those sites that were reported by both EPA and WIAC. However it was found that many of the AP-42 landfills had coded names. The only active sites identifiably the same were those already reported in the August 1999 report. It is recommended that U.S. EPA identify the coded AP-42 landfills so that a meaningful comparison could be made with the WIAC results.

The LFG HAP decline for the two closed landfills in the August 1999 report would be unrelated to improved hazardous waste management practices. However the anaerobic decomposition processes at these sites are likely to have brought about such declines through one or more mechanism. HAP compounds will tend to volatilize into newly generated anaerobic gases; the gases together with the trace constituents will ultimately exit the landfill, removing the HAP compounds. Additionally, anaerobic processes may destroy or transform some HAP compounds.

Another factor to consider in the decline of HAP compounds is the effect of improved laboratory methodologies in recent years. Areas of improvement include utilization of more sophisticated equipment and adoption of standardized procedures for all analytical aspects. Some of the improved procedures include sample container preparation, instrument calibration, and quality assurance acceptance criteria.

Equipment and procedure improvements reduce the scatter of data, increase data reliability, minimize compound misidentifications, and lower detection limits. Detection limits are especially important since several of the AP-42 compounds have few or no detections; improved detection limits would tend to lower the calculated AP-42 defaults. One laboratory submitting data for this report indicated that detection limits were more than halved in the last five years.

Urban Air Toxics Strategy

The U.S. EPA used AP-42 defaults for the recently completed Urban Air Toxics (UAT) Strategy. A review of the UAT findings based on the newer WIAC results is presented in Table 3. For all compounds detected in LFG, municipal landfills dropped in rank among industrial sources. The drop was typically from sixth to at least thirteenth or more. Four of the nine compounds dropped from the ranking and rank no more than 17th. The average MSW landfill contribution per compound dropped from 13% to 1.5%. One of the more dramatic findings concerns U.S. EPA's original attribution of 84% of all 1,1,2,2-Tetrachloroethane emissions to landfills; the WIAC findings show that the landfill emission level is about 2% of all sources. These findings indicate that municipal landfills have markedly less emissions, compared to other industrial sources, than U.S. EPA previously estimated.

Table 3. Summary of changes to Urban Air Toxic (UAT) emission estimates based on changes from AP-42 defaults to current compound levels measured by WIAC.

	Annual Tons		Portion of UAT Inventory		Rank		Number of Sources
Compound	**AP-42**	**WIAC**	**AP-42**	**WIAC**	**AP-42**	**WIAC**	
1,1,2,2-Tetrachloroethane	216	1.0	84.08%	2.37%	1	5	16
1,2-Dichloropropane	23.6	3.0	3.59%	1.48%	6	8	12
Acrylonitrile	389	2.2	15.28%	0.10%	3	15	17
Benzene	173	87.9	3.86%	2.00%	11	13	17
Chloroform	4.17	1.3	4.94%	1.63%	6	9	17
Ethylene Dichloride	47	13.7	1.15%	0.34%	10	*	17
Methylene Chloride	1550	367	1.67%	0.40%	11	*	17
Tetrachloroethylene	717	229	0.59%	0.19%	6	*	17
Trichloroethylene	429	104	0.64%	0.16%	13	*	17
Vinyl Chloride	531	77.9	19.65%	3.46%	2	4	17
Vinylidene Chloride	22.5	10.3	10.10%	3.45%	4	5	14

* Landfill emissions are less than for other ranked sources.

Conclusions

WIAC conducted a national survey of recent LFG analyses. Recent results from 75 landfills were analyzed using AP-42 methodologies. The AP-42 defaults were found to typically overestimate current levels by two to four hundred percent. For some of the more health significant compounds, the differences were larger yet. The overestimated AP-42 values may potentially misdirect U.S. EPA's policy development. For example, the recently completed Urban Air Toxics Strategy appears to have substantially overestimated actual landfill emissions. Furthermore, the existing AP-42 default values may adversely impact individual landfills required to use these values.

As a result, WIAC believes that the AP-42 defaults should be revised to reflect the decline in LFG constituents. The most recent AP-42 revision in 1995 added new data to older values and averaged the combined data sets. This approach is appropriate only for data that does not trend. It is recommended that older data be purged and replaced using current data presented in this paper.

ATTACHMENT 7.6

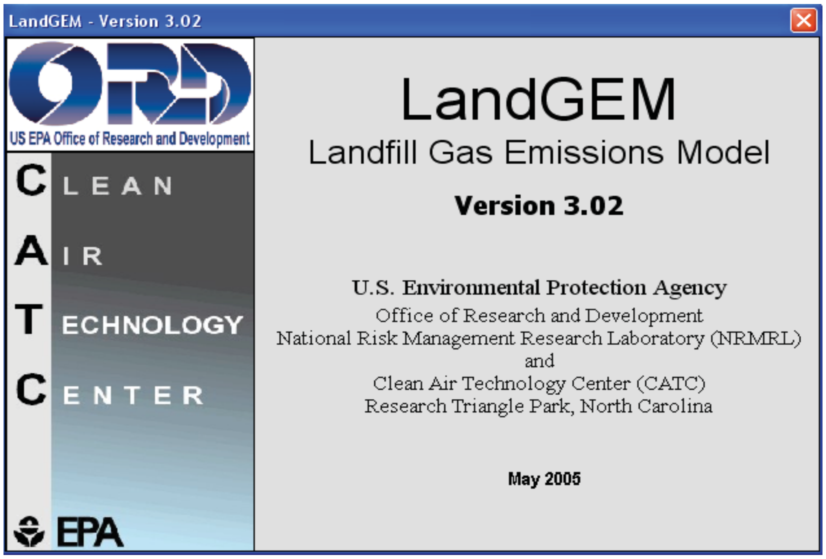
LANDGEM MODEL OUT FOR LANDFILL GAS GENERATION

SUMMARY OF LANDGEM MODEL OUTPUTS FOR TOTAL LANDFILL GAS GENERATION

Two models were required to estimate total landfill gas generation from the landfill as the LandGEM Model cannot accpet a waste intake of more than 80 years. Therefore the first model encompasses gas generated from waste intake between 1977 and 2056, and the second model represents the gas generated from waste intake between 2057 and 2081. The following table represents the summation of the LandGEM model results predicted for both models.

Year	Waste-In-Place (in tons)	LandGEM1	LandGEM2	LandGEM Total
1977	0	0		0
1978	3,650	0.3		0.3
1979	7,350	1		1
1980	11,100	1		1
1981	14,850	1		1
1982	18,650	2		2
1983	22,500	2		2
1984	26,350	2		2
1985	30,250	3		3
1986	34,200	3		3
1987	38,150	3		3
1988	343,490	29		29
1989	648,830	55		55
1990	954,170	81		81
1991	1,179,083	99		99
1992	1,424,772	119		119
1993	1,710,484	143		143
1994	1,996,196	166		166
1995	2,281,908	190		190
1996	2,567,620	213		213
1997	2,868,831	237		237
1998	3,161,906	260		260
1999	3,407,062	279		279
2000	3,672,479	300		300
2001	3,944,184	321		321
2002	4,205,712	341		341
2003	4,476,494	362		362
2004	4,812,942	388		388
2005	5,158,101	415		415
2006	5,458,922	437		437
2007	6,043,887	484		484
2008	6,654,732	533		533
2009	7,210,143	576		576
2010	7,636,743	609		609
2011	8,147,138	648		648
2012	8,636,551	685		685
2013	9,065,648	717		717
2014	9,446,598	745		745
2015	9,904,711	778		778
2016	10,405,920	816		816
2017	10,864,380	849		849
2018	11,325,132	882		882
2019	11,788,188	916		916
2020	12,253,560	949		949
2021	12,721,258	982		982
2022	13,191,294	1,016		1,016
2023	13,663,681	1,049		1,049
2024	14,138,430	1,082		1,082
2025	14,615,553	1,115		1,115
2026	15,095,061	1,148		1,148
2027	15,576,967	1,181		1,181
2028	16,061,282	1,214		1,214

2029	16,548,019	1,247		1,247
2030	17,037,189	1,280		1,280
2031	17,528,805	1,313		1,313
2032	18,022,880	1,346		1,346
2033	18,519,425	1,379		1,379
2034	19,018,452	1,412		1,412
2035	19,519,975	1,445		1,445
2036	20,024,005	1,478		1,478
2037	20,530,556	1,511		1,511
2038	21,039,639	1,544		1,544
2039	21,551,267	1,576		1,576
2040	22,065,454	1,609		1,609
2041	22,582,212	1,642		1,642
2042	23,101,553	1,675		1,675
2043	23,623,491	1,708		1,708
2044	24,148,039	1,740		1,740
2045	24,675,210	1,773		1,773
2046	25,205,016	1,806		1,806
2047	25,737,472	1,839		1,839
2048	26,272,589	1,872		1,872
2049	26,810,383	1,904		1,904
2050	27,350,865	1,937		1,937
2051	27,894,050	1,970		1,970
2052	28,439,951	2,003		2,003
2053	28,988,581	2,036		2,036
2054	29,539,954	2,068		2,068
2055	30,094,084	2,101		2,101
2056	30,650,985	2,134		2,134
2057	30,650,985	2,167	0	2,167
2058	31,213,469	2,152	48	2,200
2059	31,778,765	2,137	96	2,233
2060	32,346,888	2,122	144	2,265
2061	32,917,851	2,107	191	2,298
2062	33,491,669	2,092	239	2,331
2063	34,068,356	2,078	286	2,364
2064	34,647,927	2,063	334	2,397
2065	35,230,395	2,049	381	2,430
2066	35,815,776	2,035	428	2,463
2067	36,404,084	2,020	475	2,496
2068	36,995,333	2,006	523	2,529
2069	37,589,538	1,992	570	2,562
2070	38,186,715	1,978	616	2,595
2071	38,786,877	1,965	663	2,628
2072	39,390,041	1,951	710	2,661
2073	39,996,220	1,937	757	2,694
2074	40,605,429	1,924	804	2,727
2075	41,217,685	1,910	850	2,760
2076	41,833,003	1,897	897	2,794
2077	42,451,397	1,884	943	2,827
2078	43,072,882	1,871	989	2,860
2079	43,697,476	1,858	1,036	2,893
2080	44,325,192	1,845	1,082	2,927
2081	44,956,047	1,832	1,128	2,960
2082	45,245,910	1,819	1,145	**2,964**
2083	45,245,910	1,806	1,137	2,943
2084	45,245,910	1,794	1,129	2,923
2085	45,245,910	1,781	1,121	2,903
2086	45,245,910	1,769	1,114	2,882
2087	45,245,910	1,756	1,106	2,862
2088	45,245,910	1,744	1,098	2,842



LandGEM - Version 3.02

US EPA Office of Research and Development

CLEAN AIR TECHNOLOGY CENTER

EPA

LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Camino Real Landfill LandGEM (1977-2056)

Date: Wednesday, October 04, 2017

Description/Comments:

The NMOC concentration is from AP-42 for sites with no co-disposal, and the site-specific methane generation rate (k) was taken from the August 1999 Tier III.

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k L_o \left(\frac{M_i}{10} \right) e^{-k t_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)
M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1977**	
Landfill Closure Year (with 80-year limit)	**2056**	
Actual Closure Year (without limit)	***2056***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.007**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**100**	*m* ^{3} */Mg*
NMOC Concentration	**595**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**NMOC**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**Methane**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
1977	3,318	3,650	0	0
1978	3,364	3,700	3,318	3,650
1979	3,409	3,750	6,682	7,350
1980	3,409	3,750	10,091	11,100
1981	3,455	3,800	13,500	14,850
1982	3,500	3,850	16,955	18,650
1983	3,500	3,850	20,455	22,500
1984	3,545	3,900	23,955	26,350
1985	3,591	3,950	27,500	30,250
1986	3,591	3,950	31,091	34,200
1987	277,582	305,340	34,682	38,150
1988	277,582	305,340	312,264	343,490
1989	277,582	305,340	589,845	648,830
1990	204,466	224,913	867,427	954,170
1991	223,354	245,690	1,071,893	1,179,083
1992	259,738	285,712	1,295,248	1,424,772
1993	259,738	285,712	1,554,986	1,710,484
1994	259,738	285,712	1,814,724	1,996,196
1995	259,738	285,712	2,074,462	2,281,908
1996	273,828	301,211	2,334,200	2,567,620
1997	266,432	293,076	2,608,028	2,868,831
1998	222,869	245,156	2,874,460	3,161,906
1999	241,288	265,417	3,097,329	3,407,062
2000	247,004	271,705	3,338,617	3,672,479
2001	237,753	261,528	3,585,621	3,944,184
2002	246,165	270,782	3,823,374	4,205,712
2003	305,862	336,449	4,069,540	4,476,494
2004	313,780	345,158	4,375,402	4,812,942
2005	273,474	300,821	4,689,182	5,158,101
2006	531,787	584,966	4,962,656	5,458,922
2007	555,313	610,845	5,494,443	6,043,887
2008	504,919	555,411	6,049,756	6,654,732
2009	387,818	426,600	6,554,675	7,210,143
2010	463,996	510,396	6,942,494	7,636,743
2011	444,920	489,412	7,406,490	8,147,138
2012	390,089	429,098	7,851,410	8,636,551
2013	346,318	380,950	8,241,498	9,065,648
2014	416,466	458,113	8,587,816	9,446,598
2015	455,645	501,209	9,004,283	9,904,711
2016	416,782	458,460	9,459,927	10,405,920

WASTE ACCEPTANCE RATES (Continued)

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
2017	418,866	460,752	9,876,709	10,864,380
2018	420,960	463,056	10,295,575	11,325,132
2019	423,065	465,371	10,716,535	11,788,188
2020	425,180	467,698	11,139,600	12,253,560
2021	427,306	470,037	11,564,780	12,721,258
2022	429,443	472,387	11,992,086	13,191,294
2023	431,590	474,749	12,421,528	13,663,681
2024	433,748	477,123	12,853,118	14,138,430
2025	435,917	479,508	13,286,866	14,615,553
2026	438,096	481,906	13,722,783	15,095,061
2027	440,287	484,315	14,160,879	15,576,967
2028	442,488	486,737	14,601,165	16,061,282
2029	444,700	489,170	15,043,653	16,548,019
2030	446,924	491,616	15,488,354	17,037,189
2031	449,159	494,074	15,935,278	17,528,805
2032	451,404	496,545	16,384,436	18,022,880
2033	453,661	499,028	16,835,841	18,519,425
2034	455,930	501,523	17,289,502	19,018,452
2035	458,209	504,030	17,745,432	19,519,975
2036	460,500	506,550	18,203,641	20,024,005
2037	462,803	509,083	18,664,141	20,530,556
2038	465,117	511,629	19,126,944	21,039,639
2039	467,442	514,187	19,592,061	21,551,267
2040	469,780	516,758	20,059,504	22,065,454
2041	472,129	519,341	20,529,283	22,582,212
2042	474,489	521,938	21,001,412	23,101,553
2043	476,862	524,548	21,475,901	23,623,491
2044	479,246	527,171	21,952,763	24,148,039
2045	481,642	529,806	22,432,009	24,675,210
2046	484,050	532,455	22,913,651	25,205,016
2047	486,471	535,118	23,397,702	25,737,472
2048	488,903	537,793	23,884,172	26,272,589
2049	491,348	540,482	24,373,075	26,810,383
2050	493,804	543,185	24,864,423	27,350,865
2051	496,273	545,901	25,358,227	27,894,050
2052	498,755	548,630	25,854,500	28,439,951
2053	501,248	551,373	26,353,255	28,988,581
2054	503,755	554,130	26,854,504	29,539,954
2055	506,273	556,901	27,358,258	30,094,084
2056	508,805	559,685	27,864,532	30,650,985

Results

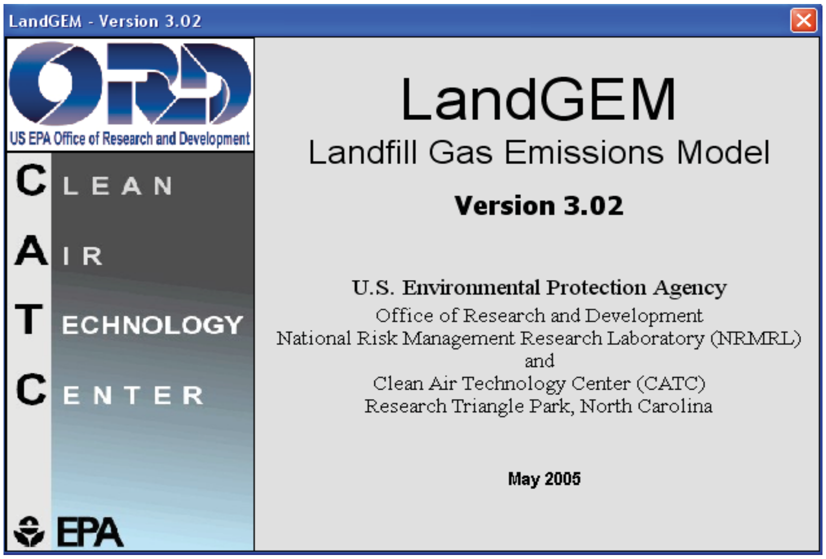
Year	Total landfill gas			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1977	0	0	0	0	0	0
1978	5.783E+00	4.631E+03	3.111E-01	9.876E-03	2.755E+00	1.851E-04
1979	1.161E+01	9.293E+03	6.244E-01	1.982E-02	5.529E+00	3.715E-04
1980	1.747E+01	1.399E+04	9.397E-01	2.983E-02	8.322E+00	5.591E-04
1981	2.329E+01	1.865E+04	1.253E+00	3.977E-02	1.109E+01	7.454E-04
1982	2.914E+01	2.334E+04	1.568E+00	4.977E-02	1.389E+01	9.330E-04
1983	3.504E+01	2.806E+04	1.885E+00	5.984E-02	1.669E+01	1.122E-03
1984	4.090E+01	3.275E+04	2.200E+00	6.984E-02	1.948E+01	1.309E-03
1985	4.679E+01	3.747E+04	2.517E+00	7.991E-02	2.229E+01	1.498E-03
1986	5.272E+01	4.222E+04	2.837E+00	9.004E-02	2.512E+01	1.688E-03
1987	5.861E+01	4.693E+04	3.154E+00	1.001E-01	2.793E+01	1.876E-03
1988	5.420E+02	4.340E+05	2.916E+01	9.256E-01	2.582E+02	1.735E-02
1989	1.022E+03	8.184E+05	5.499E+01	1.745E+00	4.869E+02	3.272E-02
1990	1.499E+03	1.200E+06	8.063E+01	2.559E+00	7.140E+02	4.798E-02
1991	1.845E+03	1.477E+06	9.924E+01	3.150E+00	8.788E+02	5.905E-02
1992	2.221E+03	1.778E+06	1.195E+02	3.793E+00	1.058E+03	7.110E-02
1993	2.658E+03	2.129E+06	1.430E+02	4.540E+00	1.266E+03	8.509E-02
1994	3.092E+03	2.476E+06	1.664E+02	5.281E+00	1.473E+03	9.899E-02
1995	3.523E+03	2.821E+06	1.896E+02	6.017E+00	1.679E+03	1.128E-01
1996	3.952E+03	3.164E+06	2.126E+02	6.748E+00	1.883E+03	1.265E-01
1997	4.401E+03	3.524E+06	2.368E+02	7.516E+00	2.097E+03	1.409E-01
1998	4.835E+03	3.872E+06	2.601E+02	8.257E+00	2.304E+03	1.548E-01
1999	5.190E+03	4.156E+06	2.792E+02	8.863E+00	2.473E+03	1.661E-01
2000	5.574E+03	4.463E+06	2.999E+02	9.519E+00	2.656E+03	1.784E-01
2001	5.966E+03	4.777E+06	3.210E+02	1.019E+01	2.842E+03	1.910E-01
2002	6.338E+03	5.075E+06	3.410E+02	1.082E+01	3.020E+03	2.029E-01
2003	6.723E+03	5.384E+06	3.617E+02	1.148E+01	3.203E+03	2.152E-01
2004	7.209E+03	5.773E+06	3.879E+02	1.231E+01	3.435E+03	2.308E-01
2005	7.706E+03	6.170E+06	4.146E+02	1.316E+01	3.671E+03	2.467E-01
2006	8.129E+03	6.509E+06	4.373E+02	1.388E+01	3.873E+03	2.602E-01
2007	8.999E+03	7.206E+06	4.842E+02	1.537E+01	4.287E+03	2.881E-01
2008	9.904E+03	7.931E+06	5.329E+02	1.691E+01	4.719E+03	3.170E-01
2009	1.071E+04	8.580E+06	5.765E+02	1.830E+01	5.105E+03	3.430E-01
2010	1.132E+04	9.061E+06	6.088E+02	1.933E+01	5.391E+03	3.623E-01
2011	1.205E+04	9.646E+06	6.481E+02	2.057E+01	5.739E+03	3.856E-01
2012	1.274E+04	1.020E+07	6.853E+02	2.175E+01	6.069E+03	4.077E-01
2013	1.333E+04	1.067E+07	7.171E+02	2.276E+01	6.350E+03	4.267E-01
2014	1.384E+04	1.108E+07	7.446E+02	2.363E+01	6.593E+03	4.430E-01
2015	1.447E+04	1.159E+07	7.784E+02	2.471E+01	6.893E+03	4.632E-01
2016	1.516E+04	1.214E+07	8.157E+02	2.589E+01	7.224E+03	4.854E-01
2017	1.578E+04	1.264E+07	8.491E+02	2.695E+01	7.519E+03	5.052E-01
2018	1.640E+04	1.313E+07	8.825E+02	2.801E+01	7.815E+03	5.251E-01
2019	1.702E+04	1.363E+07	9.158E+02	2.907E+01	8.110E+03	5.449E-01
2020	1.764E+04	1.413E+07	9.491E+02	3.013E+01	8.404E+03	5.647E-01
2021	1.826E+04	1.462E+07	9.823E+02	3.118E+01	8.699E+03	5.845E-01
2022	1.888E+04	1.511E+07	1.016E+03	3.224E+01	8.993E+03	6.042E-01
2023	1.949E+04	1.561E+07	1.049E+03	3.329E+01	9.287E+03	6.240E-01
2024	2.011E+04	1.610E+07	1.082E+03	3.434E+01	9.580E+03	6.437E-01
2025	2.072E+04	1.659E+07	1.115E+03	3.539E+01	9.874E+03	6.634E-01
2026	2.134E+04	1.709E+07	1.148E+03	3.644E+01	1.017E+04	6.831E-01

Results (Continued)

Year	**Total landfill gas**			**NMOC**		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
2027	2.195E+04	1.758E+07	1.181E+03	3.749E+01	1.046E+04	7.028E-01
2028	2.257E+04	1.807E+07	1.214E+03	3.854E+01	1.075E+04	7.225E-01
2029	2.318E+04	1.856E+07	1.247E+03	3.959E+01	1.104E+04	7.421E-01
2030	2.380E+04	1.905E+07	1.280E+03	4.064E+01	1.134E+04	7.617E-01
2031	2.441E+04	1.954E+07	1.313E+03	4.168E+01	1.163E+04	7.814E-01
2032	2.502E+04	2.004E+07	1.346E+03	4.273E+01	1.192E+04	8.010E-01
2033	2.563E+04	2.053E+07	1.379E+03	4.378E+01	1.221E+04	8.206E-01
2034	2.624E+04	2.102E+07	1.412E+03	4.482E+01	1.250E+04	8.402E-01
2035	2.686E+04	2.151E+07	1.445E+03	4.587E+01	1.280E+04	8.597E-01
2036	2.747E+04	2.199E+07	1.478E+03	4.691E+01	1.309E+04	8.793E-01
2037	2.808E+04	2.248E+07	1.511E+03	4.795E+01	1.338E+04	8.989E-01
2038	2.869E+04	2.297E+07	1.544E+03	4.900E+01	1.367E+04	9.184E-01
2039	2.930E+04	2.346E+07	1.576E+03	5.004E+01	1.396E+04	9.380E-01
2040	2.991E+04	2.395E+07	1.609E+03	5.108E+01	1.425E+04	9.575E-01
2041	3.052E+04	2.444E+07	1.642E+03	5.212E+01	1.454E+04	9.770E-01
2042	3.113E+04	2.493E+07	1.675E+03	5.316E+01	1.483E+04	9.965E-01
2043	3.174E+04	2.542E+07	1.708E+03	5.421E+01	1.512E+04	1.016E+00
2044	3.235E+04	2.590E+07	1.740E+03	5.525E+01	1.541E+04	1.036E+00
2045	3.296E+04	2.639E+07	1.773E+03	5.629E+01	1.570E+04	1.055E+00
2046	3.357E+04	2.688E+07	1.806E+03	5.733E+01	1.599E+04	1.075E+00
2047	3.418E+04	2.737E+07	1.839E+03	5.837E+01	1.628E+04	1.094E+00
2048	3.479E+04	2.786E+07	1.872E+03	5.941E+01	1.657E+04	1.114E+00
2049	3.540E+04	2.834E+07	1.904E+03	6.045E+01	1.686E+04	1.133E+00
2050	3.601E+04	2.883E+07	1.937E+03	6.149E+01	1.716E+04	1.153E+00
2051	3.662E+04	2.932E+07	1.970E+03	6.253E+01	1.745E+04	1.172E+00
2052	3.723E+04	2.981E+07	2.003E+03	6.357E+01	1.774E+04	1.192E+00
2053	3.783E+04	3.030E+07	2.036E+03	6.462E+01	1.803E+04	1.211E+00
2054	3.844E+04	3.078E+07	2.068E+03	6.566E+01	1.832E+04	1.231E+00
2055	3.905E+04	3.127E+07	2.101E+03	6.670E+01	1.861E+04	1.250E+00
2056	3.966E+04	3.176E+07	2.134E+03	6.774E+01	1.890E+04	1.270E+00
2057	4.027E+04	3.225E+07	2.167E+03	6.878E+01	1.919E+04	1.289E+00
2058	3.999E+04	3.202E+07	2.152E+03	6.830E+01	1.905E+04	1.280E+00
2059	3.971E+04	3.180E+07	2.137E+03	6.783E+01	1.892E+04	1.271E+00
2060	3.944E+04	3.158E+07	2.122E+03	6.735E+01	1.879E+04	1.262E+00
2061	3.916E+04	3.136E+07	2.107E+03	6.688E+01	1.866E+04	1.254E+00
2062	3.889E+04	3.114E+07	2.092E+03	6.642E+01	1.853E+04	1.245E+00
2063	3.862E+04	3.092E+07	2.078E+03	6.595E+01	1.840E+04	1.236E+00
2064	3.835E+04	3.071E+07	2.063E+03	6.549E+01	1.827E+04	1.228E+00
2065	3.808E+04	3.049E+07	2.049E+03	6.504E+01	1.814E+04	1.219E+00
2066	3.782E+04	3.028E+07	2.035E+03	6.458E+01	1.802E+04	1.211E+00
2067	3.755E+04	3.007E+07	2.020E+03	6.413E+01	1.789E+04	1.202E+00
2068	3.729E+04	2.986E+07	2.006E+03	6.368E+01	1.777E+04	1.194E+00
2069	3.703E+04	2.965E+07	1.992E+03	6.324E+01	1.764E+04	1.185E+00
2070	3.677E+04	2.944E+07	1.978E+03	6.280E+01	1.752E+04	1.177E+00
2071	3.651E+04	2.924E+07	1.965E+03	6.236E+01	1.740E+04	1.169E+00
2072	3.626E+04	2.904E+07	1.951E+03	6.193E+01	1.728E+04	1.161E+00
2073	3.601E+04	2.883E+07	1.937E+03	6.149E+01	1.716E+04	1.153E+00
2074	3.576E+04	2.863E+07	1.924E+03	6.106E+01	1.704E+04	1.145E+00
2075	3.551E+04	2.843E+07	1.910E+03	6.064E+01	1.692E+04	1.137E+00
2076	3.526E+04	2.823E+07	1.897E+03	6.022E+01	1.680E+04	1.129E+00
2077	3.501E+04	2.804E+07	1.884E+03	5.980E+01	1.668E+04	1.121E+00

Results (Continued)

Year	Total landfill gas			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2078	3.477E+04	2.784E+07	1.871E+03	5.938E+01	1.657E+04	1.113E+00
2079	3.453E+04	2.765E+07	1.858E+03	5.896E+01	1.645E+04	1.105E+00
2080	3.429E+04	2.745E+07	1.845E+03	5.855E+01	1.634E+04	1.098E+00
2081	3.405E+04	2.726E+07	1.832E+03	5.814E+01	1.622E+04	1.090E+00
2082	3.381E+04	2.707E+07	1.819E+03	5.774E+01	1.611E+04	1.082E+00
2083	3.357E+04	2.688E+07	1.806E+03	5.734E+01	1.600E+04	1.075E+00
2084	3.334E+04	2.670E+07	1.794E+03	5.694E+01	1.588E+04	1.067E+00
2085	3.311E+04	2.651E+07	1.781E+03	5.654E+01	1.577E+04	1.060E+00
2086	3.288E+04	2.632E+07	1.769E+03	5.614E+01	1.566E+04	1.052E+00
2087	3.265E+04	2.614E+07	1.756E+03	5.575E+01	1.555E+04	1.045E+00
2088	3.242E+04	2.596E+07	1.744E+03	5.536E+01	1.545E+04	1.038E+00
2089	3.219E+04	2.578E+07	1.732E+03	5.498E+01	1.534E+04	1.031E+00
2090	3.197E+04	2.560E+07	1.720E+03	5.459E+01	1.523E+04	1.023E+00
2091	3.174E+04	2.542E+07	1.708E+03	5.421E+01	1.512E+04	1.016E+00
2092	3.152E+04	2.524E+07	1.696E+03	5.384E+01	1.502E+04	1.009E+00
2093	3.130E+04	2.507E+07	1.684E+03	5.346E+01	1.491E+04	1.002E+00
2094	3.108E+04	2.489E+07	1.672E+03	5.309E+01	1.481E+04	9.951E-01
2095	3.087E+04	2.472E+07	1.661E+03	5.272E+01	1.471E+04	9.882E-01
2096	3.065E+04	2.455E+07	1.649E+03	5.235E+01	1.460E+04	9.813E-01
2097	3.044E+04	2.437E+07	1.638E+03	5.198E+01	1.450E+04	9.744E-01
2098	3.023E+04	2.420E+07	1.626E+03	5.162E+01	1.440E+04	9.676E-01
2099	3.002E+04	2.404E+07	1.615E+03	5.126E+01	1.430E+04	9.609E-01
2100	2.981E+04	2.387E+07	1.604E+03	5.090E+01	1.420E+04	9.542E-01
2101	2.960E+04	2.370E+07	1.592E+03	5.055E+01	1.410E+04	9.475E-01
2102	2.939E+04	2.354E+07	1.581E+03	5.020E+01	1.400E+04	9.409E-01
2103	2.919E+04	2.337E+07	1.570E+03	4.985E+01	1.391E+04	9.343E-01
2104	2.898E+04	2.321E+07	1.559E+03	4.950E+01	1.381E+04	9.278E-01
2105	2.878E+04	2.305E+07	1.548E+03	4.915E+01	1.371E+04	9.214E-01
2106	2.858E+04	2.289E+07	1.538E+03	4.881E+01	1.362E+04	9.149E-01
2107	2.838E+04	2.273E+07	1.527E+03	4.847E+01	1.352E+04	9.085E-01
2108	2.818E+04	2.257E+07	1.516E+03	4.813E+01	1.343E+04	9.022E-01
2109	2.799E+04	2.241E+07	1.506E+03	4.780E+01	1.333E+04	8.959E-01
2110	2.779E+04	2.225E+07	1.495E+03	4.746E+01	1.324E+04	8.897E-01
2111	2.760E+04	2.210E+07	1.485E+03	4.713E+01	1.315E+04	8.835E-01
2112	2.740E+04	2.194E+07	1.474E+03	4.680E+01	1.306E+04	8.773E-01
2113	2.721E+04	2.179E+07	1.464E+03	4.648E+01	1.297E+04	8.712E-01
2114	2.702E+04	2.164E+07	1.454E+03	4.615E+01	1.288E+04	8.651E-01
2115	2.684E+04	2.149E+07	1.444E+03	4.583E+01	1.279E+04	8.591E-01
2116	2.665E+04	2.134E+07	1.434E+03	4.551E+01	1.270E+04	8.531E-01
2117	2.646E+04	2.119E+07	1.424E+03	4.519E+01	1.261E+04	8.471E-01



LandGEM
Landfill Gas Emissions Model
Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Camino Real Landfill LandGEM (2057-2081)

Date: Wednesday, October 04, 2017

Description/Comments:

The NMOC concentration is from AP-42 for sites with no co-disposal, and the site-specific methane generation rate (k) was taken from the August 1999 Tier III.

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10}\right) e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2057**	
Landfill Closure Year (with 80-year limit)	**2081**	
Actual Closure Year (without limit)	***2081***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.007**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**100**	*m* ^{3} */Mg*
NMOC Concentration	**595**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**NMOC**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**Methane**

WASTE ACCEPTANCE RATES

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
2057	511,349	562,484	0	0
2058	513,906	565,296	511,349	562,484
2059	516,475	568,123	1,025,254	1,127,780
2060	519,058	570,963	1,541,730	1,695,903
2061	521,653	573,818	2,060,787	2,266,866
2062	524,261	576,687	2,582,440	2,840,684
2063	526,882	579,571	3,106,701	3,417,371
2064	529,517	582,468	3,633,583	3,996,942
2065	532,164	585,381	4,163,100	4,579,410
2066	534,825	588,308	4,695,265	5,164,791
2067	537,499	591,249	5,230,090	5,753,099
2068	540,187	594,205	5,767,589	6,344,348
2069	542,888	597,177	6,307,776	6,938,553
2070	545,602	600,162	6,850,664	7,535,730
2071	548,330	603,163	7,396,266	8,135,892
2072	551,072	606,179	7,944,596	8,739,056
2073	553,827	609,210	8,495,668	9,345,235
2074	556,596	612,256	9,049,495	9,954,445
2075	559,379	615,317	9,606,091	10,566,700
2076	562,176	618,394	10,165,471	11,182,018
2077	564,987	621,486	10,727,647	11,800,412
2078	567,812	624,593	11,292,634	12,421,897
2079	570,651	627,716	11,860,446	13,046,491
2080	573,504	630,855	12,431,097	13,674,207
2081	263,512	289,863	13,004,601	14,305,062
2082	0	0	13,268,113	14,594,925
2083	0	0	13,268,113	14,594,925
2084	0	0	13,268,113	14,594,925
2085	0	0	13,268,113	14,594,925
2086	0	0	13,268,113	14,594,925
2087	0	0	13,268,113	14,594,925
2088	0	0	13,268,113	14,594,925
2089	0	0	13,268,113	14,594,925
2090	0	0	13,268,113	14,594,925
2091	0	0	13,268,113	14,594,925
2092	0	0	13,268,113	14,594,925
2093	0	0	13,268,113	14,594,925
2094	0	0	13,268,113	14,594,925
2095	0	0	13,268,113	14,594,925
2096	0	0	13,268,113	14,594,925

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2097	0	0	13,268,113	14,594,925
2098	0	0	13,268,113	14,594,925
2099	0	0	13,268,113	14,594,925
2100	0	0	13,268,113	14,594,925
2101	0	0	13,268,113	14,594,925
2102	0	0	13,268,113	14,594,925
2103	0	0	13,268,113	14,594,925
2104	0	0	13,268,113	14,594,925
2105	0	0	13,268,113	14,594,925
2106	0	0	13,268,113	14,594,925
2107	0	0	13,268,113	14,594,925
2108	0	0	13,268,113	14,594,925
2109	0	0	13,268,113	14,594,925
2110	0	0	13,268,113	14,594,925
2111	0	0	13,268,113	14,594,925
2112	0	0	13,268,113	14,594,925
2113	0	0	13,268,113	14,594,925
2114	0	0	13,268,113	14,594,925
2115	0	0	13,268,113	14,594,925
2116	0	0	13,268,113	14,594,925
2117	0	0	13,268,113	14,594,925
2118	0	0	13,268,113	14,594,925
2119	0	0	13,268,113	14,594,925
2120	0	0	13,268,113	14,594,925
2121	0	0	13,268,113	14,594,925
2122	0	0	13,268,113	14,594,925
2123	0	0	13,268,113	14,594,925
2124	0	0	13,268,113	14,594,925
2125	0	0	13,268,113	14,594,925
2126	0	0	13,268,113	14,594,925
2127	0	0	13,268,113	14,594,925
2128	0	0	13,268,113	14,594,925
2129	0	0	13,268,113	14,594,925
2130	0	0	13,268,113	14,594,925
2131	0	0	13,268,113	14,594,925
2132	0	0	13,268,113	14,594,925
2133	0	0	13,268,113	14,594,925
2134	0	0	13,268,113	14,594,925
2135	0	0	13,268,113	14,594,925
2136	0	0	13,268,113	14,594,925

Results

Year	**Total landfill gas**			**NMOC**		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
2057	0	0	0	0	0	0
2058	8.912E+02	7.136E+05	4.795E+01	1.522E+00	4.246E+02	2.853E-02
2059	1.781E+03	1.426E+06	9.580E+01	3.041E+00	8.484E+02	5.700E-02
2060	2.668E+03	2.137E+06	1.436E+02	4.557E+00	1.271E+03	8.542E-02
2061	3.554E+03	2.846E+06	1.912E+02	6.070E+00	1.693E+03	1.138E-01
2062	4.439E+03	3.554E+06	2.388E+02	7.581E+00	2.115E+03	1.421E-01
2063	5.322E+03	4.261E+06	2.863E+02	9.088E+00	2.535E+03	1.704E-01
2064	6.203E+03	4.967E+06	3.337E+02	1.059E+01	2.955E+03	1.986E-01
2065	7.082E+03	5.671E+06	3.810E+02	1.210E+01	3.374E+03	2.267E-01
2066	7.960E+03	6.374E+06	4.283E+02	1.359E+01	3.793E+03	2.548E-01
2067	8.837E+03	7.076E+06	4.755E+02	1.509E+01	4.210E+03	2.829E-01
2068	9.712E+03	7.777E+06	5.225E+02	1.659E+01	4.627E+03	3.109E-01
2069	1.059E+04	8.477E+06	5.695E+02	1.808E+01	5.044E+03	3.389E-01
2070	1.146E+04	9.175E+06	6.165E+02	1.957E+01	5.459E+03	3.668E-01
2071	1.233E+04	9.873E+06	6.633E+02	2.106E+01	5.874E+03	3.947E-01
2072	1.320E+04	1.057E+07	7.101E+02	2.254E+01	6.289E+03	4.225E-01
2073	1.407E+04	1.126E+07	7.569E+02	2.402E+01	6.702E+03	4.503E-01
2074	1.493E+04	1.196E+07	8.035E+02	2.550E+01	7.115E+03	4.781E-01
2075	1.580E+04	1.265E+07	8.501E+02	2.698E+01	7.528E+03	5.058E-01
2076	1.666E+04	1.334E+07	8.966E+02	2.846E+01	7.940E+03	5.335E-01
2077	1.753E+04	1.404E+07	9.431E+02	2.994E+01	8.351E+03	5.611E-01
2078	1.839E+04	1.473E+07	9.895E+02	3.141E+01	8.762E+03	5.887E-01
2079	1.925E+04	1.542E+07	1.036E+03	3.288E+01	9.173E+03	6.163E-01
2080	2.011E+04	1.611E+07	1.082E+03	3.435E+01	9.583E+03	6.439E-01
2081	2.097E+04	1.679E+07	1.128E+03	3.582E+01	9.992E+03	6.714E-01
2082	2.128E+04	1.704E+07	1.145E+03	3.635E+01	1.014E+04	6.814E-01
2083	2.114E+04	1.692E+07	1.137E+03	3.610E+01	1.007E+04	6.766E-01
2084	2.099E+04	1.681E+07	1.129E+03	3.584E+01	1.000E+04	6.719E-01
2085	2.084E+04	1.669E+07	1.121E+03	3.559E+01	9.930E+03	6.672E-01
2086	2.070E+04	1.657E+07	1.114E+03	3.535E+01	9.861E+03	6.626E-01
2087	2.055E+04	1.646E+07	1.106E+03	3.510E+01	9.792E+03	6.579E-01
2088	2.041E+04	1.634E+07	1.098E+03	3.486E+01	9.724E+03	6.534E-01
2089	2.027E+04	1.623E+07	1.090E+03	3.461E+01	9.656E+03	6.488E-01
2090	2.013E+04	1.612E+07	1.083E+03	3.437E+01	9.589E+03	6.443E-01
2091	1.999E+04	1.600E+07	1.075E+03	3.413E+01	9.522E+03	6.398E-01
2092	1.985E+04	1.589E+07	1.068E+03	3.389E+01	9.455E+03	6.353E-01
2093	1.971E+04	1.578E+07	1.060E+03	3.366E+01	9.389E+03	6.309E-01
2094	1.957E+04	1.567E+07	1.053E+03	3.342E+01	9.324E+03	6.265E-01
2095	1.943E+04	1.556E+07	1.046E+03	3.319E+01	9.259E+03	6.221E-01
2096	1.930E+04	1.545E+07	1.038E+03	3.296E+01	9.194E+03	6.178E-01
2097	1.916E+04	1.534E+07	1.031E+03	3.273E+01	9.130E+03	6.135E-01
2098	1.903E+04	1.524E+07	1.024E+03	3.250E+01	9.067E+03	6.092E-01
2099	1.890E+04	1.513E+07	1.017E+03	3.227E+01	9.003E+03	6.049E-01
2100	1.876E+04	1.503E+07	1.010E+03	3.205E+01	8.941E+03	6.007E-01
2101	1.863E+04	1.492E+07	1.003E+03	3.182E+01	8.878E+03	5.965E-01
2102	1.850E+04	1.482E+07	9.956E+02	3.160E+01	8.816E+03	5.924E-01
2103	1.837E+04	1.471E+07	9.886E+02	3.138E+01	8.755E+03	5.882E-01
2104	1.825E+04	1.461E+07	9.817E+02	3.116E+01	8.694E+03	5.841E-01
2105	1.812E+04	1.451E+07	9.749E+02	3.094E+01	8.633E+03	5.800E-01
2106	1.799E+04	1.441E+07	9.681E+02	3.073E+01	8.573E+03	5.760E-01

ATTACHMENT 7.7

TANKS 4.09D MODEL OUTPUT FILES FOR DIESEL TANKS

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	CRLF 10k Diesel Tank
City:	Sunland Park
State:	New Mexico
Company:	Camino Real Environment
Type of Tank:	Horizontal Tank
Description:	Camino Real Landfill 10,000-gallon Diesel Storage Tank

Tank Dimensions

Shell Length (ft):	26.67
Diameter (ft):	8.00
Volume (gallons):	10,000.00
Turnovers:	0.00
Net Throughput(gal/yr):	1,000,000.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Poor

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig)	0.03

Meterological Data used in Emissions Calculations: El Paso, Texas (Avg Atmospheric Pressure = 12.79 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

CRLF 10k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

		Daily Liquid Surf. Temperature (deg F)			Liquid Bulk Temp	Vapor Pressure (psia)			Vapor Mol.	Liquid Mass	Vapor Mass	Mol.	Basis for Vapor Pressure
Mixture/Component	Month	Avg.	Min.	Max.	(deg F)	Avg.	Min.	Max.	Weight.	Fract.	Fract.	Weight	Calculations
Distillate fuel oil no. 2	Jan	57.75	50.32	65.17	64.25	0.0060	0.0046	0.0078	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065
Distillate fuel oil no. 2	Feb	60.99	52.47	69.51	64.25	0.0067	0.0050	0.0089	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Mar	65.19	55.43	74.96	64.25	0.0078	0.0056	0.0105	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Apr	69.90	59.02	80.78	64.25	0.0090	0.0063	0.0123	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	May	74.25	62.83	85.67	64.25	0.0103	0.0072	0.0143	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Jun	78.20	66.34	90.06	64.25	0.0115	0.0081	0.0160	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Jul	78.45	67.90	89.00	64.25	0.0115	0.0085	0.0156	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Aug	76.96	67.02	86.91	64.25	0.0111	0.0083	0.0148	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Sep	73.69	64.67	82.71	64.25	0.0101	0.0077	0.0131	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Oct	68.34	59.44	77.25	64.25	0.0086	0.0064	0.0112	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Nov	62.27	54.37	70.18	64.25	0.0071	0.0054	0.0091	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Dec	58.11	50.87	65.36	64.25	0.0061	0.0047	0.0078	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

CRLF 10k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Standing Losses (lb):	0.1983	0.2289	0.3336	0.4093	0.5015	0.5547	0.5092	0.4624	0.3719	0.3288	0.2358	0.1951
Vapor Space Volume (cu ft):	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729
Vapor Density (lb/cu ft):	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001
Vapor Space Expansion Factor:	0.0530	0.0611	0.0701	0.0780	0.0814	0.0841	0.0743	0.0699	0.0634	0.0632	0.0562	0.0515
Vented Vapor Saturation Factor:	0.9987	0.9986	0.9983	0.9981	0.9978	0.9976	0.9976	0.9977	0.9979	0.9982	0.9985	0.9987
Tank Vapor Space Volume:												
Vapor Space Volume (cu ft):	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729	853.8729
Tank Diameter (ft):	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
Effective Diameter (ft):	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862	16.4862
Vapor Space Outage (ft):	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Tank Shell Length (ft):	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700	26.6700
Vapor Density												
Vapor Density (lb/cu ft):	0.0001	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0060	0.0067	0.0078	0.0090	0.0103	0.0115	0.0115	0.0111	0.0101	0.0086	0.0071	0.0061
Daily Avg. Liquid Surface Temp. (deg. R):	517.4176	520.6615	524.8638	529.5691	533.9194	537.8679	538.1178	536.6333	533.3643	528.0144	521.9440	517.7850
Daily Average Ambient Temp. (deg. F):	42.7500	48.0500	55.0500	63.3500	71.8000	80.4000	82.2500	80.0500	74.3500	64.0000	52.4000	44.1000
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731
Liquid Bulk Temperature (deg. R):	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225	523.9225
Tank Paint Solar Absorptance (Shell):	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400	0.3400
Daily Total Solar Insulation Factor (Btu/sqft day):	1,100.6096	1,440.0885	1,857.9331	2,250.0788	2,485.4932	2,546.7263	2,336.6936	2,144.4279	1,861.1058	1,564.7756	1,204.9915	1,016.2158
Vapor Space Expansion Factor												
Vapor Space Expansion Factor:	0.0530	0.0611	0.0701	0.0780	0.0814	0.0841	0.0743	0.0699	0.0634	0.0632	0.0562	0.0515
Daily Vapor Temperature Range (deg. R):	29.7018	34.0856	39.0715	43.5248	45.6939	47.4288	42.1893	39.7830	36.0777	35.6327	31.6315	28.9704
Daily Vapor Pressure Range (psia):	0.0032	0.0039	0.0049	0.0060	0.0071	0.0079	0.0071	0.0065	0.0054	0.0048	0.0037	0.0032
Breather Vent Press. Setting Range(psia):	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0060	0.0067	0.0078	0.0090	0.0103	0.0115	0.0115	0.0111	0.0101	0.0086	0.0071	0.0061
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0046	0.0050	0.0056	0.0063	0.0072	0.0081	0.0085	0.0083	0.0077	0.0064	0.0054	0.0047
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0078	0.0089	0.0105	0.0123	0.0143	0.0160	0.0156	0.0148	0.0131	0.0112	0.0091	0.0078
Daily Avg. Liquid Surface Temp. (deg R):	517.4176	520.6615	524.8638	529.5691	533.9194	537.8679	538.1178	536.6333	533.3643	528.0144	521.9440	517.7850
Daily Min. Liquid Surface Temp. (deg R):	509.9922	512.1401	515.0959	518.6879	522.4960	526.0107	527.5704	526.6876	524.3449	519.1062	514.0361	510.5424
Daily Max. Liquid Surface Temp. (deg R):	524.8431	529.1829	534.6317	540.4503	545.3429	549.7251	548.6651	546.5791	542.3838	536.9226	529.8519	525.0275
Daily Ambient Temp. Range (deg. R):	26.7000	28.3000	29.7000	30.7000	30.6000	32.2000	27.7000	26.9000	25.5000	28.8000	28.0000	26.8000
Vented Vapor Saturation Factor												
Vented Vapor Saturation Factor:	0.9987	0.9986	0.9983	0.9981	0.9978	0.9976	0.9976	0.9977	0.9979	0.9982	0.9985	0.9987
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0060	0.0067	0.0078	0.0090	0.0103	0.0115	0.0115	0.0111	0.0101	0.0086	0.0071	0.0061
Vapor Space Outage (ft):	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Working Losses (lb):	1.5604	1.7405	2.0115	2.3149	2.6503	2.9558	2.9751	2.8603	2.6073	2.2147	1.8232	1.5793
Vapor Molecular Weight (lb/lb-mole):	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0060	0.0067	0.0078	0.0090	0.0103	0.0115	0.0115	0.0111	0.0101	0.0086	0.0071	0.0061
Net Throughput (gal/mo.):	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333
Annual Turnovers:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Turnover Factor:	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Tank Diameter (ft):	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
Working Loss Product Factor:	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total Losses (lb):	1.7587	1.9695	2.3451	2.7242	3.1517	3.5105	3.4843	3.3227	2.9792	2.5434	2.0590	1.7744

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: January, February, March, April, May, June, July, August, September, October, November, December

CRLF 10k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	27.29	4.33	31.62

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification

User Identification:	CRLF 0.5k Diesel Tank
City:	Sunland Park
State:	New Mexico
Company:	Camino Real Environmental Center, Inc.
Type of Tank:	Horizontal Tank
Description:	Camino Real Landfill Portable 500-gallon Diesel Storage Tank

Tank Dimensions

Shell Length (ft):	5.33
Diameter (ft):	4.00
Volume (gallons):	500.00
Turnovers:	0.00
Net Throughput(gal/yr):	1,000,000.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N

Paint Characteristics

Shell Color/Shade:	White/White
Shell Condition	Good

Breather Vent Settings

Vacuum Settings (psig):	-0.03
Pressure Settings (psig)	0.03

Meterological Data used in Emissions Calculations: El Paso, Texas (Avg Atmospheric Pressure = 12.79 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

CRLF 0.5k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Distillate fuel oil no. 2	Jan	55.70	49.58	61.81	63.23	0.0056	0.0044	0.0070	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065
Distillate fuel oil no. 2	Feb	58.49	51.68	65.29	63.23	0.0062	0.0048	0.0078	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065
Distillate fuel oil no. 2	Mar	62.13	54.57	69.68	63.23	0.0070	0.0054	0.0089	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Apr	66.31	58.10	74.51	63.23	0.0081	0.0061	0.0104	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	May	70.34	61.87	78.81	63.23	0.0091	0.0070	0.0116	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Jun	74.21	65.38	83.03	63.23	0.0103	0.0078	0.0132	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Jul	74.74	66.97	82.51	63.23	0.0104	0.0082	0.0130	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Aug	73.51	66.12	80.91	63.23	0.0101	0.0080	0.0124	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Sep	70.62	63.82	77.43	63.23	0.0092	0.0075	0.0112	130.0000			188.00	Option 1: VP70 = .009 VP80 = .012
Distillate fuel oil no. 2	Oct	65.67	58.63	72.72	63.23	0.0079	0.0062	0.0098	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Nov	60.08	53.61	66.56	63.23	0.0065	0.0052	0.0081	130.0000			188.00	Option 1: VP60 = .0065 VP70 = .009
Distillate fuel oil no. 2	Dec	56.18	50.15	62.21	63.23	0.0057	0.0045	0.0071	130.0000			188.00	Option 1: VP50 = .0045 VP60 = .0065

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

CRLF 0.5k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

Month:	January	February	March	April	May	June	July	August	September	October	November	December
Standing Losses (lb):	0.0075	0.0083	0.0115	0.0138	0.0164	0.0184	0.0168	0.0154	0.0126	0.0119	0.0088	0.0075
Vapor Space Volume (cu ft):	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616
Vapor Density (lb/cu ft):	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
Vapor Space Expansion Factor:	0.0430	0.0481	0.0535	0.0580	0.0596	0.0619	0.0538	0.0511	0.0469	0.0492	0.0454	0.0423
Vented Vapor Saturation Factor:	0.9994	0.9993	0.9993	0.9991	0.9990	0.9989	0.9989	0.9989	0.9990	0.9992	0.9993	0.9994
Tank Vapor Space Volume:												
Vapor Space Volume (cu ft):	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616	42.6616
Tank Diameter (ft):	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Effective Diameter (ft):	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115	5.2115
Vapor Space Outage (ft):	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Tank Shell Length (ft):	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300	5.3300
Vapor Density												
Vapor Density (lb/cu ft):	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
Vapor Molecular Weight (lb/lb-mole):	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0056	0.0062	0.0070	0.0081	0.0091	0.0103	0.0104	0.0101	0.0092	0.0079	0.0065	0.0057
Daily Avg. Liquid Surface Temp. (deg. R):	515.3683	518.1562	521.7974	525.9761	530.0102	533.8765	534.4084	533.1822	530.2937	525.3417	519.7545	515.8490
Daily Average Ambient Temp. (deg. F):	42.7500	48.0500	55.0500	63.3500	71.8000	80.4000	82.2500	80.0500	74.3500	64.0000	52.4000	44.1000
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731	10.731
Liquid Bulk Temperature (deg. R):	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025	522.9025
Tank Paint Solar Absorptance (Shell):	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700	0.1700
Daily Total Solar Insulation Factor (Btu/sqft day):	1,100.6096	1,440.0885	1,857.9331	2,250.0788	2,485.4932	2,546.7263	2,336.6936	2,144.4279	1,861.1058	1,564.7756	1,204.9915	1,016.2158
Vapor Space Expansion Factor												
Vapor Space Expansion Factor:	0.0430	0.0481	0.0535	0.0580	0.0596	0.0619	0.0538	0.0511	0.0469	0.0492	0.0454	0.0423
Daily Vapor Temperature Range (deg. R):	24.4629	27.2308	30.2278	32.8144	33.8629	35.3064	31.0667	29.5755	27.2189	28.1843	25.8958	24.1332
Daily Vapor Pressure Range (psia):	0.0025	0.0030	0.0035	0.0042	0.0047	0.0054	0.0048	0.0043	0.0038	0.0036	0.0029	0.0025
Breather Vent Press. Setting Range(psia):	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0056	0.0062	0.0070	0.0081	0.0091	0.0103	0.0104	0.0101	0.0092	0.0079	0.0065	0.0057
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0044	0.0048	0.0054	0.0061	0.0070	0.0078	0.0082	0.0080	0.0075	0.0062	0.0052	0.0045
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0070	0.0078	0.0089	0.0104	0.0116	0.0132	0.0130	0.0124	0.0112	0.0098	0.0081	0.0071
Daily Avg. Liquid Surface Temp. (deg R):	515.3683	518.1562	521.7974	525.9761	530.0102	533.8765	534.4084	533.1822	530.2937	525.3417	519.7545	515.8490
Daily Min. Liquid Surface Temp. (deg R):	509.2526	511.3485	514.2405	517.7725	521.5445	525.0498	526.6417	525.7883	523.4889	518.2956	513.2806	509.8157
Daily Max. Liquid Surface Temp. (deg R):	521.4840	524.9639	529.3543	534.1796	538.4760	542.7031	542.1750	540.5760	537.0984	532.3878	526.2284	521.8823
Daily Ambient Temp. Range (deg. R):	26.7000	28.3000	29.7000	30.7000	30.6000	32.2000	27.7000	26.9000	25.5000	28.8000	28.0000	26.8000
Vented Vapor Saturation Factor												
Vented Vapor Saturation Factor:	0.9994	0.9993	0.9993	0.9991	0.9990	0.9989	0.9989	0.9989	0.9990	0.9992	0.9993	0.9994
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0056	0.0062	0.0070	0.0081	0.0091	0.0103	0.0104	0.0101	0.0092	0.0079	0.0065	0.0057
Vapor Space Outage (ft):	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
Working Losses (lb):	1.4547	1.5985	1.8138	2.0832	2.3478	2.6469	2.6881	2.5932	2.3697	2.0423	1.6820	1.4795
Vapor Molecular Weight (lb/lb-mole):	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000	130.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0056	0.0062	0.0070	0.0081	0.0091	0.0103	0.0104	0.0101	0.0092	0.0079	0.0065	0.0057
Net Throughput (gal/mo.):	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333	83,333.3333
Annual Turnovers:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Turnover Factor:	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Tank Diameter (ft):	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000
Working Loss Product Factor:	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Total Losses (lb):	1.4622	1.6068	1.8253	2.0970	2.3641	2.6653	2.7049	2.6086	2.3823	2.0542	1.6909	1.4870

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: January, February, March, April, May, June, July, August, September, October, November, December

CRLF 0.5k Diesel Tank - Horizontal Tank
Sunland Park, New Mexico

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Distillate fuel oil no. 2	24.80	0.15	24.95

ATTACHMENT 7.8

AP-42, SECTION 3.3 GASOLINE AND DIESEL INDUSTRIAL ENGINES

3.3 Gasoline And Diesel Industrial Engines

3.3.1 General

The engine category addressed by this section covers a wide variety of industrial applications of both gasoline and diesel internal combustion (IC) engines such as aerial lifts, fork lifts, mobile refrigeration units, generators, pumps, industrial sweepers/scrubbers, material handling equipment (such as conveyors), and portable well-drilling equipment. The three primary fuels for reciprocating IC engines are gasoline, diesel fuel oil (No.2), and natural gas. Gasoline is used primarily for mobile and portable engines. Diesel fuel oil is the most versatile fuel and is used in IC engines of all sizes. The rated power of these engines covers a rather substantial range, up to 250 horsepower (hp) for gasoline engines and up to 600 hp for diesel engines. (Diesel engines greater than 600 hp are covered in Section 3.4, "Large Stationary Diesel And All Stationary Dual-fuel Engines".) Understandably, substantial differences in engine duty cycles exist. It was necessary, therefore, to make reasonable assumptions concerning usage in order to formulate some of the emission factors.

3.3.2 Process Description

All reciprocating IC engines operate by the same basic process. A combustible mixture is first compressed in a small volume between the head of a piston and its surrounding cylinder. The mixture is then ignited, and the resulting high-pressure products of combustion push the piston through the cylinder. This movement is converted from linear to rotary motion by a crankshaft. The piston returns, pushing out exhaust gases, and the cycle is repeated.

There are 2 methods used for stationary reciprocating IC engines: compression ignition (CI) and spark ignition (SI). This section deals with both types of reciprocating IC engines. All diesel-fueled engines are compression ignited, and all gasoline-fueled engines are spark ignited.

In CI engines, combustion air is first compression heated in the cylinder, and diesel fuel oil is then injected into the hot air. Ignition is spontaneous because the air temperature is above the autoignition temperature of the fuel. SI engines initiate combustion by the spark of an electrical discharge. Usually the fuel is mixed with the air in a carburetor (for gasoline) or at the intake valve (for natural gas), but occasionally the fuel is injected into the compressed air in the cylinder.

CI engines usually operate at a higher compression ratio (ratio of cylinder volume when the piston is at the bottom of its stroke to the volume when it is at the top) than SI engines because fuel is not present during compression; hence there is no danger of premature autoignition. Since engine thermal efficiency rises with increasing pressure ratio (and pressure ratio varies directly with compression ratio), CI engines are more efficient than SI engines. This increased efficiency is gained at the expense of poorer response to load changes and a heavier structure to withstand the higher pressures.[1]

3.3.3 Emissions

Most of the pollutants from IC engines are emitted through the exhaust. However, some total organic compounds (TOC) escape from the crankcase as a result of blowby (gases that are vented from the oil pan after they have escaped from the cylinder past the piston rings) and from the fuel tank and carburetor because of evaporation. Nearly all of the TOCs from diesel CI engines enter the atmosphere from the exhaust. Evaporative losses are insignificant in diesel engines due to the low volatility of diesel fuels.

The primary pollutants from internal combustion engines are oxides of nitrogen (NO_x), total organic compounds (TOC), carbon monoxide (CO), and particulates, which include both visible (smoke) and nonvisible emissions. Nitrogen oxide formation is directly related to high pressures and temperatures during the combustion process and to the nitrogen content, if any, of the fuel. The other pollutants, HC, CO, and smoke, are primarily the result of incomplete combustion. Ash and metallic additives in the fuel also contribute to the particulate content of the exhaust. Sulfur oxides (SO_x) also appear in the exhaust from IC engines. The sulfur compounds, mainly sulfur dioxide (SO_2), are directly related to the sulfur content of the fuel.[2]

3.3.3.1 Nitrogen Oxides -

Nitrogen oxide formation occurs by two fundamentally different mechanisms. The predominant mechanism with internal combustion engines is thermal NO_x which arises from the thermal dissociation and subsequent reaction of nitrogen (N_2) and oxygen (O_2) molecules in the combustion air. Most thermal NO_x is formed in the high-temperature region of the flame from dissociated molecular nitrogen in the combustion air. Some NO_x, called prompt NO_x, is formed in the early part of the flame from reaction of nitrogen intermediary species, and HC radicals in the flame. The second mechanism, fuel NO_x, stems from the evolution and reaction of fuel-bound nitrogen compounds with oxygen. Gasoline, and most distillate oils have no chemically-bound fuel N_2 and essentially all NO_x formed is thermal NO_x.

3.3.3.2 Total Organic Compounds -

The pollutants commonly classified as hydrocarbons are composed of a wide variety of organic compounds and are discharged into the atmosphere when some of the fuel remains unburned or is only partially burned during the combustion process. Most unburned hydrocarbon emissions result from fuel droplets that were transported or injected into the quench layer during combustion. This is the region immediately adjacent to the combustion chamber surfaces, where heat transfer outward through the cylinder walls causes the mixture temperatures to be too low to support combustion.

Partially burned hydrocarbons can occur because of poor air and fuel homogeneity due to incomplete mixing, before or during combustion; incorrect air/fuel ratios in the cylinder during combustion due to maladjustment of the engine fuel system; excessively large fuel droplets (diesel engines); and low cylinder temperature due to excessive cooling (quenching) through the walls or early cooling of the gases by expansion of the combustion volume caused by piston motion before combustion is completed.[2]

3.3.3.3 Carbon Monoxide -

Carbon monoxide is a colorless, odorless, relatively inert gas formed as an intermediate combustion product that appears in the exhaust when the reaction of CO to CO_2 cannot proceed to completion. This situation occurs if there is a lack of available oxygen near the hydrocarbon (fuel) molecule during combustion, if the gas temperature is too low, or if the residence time in the cylinder is too short. The oxidation rate of CO is limited by reaction kinetics and, as a consequence, can be accelerated only to a certain extent by improvements in air and fuel mixing during the combustion process.[2-3]

3.3.3.4 Smoke and Particulate Matter -

White, blue, and black smoke may be emitted from IC engines. Liquid particulates appear as white smoke in the exhaust during an engine cold start, idling, or low load operation. These are formed in the quench layer adjacent to the cylinder walls, where the temperature is not high enough to ignite the fuel. Blue smoke is emitted when lubricating oil leaks, often past worn piston rings, into the combustion chamber and is partially burned. Proper maintenance is the most effective method of preventing blue smoke emissions from all types of IC engines. The primary constituent of black smoke is agglomerated carbon particles (soot) formed in regions of the combustion mixtures that are oxygen deficient.[2]

3.3.3.5 Sulfur Oxides -

Sulfur oxides emissions are a function of only the sulfur content in the fuel rather than any combustion variables. In fact, during the combustion process, essentially all the sulfur in the fuel is oxidized to SO_2. The oxidation of SO_2 gives sulfur trioxide (SO_3), which reacts with water to give sulfuric acid (H_2SO_4), a contributor to acid precipitation. Sulfuric acid reacts with basic substances to give sulfates, which are fine particulates that contribute to PM-10 and visibility reduction. Sulfur oxide emissions also contribute to corrosion of the engine parts.[2-3]

3.3.4 Control Technologies

Control measures to date are primarily directed at limiting NO_x and CO emissions since they are the primary pollutants from these engines. From a NO_x control viewpoint, the most important distinction between different engine models and types of reciprocating engines is whether they are rich-burn or lean-burn. Rich-burn engines have an air-to-fuel ratio operating range that is near stoichiometric or fuel-rich of stoichiometric and as a result the exhaust gas has little or no excess oxygen. A lean-burn engine has an air-to-fuel operating range that is fuel-lean of stoichiometric; therefore, the exhaust from these engines is characterized by medium to high levels of O_2. The most common NO_x control technique for diesel and dual-fuel engines focuses on modifying the combustion process. However, selective catalytic reduction (SCR) and nonselective catalytic reduction (NSCR) which are post-combustion techniques are becoming available. Controls for CO have been partly adapted from mobile sources.[4]

Combustion modifications include injection timing retard (ITR), preignition chamber combustion (PCC), air-to-fuel ratio adjustments, and derating. Injection of fuel into the cylinder of a CI engine initiates the combustion process. Retarding the timing of the diesel fuel injection causes the combustion process to occur later in the power stroke when the piston is in the downward motion and combustion chamber volume is increasing. By increasing the volume, the combustion temperature and pressure are lowered, thereby lowering NO_x formation. ITR reduces NO_x from all diesel engines; however, the effectiveness is specific to each engine model. The amount of NO_x reduction with ITR diminishes with increasing levels of retard.[4]

Improved swirl patterns promote thorough air and fuel mixing and may include a precombustion chamber (PCC). A PCC is an antechamber that ignites a fuel-rich mixture that propagates to the main combustion chamber. The high exit velocity from the PCC results in improved mixing and complete combustion of the lean air/fuel mixture which lowers combustion temperature, thereby reducing NO_x emissions.[4]

The air-to-fuel ratio for each cylinder can be adjusted by controlling the amount of fuel that enters each cylinder. At air-to-fuel ratios less than stoichiometric (fuel-rich), combustion occurs under conditions of insufficient oxygen which causes NO_x to decrease because of lower oxygen and lower temperatures. Derating involves restricting the engine operation to lower than normal levels of power production for the given application. Derating reduces cylinder pressures and temperatures, thereby lowering NO_x formation rates.[4]

SCR is an add-on NO_x control placed in the exhaust stream following the engine and involves injecting ammonia (NH_3) into the flue gas. The NH_3 reacts with NO_x in the presence of a catalyst to form water and nitrogen. The effectiveness of SCR depends on fuel quality and engine duty cycle (load fluctuations). Contaminants in the fuel may poison or mask the catalyst surface causing a reduction or termination in catalyst activity. Load fluctuations can cause variations in exhaust temperature and NO_x concentration which can create problems with the effectiveness of the SCR system.[4]

NSCR is often referred to as a three-way conversion catalyst system because the catalyst reactor simultaneously reduces NO_x, CO, and HC and involves placing a catalyst in the exhaust stream of the engine. The reaction requires that the O_2 levels be kept low and that the engine be operated at fuel-rich air-to-fuel ratios.[4]

The most accurate method for calculating such emissions is on the basis of "brake-specific" emission factors (pounds per horsepower-hour [lb/hp-hr]). Emissions are the product of the brake-specific emission factor, the usage in hours, the rated power available, and the load factor (the power actually used divided by the power available). However, for emission inventory purposes, it is often easier to assess this activity on the basis of fuel used.

Once reasonable usage and duty cycles for this category were ascertained, emission values were aggregated to arrive at the factors for criteria and organic pollutants presented. Factors in Table 3.3-1 are in pounds per million British thermal unit (lb/MMBtu). Emission data for a specific design type were weighted according to estimated material share for industrial engines. The emission factors in these tables, because of their aggregate nature, are most appropriately applied to a population of industrial engines rather than to an individual power plant. Table 3.3-2 shows unweighted speciated organic compound and air toxic emission factors based upon only 2 engines. Their inclusion in this section is intended for rough order-of-magnitude estimates only.

Table 3.3-3 summarizes whether the various diesel emission reduction technologies (some of which may be applicable to gasoline engines) will generally increase or decrease the selected parameter. These technologies are categorized into fuel modifications, engine modifications, and exhaust after-treatments. Current data are insufficient to quantify the results of the modifications. Table 3.3-3 provides general information on the trends of changes on selected parameters.

3.3.5 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the memoranda describing each supplement or the background report for this section.

Supplement A, February 1996

No changes.

Supplement B, October 1996

- Text was revised concerning emissions and controls.
- The CO_2 emission factor was adjusted to reflect 98.5 percent conversion efficiency.

Table 3.3-1. EMISSION FACTORS FOR UNCONTROLLED GASOLINE AND DIESEL INDUSTRIAL ENGINES[a]

Pollutant	Gasoline Fuel (SCC 2-02-003-01, 2-03-003-01)		Diesel Fuel (SCC 2-02-001-02, 2-03-001-01)		EMISSION FACTOR RATING
	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	
NO_x	0.011	1.63	0.031	4.41	D
CO	6.96 E-03[d]	0.99[d]	6.68 E-03	0.95	D
SO_x	5.91 E-04	0.084	2.05 E-03	0.29	D
PM-10[b]	7.21 E-04	0.10	2.20 E-03	0.31	D
CO_2[c]	1.08	154	1.15	164	B
Aldehydes	4.85 E-04	0.07	4.63 E-04	0.07	D
TOC					
Exhaust	0.015	2.10	2.47 E-03	0.35	D
Evaporative	6.61 E-04	0.09	0.00	0.00	E
Crankcase	4.85 E-03	0.69	4.41 E-05	0.01	E
Refueling	1.08 E-03	0.15	0.00	0.00	E

[a] References 2,5-6,9-14. When necessary, an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr was used to convert from lb/MMBtu to lb/hp-hr. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code. TOC = total organic compounds.

[b] PM-10 = particulate matter less than or equal to 10 µm aerodynamic diameter. All particulate is assumed to be ≤ 1 µm in size.

[c] Assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 86 weight % carbon in gasoline, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and gasoline heating value of 20,300 Btu/lb.

[d] Instead of 0.439 lb/hp-hr (power output) and 62.7 lb/mmBtu (fuel input), the correct emissions factors values are 6.96 E-03 lb/hp-hr (power output) and 0.99 lb/mmBtu (fuel input), respectively. This is an editorial correction. March 24, 2009

Table 3.3-2. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR UNCONTROLLED DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (Fuel Input) (lb/MMBtu)
Benzene[b]	9.33 E-04
Toluene[b]	4.09 E-04
Xylenes[b]	2.85 E-04
Propylene	2.58 E-03
1,3-Butadiene[b,c]	<3.91 E-05
Formaldehyde[b]	1.18 E-03
Acetaldehyde[b]	7.67 E-04
Acrolein[b]	<9.25 E-05
Polycyclic aromatic hydrocarbons (PAH)	
Naphthalene[b]	8.48 E-05
Acenaphthylene	<5.06 E-06
Acenaphthene	<1.42 E-06
Fluorene	2.92 E-05
Phenanthrene	2.94 E-05
Anthracene	1.87 E-06
Fluoranthene	7.61 E-06
Pyrene	4.78 E-06
Benzo(a)anthracene	1.68 E-06
Chrysene	3.53 E-07
Benzo(b)fluoranthene	<9.91 E-08
Benzo(k)fluoranthene	<1.55 E-07
Benzo(a)pyrene	<1.88 E-07
Indeno(1,2,3-cd)pyrene	<3.75 E-07
Dibenz(a,h)anthracene	<5.83 E-07
Benzo(g,h,l)perylene	<4.89 E-07
TOTAL PAH	1.68 E-04

[a] Based on the uncontrolled levels of 2 diesel engines from References 6-7. Source Classification Codes 2-02-001-02, 2-03-001-01. To convert from lb/MMBtu to ng/J, multiply by 430.

[b] Hazardous air pollutant listed in the *Clean Air Act*.

[c] Based on data from 1 engine.

Table 3.3-3. EFFECT OF VARIOUS EMISSION CONTROL TECHNOLOGIES ON DIESEL ENGINES[a]

Technology	Affected Parameter	
	Increase	Decrease
Fuel modifications		
Sulfur content increase	PM, wear	
Aromatic content increase	PM, NO_x	
Cetane number		PM, NO_x
10% and 90% boiling point		PM
Fuel additives		PM, NO_x
Water/Fuel emulsions		NO_x
Engine modifications		
Injection timing retard	PM, BSFC	NO_x, power
Fuel injection pressure	PM, NO_x	
Injection rate control		NO_x, PM
Rapid spill nozzles		PM
Electronic timing & metering		NO_x, PM
Injector nozzle geometry		PM
Combustion chamber modifications		NO_x, PM
Turbocharging	PM, power	NO_x
Charge cooling		NO_x
Exhaust gas recirculation	PM, power, wear	NO_x
Oil consumption control		PM, wear
Exhaust after-treatment		
Particulate traps		PM
Selective catalytic reduction		NO_x
Oxidation catalysts		TOC, CO, PM

[a] Reference 8. PM = particulate matter. BSFC = brake-specific fuel consumption.

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ATTACHMENT 7.9

HEAVY EQUIPMENT MANUFACTURER'S SPECIFICATION SHEETS

Wheel Tractor-Scrapers (cont'd)

Model	Product Ident. No. Prefix	Years Built	Horse-power Max/ Rated	Capacity Struck/ Heaped m^3 (yd^3)	Approx. Shipping Weight kg (lb)	Dimensions m (ft)				Tire Size (Standard) & ply rating Tractor & Scraper	Approx. % Weight on Drivers Loaded/ Empty	Turning Circle m (ft)
						Length	Width	Height	Width of Tread			
621	43H	65-72	/300	10.7/15.3 **(14/20)**	28 400 **(62,600)**	12.00 **(39'5")**	3.60 **(11'10")**	3.45 **(11'4")**	2.19 **(7'3")**	29.5 × 29-22	53/68	11.50 **(37'8")**
621	23H	65-74	/300	10.7/15.3 **(14/20)**	24 900 **(55,000)**	11.60 **(38'1")**	3.50 **(11'7")**	3.40 **(11'2")**	2.10 **(6'10")**	29.5 × 29-22	53/68	13.00 **(42'6")**
621B	45P	73-86	/330	10.7/15.3 **(14/20)**	30 205 **(66,590)**	12.7 **(41'7")**	3.45 **(11'4")**	3.63 **(11'11")**	2.21 **(7'3")**	29.5-29, 28 PR (E-3)	53/68	11.10 **(36'6")**
621E	6AB 2PD	86-93	/330	10.7/15.3 **(14/20)**	30 480 **(67,195)**	12.93 **(42'5")**	3.47 **(11'4")**	3.71 **(12'2")**	2.21 **(7'3")**	33.25-29, 26 PR (E-3)	53/68	10.9 **(35'8")**
621F	4SK	93-00	330	10.7/15.3 **(14/20)**	32 090 **(70,740)**	12.93 **(42'5")**	3.47 **(11'4")**	3.71 **(12'2")**	2.21 **(7'3")**	33.25-29 ★★ (E-2/E-3)	53/68	10.2 **(33'5")**
621G	ALP	00-03	330/365	10.7/15.3 **(14/20)**	32 250 **(71,090)**	12.93 **(42'5")**	3.47 **(11'4")**	3.71 **(12'2")**	2.20 **(7'3")**	33.25R29	68/53	11.7 **(38'5")**
621G	CEN	03-05	330/365	12/17 **(15.7/22)**	32 563 **(71,790)**	12.93 **(42'5")**	3.47 **(11'4")**	3.71 **(12'2")**	2.20 **(7'3")**	33.25R29	68/53	11.7 **(38'5")**
623	52U	72-74	/300	16.8 **(22)**	29 900 **(66,000)**	11.90 **(39'0")**	3.50 **(11'7")**	3.70 **(12'1")**	2.20 **(7'3")**	29.5 × 29-28	53/68	13.70 **(44'11")**
623B	46P	73-86	/330	16.8 **(22)**	32 546 **(71,750)**	12.5 **(41'1")**	3.55 **(11'8")**	3.81 **(12'6")**	2.18 **(7'2")**	29.5-29, 28 PR (E-2)	53/68	8.90 **(29'4")**
623E	6CB	86-89	/330	16.8 **(22)**	33 317 **(73,450)**	12.61 **(41'4")**	3.55 **(11'8")**	3.81 **(12'6")**	2.21 **(7'3")**	29.5-29, 34 PR (E-2)	52/65	10.9 **(35'9")**
623E	6YF	89-93	/365	13.8/17.6 **(18/23)**	35 290 **(77,800)**	12.61 **(41'4")**	3.55 **(11'8")**	3.94 **(12'11")**	2.18 **(7'2")**	29.5R25	51/66	10.9 **(35'8")**
623F	6BK	93-98	365	13.8/17.6 **(18/23)**	35 305 **(77,830)**	12.61 **(41'4")**	3.55 **(11'8")**	3.94 **(12'11")**	2.18 **(7'2")**	29.5-29, 34 PR (E-2)	51/66	10.9 **(35'8")**
623F Series II	5EW	98-00	365	13.8/17.6 **(18/23)**	37 122 **(81,840)**	13.28 **(43'7")**	3.55 **(11'8")**	3.55 **(11'8")**	2.21 **(7'3")**	33.25-R29 ★★ (E-2)	50/64	8.6 **(28'5")**
623G	ARW	00-02	330/365	13.8/17.6 **(18/23)**	37 120 **(81,840)**	13.21 **(43'4")**	3.55 **(11'8")**	3.68 **(12'1")**	2.2 **(7'3")**	33.25R29	64/50	10.9 **(35'8")**
623G	CES	03-05	330/365	13.8/17.6 **(18/23)**	37 120 **(81,840)**	13.21 **(43'4")**	3.55 **(11'8")**	3.68 **(12'1")**	2.2 **(7'3")**	33.25R29	64/50	10.9 **(35'8")**

PRODUCTION

The motor grader is used in a variety of applications in a variety of industries. Therefore, there are many ways to measure its operating capacity, or production. One method expresses a motor grader's production in relation to the area covered by the moldboard.

Formula:

$$A = S \times (L_e - L_o) \times 1000 \times E \quad \text{(Metric)}$$
$$A = S \times (L_e - L_o) \times 5280 \times E \quad \text{(English)}$$

where A: Hourly operating area (m^2/h or ft^2/h)
S: Operating speed (km/h or mph)
L_e: Effective blade length (m or ft)
L_o: Width of overlap (m or ft)
E: Job efficiency

Operating Speeds:

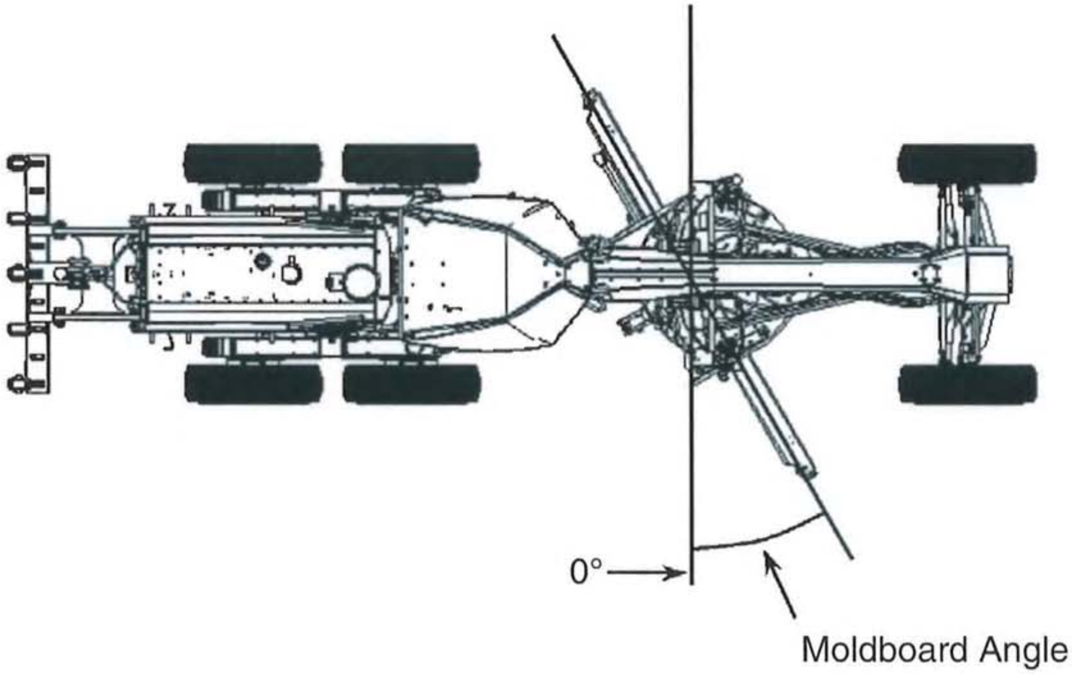
Typical operating speeds by application

Finish Grading:	0-4 km/h	(0-2.5 mph)
Heavy Blading:	0-9 km/h	(0-6 mph)
Ditch Repair:	0-5 km/h	(0-3 mph)
Ripping:	0-5 km/h	(0-3 mph)
Road Maintenance:	5-16 km/h	(3-9.5 mph)
Haul Road Maintenance:	5-16 km/h	(3-9.5 mph)
Snow Plowing:	7-21 km/h	(4-13 mph)
Snow Winging:	15-28 km/h	(9-17 mph)

Effective Blade Length:

Since the moldboard is usually angled when moving material, an effective blade length must be computed to account for this angle. This is the actual width of material swept by the moldboard.

NOTE: Angles are measured as shown below. The effective length becomes shorter as the angle increases.



BULLDOZER PRODUCTION OFF-THE-JOB

You can estimate bulldozer production using the production curves that follow and the correction factors that are applicable. Use this formula:

$$\text{Production } \frac{(\text{Lm}^3/\text{hr})}{(\text{LCY/hr})} = \text{Maximum production} \times \text{Correction factors}$$

The bulldozer production curves give maximum uncorrected production for universal, semi-universal, and straight blades and are based on the following conditions:

1. 100% efficiency (60 minute hour — level cycle).
2. Power shift machines with 0.05 min. fixed times.
3. Machine cuts for 15 m (50 feet), then drifts blade load to dump over a high wall. (Dump time — 0 sec.)
4. Soil density of 1370 kg/Lm^3 (2300 lb/LCY).
5. Coefficient of traction:*
    a. Track machines — 0.5 or better
    b. Wheel machines — 0.4 or better
6. Hydraulic controlled blades used.
7. Dig 1F**
    Carry 2F**
    Return 2R**

To obtain estimated production in bank cubic meters or bank cubic yards, appropriate load factor from the Tables section should be applied to the corrected production as calculated above.

$$\text{Production } \frac{\text{Bm}^3/\text{hr}}{(\text{BCY/h})} = \frac{\text{Lm}^3/\text{hr} \times \text{LF}}{(\text{LCY/h}) \times \text{LF}}$$

---

*Coefficient of traction assumed to be at least 0.4. While poor traction affects both track and wheel vehicles, causing them to take smaller blade loads, wheeled units are affected more severely and production falls much more rapidly. While no fixed rules can predict this production loss, a rough rule of thumb is that wheel dozer production falls off 4% for each one-hundredth decrease in coefficient of traction below 0.40. If, for example, coefficient of traction is 0.30, the difference is ten-hundredths (0.10), and production is 60% (10 × 4% = 40% decrease).

**This gear sequence is based on level to downhill terrain, light to medium density material, and no blade extensions such as spill plates, rock guards, etc. Exceeding these conditions may require carry in 1F, but productivity should equal or exceed "standard conditions" due to the larger loads that can be carried in 1F.

ATTACHMENT 7.10

AP-42, SECTION 13.5 INDUSTRIAL FLARES

13.5 Industrial Flares

13.5.1 General

Flaring is a high-temperature oxidation process used to burn combustible components, mostly hydrocarbons, of waste gases from industrial operations. Natural gas, propane, ethylene, propylene, butadiene and butane constitute over 95 percent of the waste gases flared. In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide (CO_2) and water. In some waste gases, carbon monoxide (CO) is the major combustible component. Presented below, as an example, is the combustion reaction of propane.

$$C_3H_8 + 5\ O_2 \quad > 3\ CO_2 + 4\ H_2O$$

During a combustion reaction, several intermediate products are formed, and eventually, most are converted to CO_2 and water. Some quantities of stable intermediate products such as carbon monoxide, hydrogen, and hydrocarbons will escape as emissions.

Flares are used extensively to dispose of (1) purged and wasted products from refineries, (2) unrecoverable gases emerging with oil from oil wells, (3) vented gases from blast furnaces, (4) unused gases from coke ovens, and (5) gaseous wastes from chemical industries. Gases flared from refineries, petroleum production, chemical industries, and to some extent, from coke ovens, are composed largely of low molecular weight hydrocarbons with high heating value. Blast furnace flare gases are largely of inert species and CO, with low heating value. Flares are also used for burning waste gases generated by sewage digesters, coal gasification, rocket engine testing, nuclear power plants with sodium/water heat exchangers, heavy water plants, and ammonia fertilizer plants.

There are two types of flares, elevated and ground flares. Elevated flares, the more common type, have larger capacities than ground flares. In elevated flares, a waste gas stream is fed through a stack anywhere from 10 to over 100 meters tall and is combusted at the tip of the stack. The flame is exposed to atmospheric disturbances such as wind and precipitation. In ground flares, combustion takes place at ground level. Ground flares vary in complexity, and they may consist either of conventional flare burners with no enclosures or of multiple burners in refractory-lined steel enclosures.

The typical flare system consists of (1) a gas collection header and piping for collecting gases from processing units, (2) a knockout drum (disentrainment drum) to remove and store condensables and entrained liquids, (3) a proprietary seal, water seal, or purge gas supply to prevent flash-back, (4) a single- or multiple-burner unit and a flare stack, (5) gas pilots and an ignitor to ignite the mixture of waste gas and air, and, if required, (6) a provision for external momentum force (steam injection or forced air) for smokeless flaring. Natural gas, fuel gas, inert gas, or nitrogen can be used as purge gas. Figure 13.5-1 is a diagram of a typical steam-assisted elevated smokeless flare system.

Combustion requires three ingredients: fuel, an oxidizing agent (typically oxygen in air), and heat (or ignition source). Flares typically operate with pilot flames to provide the ignition source, and they use ambient air as the oxidizing agent. The waste gases to be flared typically provide the fuel necessary for combustion. Combustible gases generally have an upper and lower flammability limit. The upper flammability limit (UFL) is the highest concentration of a gas in air that is capable of burning. Above this flammability limit, the fuel is too rich to burn. The lower flammability limit (LFL) is the lowest concentration of the gas in air that is capable of burning. Below the LFL, the fuel is too lean to burn. Between the upper and lower flammability limits, combustion can occur. Flare waste gases with concentrations above the UFL will become more dilute as the waste gas mixes with ambient air above the flare tip. As this dilution occurs, the air-waste gas mixture will pass through the flammability region, and combustion will occur. However, if flare waste gas concentrations are near the LFL prior to mixing with air, the air-waste gas mixture can fall below the flammability region, and reduced combustion efficiencies can occur. If steam is added to the flare waste gas at or prior to the flare tip (i.e., prior to the "combustion zone" where the mixing with air occurs), the steam will act to dilute the waste gas. Thus, even if there are adequate concentrations of combustibles in the waste gas, if too much steam is added to the waste gas so that the combustibles concentration becomes diluted to near the LFL as the steam-waste gas mixture enters the combustion zone, reduced combustion efficiencies will result. Consequently, critical considerations of flare combustion include the net heating value and the combustibles concentration in the flare gas and in the combustion zone (e.g., accounting for the amount of dilution by steam or other assist gas that occurs to the waste gas prior to the combustion zone).

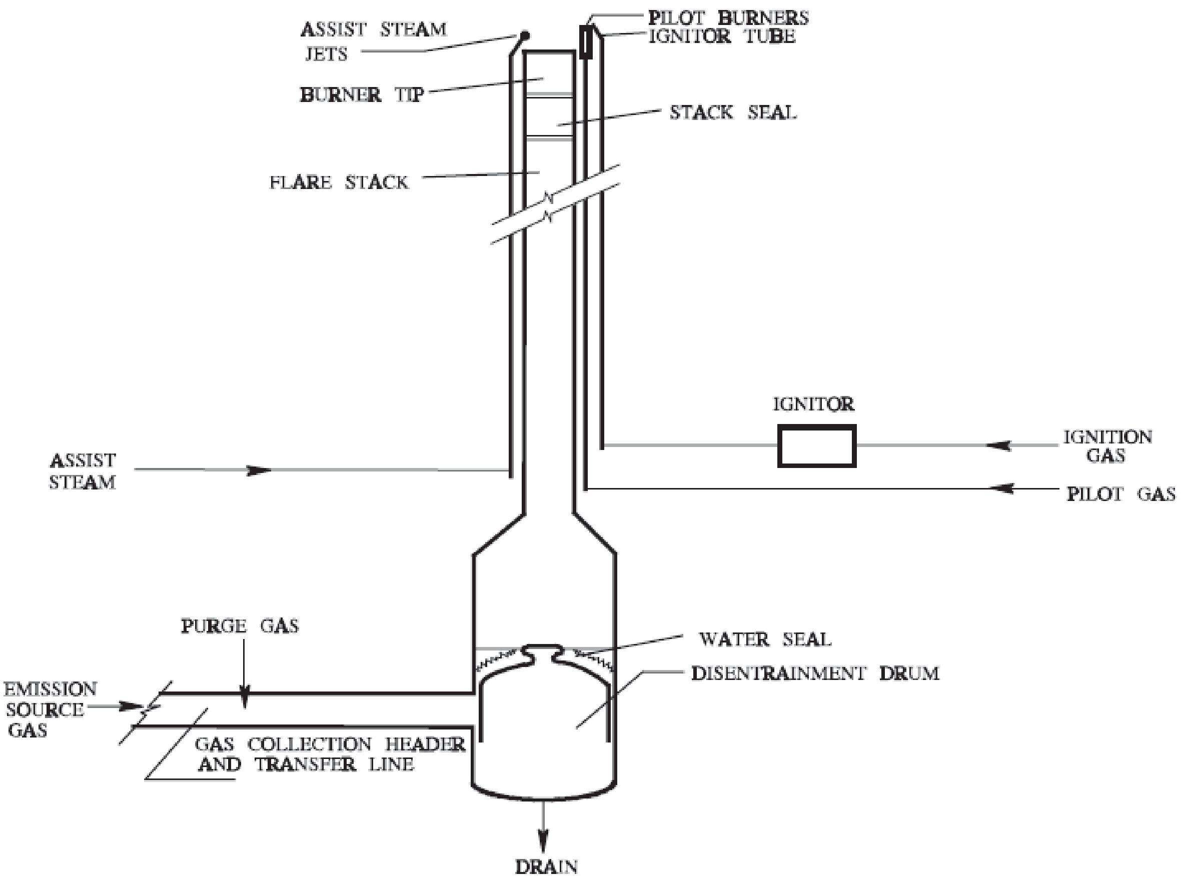


Figure 13.5-1. Diagram of a typical steam-assisted smokeless elevated flare.

Combustion efficiency is the percentage of hydrocarbon in the flare vent gas that is completely converted to CO_2 and water vapor. Destruction efficiency is the percentage of a specific pollutant in the flare vent gas that is converted to a different compound (such as CO_2, CO or other hydrocarbon intermediate). The destruction efficiency of a flare will always be greater than the combustion efficiency of a flare. It is generally estimated that a combustion efficiency of 96.5 percent is equivalent to a destruction efficiency of 98 percent.[10]

Smoking may result from combustion, depending upon waste gas components and the quantity and distribution of combustion air. Waste gases containing methane, hydrogen, CO, and ammonia usually burn without smoke. Waste gases containing heavy hydrocarbons such as paraffins above methane, olefins, and aromatics, have a higher tendency to smoke. An external momentum force, such as steam injection or blowing air, is used for efficient air/waste gas mixing and turbulence, which promotes smokeless flaring of heavy hydrocarbon waste gas. Other external forces may be used for this purpose, including water spray, high velocity vortex action, or natural gas. External momentum force is rarely required in ground flares.

Steam injection is accomplished either by nozzles on an external ring around the top of the flare tip or by a single nozzle located concentrically within the tip. At installations where waste gas flow varies, both are used. The internal nozzle provides steam at low waste gas flow rates, and the external jets are used with large waste gas flow rates. Several other special-purpose flare tips are commercially available, one of which is for injecting both steam and air.

Flares are generally designed to handle large quantities of waste gases that may be intermittently generated during plant emergencies, although they may also be used routinely to dispose of low-volume continuous or intermittent emissions from various sources at the plant. Flare gas volumes can vary from a few cubic meters per hour during regular operations up to several thousand cubic meters per hour during major upsets. Flow rates at a refinery could be 45 to 90 kilograms per hour (kg/hr) (100 - 200 pounds per hour [lb/hr]) during regular operation but could reach a full plant emergency rate of 700 megagrams per hour (Mg/hr) (750 tons/hr). Normal process blowdowns may release 450 to 900 kg/hr (1000 - 2000 lb/hr), and unit maintenance or minor failures may release 25 to 35 Mg/hr (27 - 39 tons/hr). Thus, the required flare turndown ratio can be over 15,000 to 1.

Many plants have 2 or more flares, in parallel or in series. In the former, 1 flare can be shut down for maintenance while the other serves the system. In systems of flares in series, 1 flare is intended to handle regular gas volumes and the other flare is generally intended to handle excess gas flows from emergencies.

13.5.2 Emissions

Noise, heat, and visible flame and/or smoke are the most apparent undesirable effects of flare operation. Flares are usually located away from populated areas or are sufficiently isolated, thus minimizing their effects on populations.

Emissions from flaring may include carbon particles (soot), unburned hydrocarbons, CO, and partially burned and altered hydrocarbons. Also emitted are nitrogen oxides (NO_x) and, if sulfur-containing material such as hydrogen sulfide or mercaptans is flared, sulfur dioxide (SO_2). The quantities of hydrocarbon emissions generated relate to the degree of combustion. The degree of combustion depends largely on the rate and extent of fuel-air mixing and on the flame temperatures achieved and maintained. Properly operated flares achieve at least 98 percent destruction efficiency in the flare plume, meaning that hydrocarbon emissions amount to less than 2 percent of the hydrocarbons in the gas stream.

The tendency of a fuel to smoke or make soot is influenced by fuel characteristics and by the amount and distribution of oxygen in the combustion zone. For complete combustion, at least the stoichiometric amount of oxygen must be provided in the combustion zone. The theoretical amount of oxygen required increases with the molecular weight of the gas burned. The oxygen supplied as air ranges from 9.6 units of air per unit of methane to 38.3 units of air per unit of pentane, by volume. Air is supplied to the flame as primary air and secondary air. Primary air is mixed with the gas before combustion, whereas secondary air is drawn into the flame. For smokeless combustion, sufficient primary air must be supplied, this varying from about 20 percent of stoichiometric air for a paraffin to about 30 percent for an olefin. If the amount of primary air is insufficient, the gases entering the base of the flame are preheated by the combustion zone, and larger hydrocarbon molecules crack to form hydrogen, unsaturated hydrocarbons, and carbon. The carbon particles may escape further combustion and cool down to form soot or smoke. Olefins and other unsaturated hydrocarbons may polymerize to form larger molecules which crack, in turn forming more carbon.

The fuel characteristics influencing soot formation include the carbon-to-hydrogen (C-to-H) ratio and the molecular structure of the gases to be burned. All hydrocarbons above methane, i. e., those with a C-to-H ratio of greater than 0.33, tend to soot. Branched chain paraffins smoke more readily than corresponding normal isomers. The more highly branched the paraffin, the greater the tendency to smoke. Unsaturated hydrocarbons tend more toward soot formation than do saturated ones. Soot is eliminated by adding steam or air; hence, most industrial flares are steam-assisted and some are air-assisted. Flare gas composition is a critical factor in determining the amount of steam necessary.

Since flares do not lend themselves to conventional emission testing techniques, until recently only a few attempts have been made to characterize flare emissions. Early EPA tests using propylene as flare gas indicated that efficiencies of 98 percent can be achieved when burning an offgas with at least 11,200 kJ/m^3 (300 Btu/ft^3).[1] However, recent studies on flare performance using passive Fourier Transform Infrared (pFTIR) spectroscopy have been performed on a number of different flares.[4-8] The studies cover a number of flares at refineries, chemical plants and flare test facilities with varying waste gas compositions. The pFTIR studies support the conclusion that the combustion zone properties of the steam-waste gas mixture are predictive of proper flare combustion.[10] There have also been recent studies on sources, including flares, using differential infrared absorption LIDAR [light detection and ranging] (DIAL). To date, many of these studies do not provide the data necessary to isolate the emissions from a particular flare. But enough data existed in one study that the emissions measured by DIAL could be attributed to the flare.[9] For flares operated at petroleum refineries, EPA has determined that the net heating value of the gas in the combustion zone of the flare should be greater than or equal to 270 Btu/ft^3 to obtain a destruction efficiency of at least 98%.[a]

Table 13.5-1 presents flare emissions factors from the EPA tests[1]; Table 13.5-2 presents flare emissions factors from pFTIR and DIAL studies.[4-9] Crude propylene was used as flare gas during the early EPA tests. Methane was a major fraction of hydrocarbons in the flare emissions, and acetylene was the dominant intermediate hydrocarbon species. Many other reports on flares indicate that acetylene is always formed as a stable intermediate product. The acetylene formed in the combustion reactions may react further with hydrocarbon radicals to form polyacetylenes followed by polycyclic hydrocarbons.[2] Typical refinery waste gas feeds were used as flare gas during the pFTIR and DIAL studies.

In flaring waste gases containing no nitrogen compounds, NO is formed either by the fixation of atmospheric nitrogen (N) with oxygen (O) or by the reaction between the hydrocarbon radicals present in the combustion products and atmospheric nitrogen, by way of the intermediate stages, HCN, CN, and OCN.[2] Sulfur compounds contained in a flare gas stream are converted to SO_2 when burned. The amount of SO_2 emitted depends directly on the quantity of sulfur in the flared gases.

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[a] See Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards Final Rule, December 1, 2015 (80 FR 75183). Net heating value of the combustion zone is determined on a 15-minute average, and refinery owners and operators may use a corrected heat content for hydrogen when determining the combustion zone heat value.

Table 13.5-1 (English Units). THC, NOx AND SOOT EMISSIONS FACTORS FOR FLARE OPERATIONS[a]

EMISSIONS FACTOR RATING: B

Pollutant	SCC[d]	Emissions Factor Value	Emissions Factor Units
Total hydrocarbons[b]	30190099; 30119701; 30119705; 30119709; 30119741	0.14	lb/10^6 Btu
Nitrogen oxides[c]		0.068	lb/10^6 Btu
Soot[c]		0 - 274	µg/L

[a] Reference 1. Based on tests using crude propylene containing 80% propylene and 20% propane.

[b] Measured as methane equivalent. The THC emissions factor may not be appropriate for reporting VOC emissions when a VOC emissions factor exists.

[c] Soot in concentration values: nonsmoking flares, 0 micrograms per liter (µg/L); lightly smoking flares, 40 µg/L; average smoking flares, 177 µg/L; and heavily smoking flares, 274 µg/L.

[d] See Table 13.5-3 for a description of these SCCs.

Table 13.5-2 (English Units). VOC and CO EMISSIONS FACTORS FOR FLARE OPERATIONS[a]

Pollutant	SCC[d]	Emissions Factor (lb/10^6 Btu)	Representativeness
Volatile organic compounds[b]	30190099; 30600904; 30119701; 30119705; 30119709; 30119741; 30119799; 30130115; 30600201; 30600401; 30600508; 30600903; 30600999; 30601701; 30601801; 30688801; 40600240	0.66	Poorly
Carbon monoxide[c]		0.31	Poorly

[a] These factors apply to well operated flares achieving at least 98% destruction efficiency and operating in compliance with the current General Provisions requirements of 40 CFR Part 60, i.e. >300 btu/scf net heating value in the vent gas and less than the specified maximum flare tip velocity. The VOC emissions factor data set had an average destruction efficiency of 98.9%, and the CO emissions factor data set had an average destruction efficiency of 99.1% (based on test reports where destruction efficiency was provided). These factors are based on steam-assisted and air-assisted flares burning a variety of vent gases.

[b] References 4-9 and 11.

[c] References 1, 4-8 and 11.

[d] See Table 13.5-3 for a description of these SCCs.

Table 13.5-3. SCC Descriptions

SCC	Level 1 Description	Level 2 Description	Level 3 Description	Level 4 Description
30600903	Industrial Processes	Petroleum Industry	Flares	Natural Gas
30600904	Industrial Processes	Petroleum Industry	Flares	Process Gas
30190099	Industrial Processes	Chemical Manufacturing	Fuel Fired Equipment	User Specified
30600999	Industrial Processes	Petroleum Industry	Flares	Not Classified
30600201	Industrial Processes	Petroleum Industry	Catalytic Cracking Units	Fluid Catalytic Cracking Unit
30130115	Industrial Processes	Chemical Manufacturing	Chlorobenzene	Atmospheric Distillation Vents
30688801	Industrial Processes	Petroleum Industry	Fugitive Emissions	User Specified
30600401	Industrial Processes	Petroleum Industry	Blowdown Systems	Blowdown System with Vapor Recovery System with Flaring
30601801	Industrial Processes	Petroleum Industry	Hydrogen Generation Unit	General
30601701	Industrial Processes	Petroleum Industry	Catalytic Hydrotreating Unit	General
30600508	Industrial Processes	Petroleum Industry	Wastewater Treatment	Oil/Water Separator
40600240	Petroleum and Solvent Evaporation	Transportation and Marketing of Petroleum Products	Marine Vessels	Gasoline: Barge Loading - Average Tank Condition
30119701	Industrial Processes	Chemical Manufacturing	Butylene, Ethylene, Propylene, Olefin Production	Ethylene: General
30119741	Industrial Processes	Chemical Manufacturing	Butylene, Ethylene, Propylene, Olefin Production	Ethylene: Flue Gas Vent
30119705	Industrial Processes	Chemical Manufacturing	Butylene, Ethylene, Propylene, Olefin Production	Propylene: General
30119709	Industrial Processes	Chemical Manufacturing	Butylene, Ethylene, Propylene, Olefin Production	Propylene: Fugitive Emissions
30119799	Industrial Processes	Chemical Manufacturing	Butylene, Ethylene, Propylene, Olefin Production	Other Not Classified

References for Section 13.5

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ATTACHMENT 7.11

DUST CONTROL PLAN

DUST CONTROL PLAN
(UPDATED APRIL 2011)
Camino Real Landfill

I. BACKGROUND

Since 1988, the Camino Real Landfill (CRLF) has implemented a number of dust control measures to mitigate potential fugitive dust emissions during typical landfill operations. In addition, CRLF continues to evaluate the effectiveness of alternative dust control measures (surfactants, wind fences, soil amendments, etc.) as new industry technologies and approaches are developed and tested. Many of the dust control measures described below were implemented consistent with the landfill's Plan of Operations, which is an integral component of the approved Solid Waste Application for Permit Renewal (July 2008).

II. SUMMARY OF DUST CONTROL MEASURES

The dust control methods outlined in this Plan are indicative of the control measures currently employed at the site, as well as those planned for the duration of the next 5-year Title V Permit term. Using a variety proven techniques, CRLF has mitigated the emission of fugitive dust by implementing a combination of control measures:

1) Watering – Potential fugitive dust emissions are controlled via water application to the following areas of the landfill:
    - Disposal Route
    - Access Roads
    - Landfill Office Parking Lot
    - Maintenance Compound
    - Active Disposal Area Fill Face Under High Wind Conditions
    - Daily Cover Soil Borrow Areas

    Over 2 million gallons of water per month are applied to site roads, parking lots, and landfill operations areas in order to minimize dust emissions. Roads receiving the most traffic (e.g., the disposal route, parking lots) receive more frequent water applications. Landfill access roads and daily cover soil borrow areas are also watered.

2) Chemical Surfactants – On a periodic basis, dust palliatives or surfactants are used as a supplement to the water in order to promote the formation of a surficial crust resistant to erosion. Approximately 5,000 gallons of the chemical surfactant Road Boss®) are currently

applied to areas of heavy traffic (e.g., disposal route, Landfill Office, and Maintenance Compound parking lots) once every three months.

3) Racetrack Waste – Race track waste material supplied by the Sunland Park Race Track has proven to be more resistant to wind erosion than the native silty sands/sandy silts. The race track waste is a combination of straw and decomposing horse manure, and contains larger particle sizes, moisture, and organic content than the native on-site material. Consequently, this material is used to supplement the intermediate cover overlying waste deposits.

4) Rock Armoring – Rock has been deployed over approximately 6 acres of undisturbed portions of the Closed Area. The rock, whose average size is 5 – 6 inches, resists both wind and water erosion. While the rock remains in place, much of it has been covered by wind-blown soil as a result of the activities associated with the installation of the site's gas collection and control system (GCCS) in 1999 and 2000. Racetrack waste has been applied to the area once covered by rock armoring.

5) Vegetative Test Plots – Commencing in 1997, the site initiated a long-term study to evaluate the effectiveness of stabilizing closed areas by planting a variety of plant species indigenous to the area. Since issuance of the first Title V Permit in April 2001, some of the plant growth was temporarily impacted by the excavation and drilling activities associated with the installation of the GCCS. Reseeding of select portions of the Closed Area commenced in August 2002, and recovery of the vegetation continues to be monitored.

6) Limits on Vehicle Speed – Signs posted along the disposal route and access roads limit all vehicle speeds to 15 miles per hour.

7) Site Access Restrictions – Access to the site continues to be controlled by a single point of ingress/egress. Vehicles entering the site can only gain authorized access by first checking in at the Gate House, and entering past the security gate. The remainder of the site is protected by fencing, topography, and "No Trespassing" signs.

8) Natural Topography and Engineered Development – The landfill's topographic setting within a low point surrounded by mesa walls on three sides continues to create favorable conditions for limiting wind erosion. Current landfilling activities are conducted to the south of the Closed Area, which acts as a wind barrier to potential dust generation by these activities. Approximately 0.6 miles of temporary wind fencing have been deployed at selective downwind locations to trap particulates before they leave the site.

9) Paving – In 2004, Camino Real paved the 1-mile-long public access road from McNutt Road to the landfill entrance. Additional paving was applied to the Landfill Office parking lot, Gate House area, and the intersection of the facility's unpaved access roads and disposal route. Approximately 400 feet of paved road was constructed from the Gate House (i.e., site entrance) to the Landfill Office, and approximately 2,800 ft^2 of the Landfill Office parking lot was also paved. In addition, approximately 140 feet of the disposal route south of the site entrance and approximately 350 feet of access road east of the Gate House were paved.

The following discussion provides additional detail on dust control measures being implemented at the site. The discussion is generally formatted after the Maricopa County, Arizona Rule 310 Plan, which creates some repetition.

III. ACCESS RESTRICTIONS

A. Restricted Access

No Trespassing signs in Spanish and English have been in-place since 1988 leading up to the landfill entrance. CRLF is secured on the perimeters with both chain link fencing and 5-strand barbed wire where natural barriers do not preclude accessibility. The US Border Patrol maintains active surveillance of the perimeter 24 hours per day, 365 days per year. Site ingress/egress is controlled by both vertical and horizontal automatic swing-arm gates operated by an attendant at the Gate House during operating hours. After hours, site ingress/egress may be controlled by a gate attendant and/or a security keypad. **Figure 5.1**, **Section 5** shows the location of existing fencing, gates, and other access control measure. In the spring of 2008, a fence was completed by the Federal Government along the U.S./Mexico border. The fence is constructed of 21-foot steel sections which extend 15 feet above grade and 6 feet below grade. A mesh fence on steel posts is used in flat areas and sheet pile sections are used to traverse steep grades.

B. Physical Barriers That Limit Unauthorized Access

The landfill currently uses the following physical barriers to limit unauthorized access:

- Five-strand wire fencing prevents access from the Gate House to the former U.S. Border Patrol staging area (i.e., Stable) along the north property line.
- From the former Border Patrol staging area to the northern property boundary, elevated railroad tracks and natural barriers (e.g., steep hillsides, sand dunes) prevent vehicular access to the site and limit pedestrian traffic.
- Access to the remaining perimeter of the northern boundary is controlled by the elevated railroad tracks and a constructed elevated earthern berm approximately 2,800 feet in length.
- Five-strand barbed wire fencing prevents access to the western boundary of the landfill.
- Along the southern property boundary (the Mexico border), a fence is constructed of 21-foot steel sections which extend 15 feet above grade and 6 feet below grade.
- Access is prevented along the eastern property boundary by 5-strand wire fencing and steep canyon walls.
- Access through the single authorized entrance to the landfill is controlled by automated gates operated by landfill staff during operational hours.

IV. CONTROL OF EMISSIONS

A. Unpaved Parking Lots

Potential fugitive dust emissions from unpaved portions of parking lots are controlled by a combination of applying gravel as a base course, and the routine application of water by water wagons. On a periodic basis (e.g., once every three months), dust palliatives or chemical surfactants (e.g., Road Boss® and magnesium or calcium chloride) are used as a supplement to the water in order to promote the formation of a surficial crust resistant to erosion.

B. Unpaved Disposal Route/Access Roads

1.0 Vehicle Speed Limitations

Signs are posted along the disposal route and access roads that limit all vehicle speeds to 15 miles per hour.

2.0 Water Application

Potential fugitive dust emissions from landfill roads and disposal operations are controlled by application of water by the following equipment:

- A CAT® 623E water wagon (8,000-gallon capacity) serves as the site's primary water truck and is used on a daily basis when the landfill is operational. The primary water truck makes approximately 12 round trips per day (12 cycles of emptying and refilling) and applies over 95,000 gallons of water per day to landfill roads (e.g., disposal route and access roads), parking lot areas (e.g., Landfill Office and Maintenance Compound), and disposal operations areas (e.g., waste disposal and daily cover soil borrow areas). The frequency of water application to the above-mentioned areas is approximately once every 30 minutes. These areas are shown on **Figure 5.1**, **Section 5**.
- A CAT® 621B water wagon (8,000-gallon capacity) serves as a backup in the event the primary water truck is not operational. The backup water truck may also serve to apply water to waste deposits at the active fill face of disposal areas during high wind events when the primary water truck is occupied with increased water application at other site locations. High wind events during landfill operations increase the frequency and application rate of water, or cessation of operations until the wind subsides.
- In the event the site's water supply well becomes inoperable, water previously stored in the two on-site water tanks would be used until empty (combined volume of 312,000 gallons). As an additional emergency measure, the site could purchase additional water from the City of Sunland Park water tank, which is located approximately 500 feet northeast of the Maintenance Compound.

3.0 Chemical Surfactants

On a periodic basis, dust palliatives or surfactants are currently used as a supplement to the water in order to promote the formation of a surficial crust resistant to erosion. Approximately 5,000 gallons of chemical surfactant are applied to areas of heavy traffic (e.g., disposal route, Landfill Office and Maintenance Compound parking lots) once every three months.

C. Disturbed Surface Areas

1.0 Daily Cover Soil Borrow Areas

Control of potential fugitive dust emissions from operations associated with the excavation of daily cover soil is accomplished with an 8,000-gallon CAT® 623E water wagon. Water is routinely applied to control fugitive dust emissions and to facilitate more efficient removal of excavated soil. Previous experience has shown that when the native silty sands/sandy silts are amended with moisture, excavation is more efficient, and less passes of the scraper are necessary.

2.0 Phasing of Work

Routine landfill operations include the daily excavation, hauling, and stockpiling of soil from areas where the next landfill cell will be located. Soil not needed for daily cover is stockpiled at a location proximate to the cell being constructed and the cell being filled. After the day's waste receipts are accepted, stockpiling of soil ceases and only the amount of soil needed for that day's daily cover is applied. This procedure serves to eliminate double-handling of daily cover soil.

In order to minimize potential fugitive dust emissions, the site has also reduced the size of new cells to be constructed by subdividing cells into smaller parcels (e.g., the 17-acre± cell 7 was subdivided into cells 7A and 7B). Consistent with the intent of minimizing the amount of disturbed area at any one time, the future construction of cells will be limited to approximately eight acres. Once the soil subgrade is prepared for each cell, the entire footprint is covered with a GCL/FML composite liner system. The proposed site development sequence over the next five years would direct the placement of fill deposits from Cell 9 towards Cell 3.1. Installing these cells in this sequence will allow future landfill construction and operations to be conducted below-grade and behind the barrier formed by the Closed Area and Cells 1 through 8.

D. Control of Emissions During Dust Generating Operations

1.0 Application of Suitable Dust Suppressant

Currently, water is the primary dust suppressant used at the landfill. Water for dust suppression is obtained from an on-site water tank (400,000-gallon capacity) that is supplied by a 150-gallon-per-minute, on-site production well. Water is also available (upon arrangement with the city of Sunland Park, NM) from a 1.2 million gallon City water tank that is located adjacent to the landfill at the northeast corner of the site. Currently, the chemical surfactant Road Boss® is applied periodically (once every three months) to unpaved portions of facility parking lots and the disposal route. Consistent with manufacturer's specifications and recommendations for application rates and maintenance frequencies, the landfill intends to implement the routine application of these or comparable dust palliatives to areas of activity that generate the most dust. The Camino Real Landfill will evaluate the applicability of the various surfactants that are commercially available to actual site conditions, and select the most feasible application for the suppression of dust at the site.

2.0 Water Application

During dust generating operations, water is applied to minimize potential fugitive dust emissions on the routine schedule as describe above. Water is regularly applied to the disposal route and access roads; daily cover soil borrow areas; and, under high wind conditions, to the active fill face of waste disposal areas.

3.0 Wind Barriers

Currently, approximately 0.6 miles of 3-foot high wind fences have been deployed at strategic downwind locations to trap particulates before they exit the site. The wind fences are periodically re-positioned as a function of the locations of the daily active fill face and current cell under construction. In addition, a man-made vegetative barrier comprised of 2,800 feet of 6-foot high Oleander bushes are positioned atop the screening berm located parallel to the northern property boundary. The fences and Oleanders are positioned downwind of the prevailing wind direction (northeast).

4.0 Topographic Screening

The sequence of cell construction and waste disposal has been deliberately designed to take advantage of favorable natural topographic conditions. Natural topographic conditions allowed for filling in a low area that was surrounded by mesa walls on three sides (east, west and south). Waste accepted through July 1993 was placed in a 50± acre area near the north property line, and these deposits now represent the Closed Area. The current landfill cells (Cell 1 – Cell 10A) are located south of and behind the Closed Area. Future cells (Cell 10B through Cell 3.1) will be located south of and behind waste deposits in Cell 9 and west of deposits in Cells 4 Down, 5A, and 5B. The positioning of current and future cells increases the distance particulates must travel prior to exiting the site. The Closed Area and Cells 1 through 8 represent a barrier between landfill operations and the north perimeter. The surrounding natural sidewalls and the man-made barrier allow most activities to take place below-grade. Existing and proposed landfill operations are set back from the north property line by over 1,000 feet.

E. Temporary Stabilization During Non-Operating Hours

1.0 Vegetative Ground Cover

Vegetative test plots constructed in the Closed Area in 1997 were heavily impacted by the construction and installation of the GCCS. Reseeding of select portions of the Closed Area commenced in August 2002. Due to the semi-arid climate in the El Paso, TX region, recovery of the vegetation is slow and continues to be monitored. As new fill areas reach final grade, additional vegetative species will be tested and maintained.

2.0 Vehicular Access

Current and proposed traffic from all solid waste delivery vehicles and daily operations vehicles does not occur on Sundays and holidays. Border Patrol vehicular traffic is not controlled under this Plan. Restriction of vehicular access to the site is outlined in Section III above.

F. Permanent Stabilization

1.0 Phased Landfill Stabilization

Due to the sequencing of landfill construction and operations, most disposal cells are filled until a prescribed intermediate grade is achieved. At this point, the intermediate-grade slopes are covered with 12 inches of soil, supplemented by race track waste supplied by the City of Sunland Park Race Track. Previous experience at the landfill has shown that the race track waste, comprised primarily of straw and decaying horse manure, possesses a larger particle size and higher moisture content than the native materials, making the race track waste more erosion resistant. Landfill equipment is used to spread the race track waste across the intermediate slopes, which will occupy approximately 175 acres± (i.e., Cells 1 through 10B) of the site at the end of the next Title V Permit 5-year term.

2.0 Ultimate Landfill Stabilization

As part of ultimate site closure, a final cover system will be constructed that includes the planting of vegetation known to be successful in southern Doña Ana County. The NMED-approved Closure/Post-Closure Plan (July 2008) outlines the steps leading to site restoration, including the establishment of vegetation.

G. Restoration of Open Areas and Vacant Lots

1.0 Area Restoration

The configuration of the landfill has been designed to allow development of the permitted landfill footprint while minimizing disturbance of adjacent areas. Therefore, at the time of ultimate site closure, the areas that are “open” or vacant will be minimal compared to the landfilled area subject to vegetation, as prescribed in the NMED-approved Closure/Post-Closure Plan. In addition, vacant areas will occupy perimeter locations much lower in elevation than the landfill final grades. As part of routine operations, open areas (e.g., parking lots) are watered or treated with chemical surfactants to control fugitive dust emissions.

2.0 Application of Suitable Dust Suppressant

Currently, potential fugitive dust emissions from unpaved parking lots are minimized by a combination of applying water, using gravel as a base course, and on a periodic basis, supplementing the water with Road Boss®.

3.0 Vegetative Ground Cover

Vegetative test plots impacted by GCCS construction activities were reseeded in 2002. Though re-vegetative growth is slowed by the regional climate, the progress of re-growth continues to be monitored.

H. Bulk Material Handling Operations and Open Storage Piles (During Loading and Unloading Operations)

1.0 Water Application

Two primary materials are handled at the landfill: waste and soil. If high winds occur at the active disposal fill face, water is applied to the waste and daily cover soils, as necessary, to minimize potential fugitive dust emissions. Water is also applied (as necessary) to the areas where daily cover soil is obtained. High wind events during application of daily cover soil over waste deposits and disposal operations at the active fill face prompt increased water application rates and frequency. In the event of excessively high winds, non-essential dust generating landfill operations (e.g., cell preparation and routine road maintenance) are discontinued.

2.0 Application of Alternative Excavation Techniques

New earthmoving techniques are being evaluated and tested in an effort to minimize dust generation and maximize equipment and technology efficiencies. For example, on an as-needed basis, a bulldozer is used to loosen onsite soils in daily cover soil borrow areas that occasionally are either too difficult to remove with a scraper or need to be loosened from steep embankments that cannot be accessed by the scraper. In addition, in limited areas within daily cover soil borrow areas that are inaccessible by scrapers, front end loaders are used for excavation, and the loaders place the soil into articulated dump trucks for transportation to the active fill face for use as daily cover. Unlike soil removal by scrapers, use of the bulldozer and end loaders serves to localize and confine the disturbed soil to a smaller volume, enhancing control efficiencies and lowering potential fugitive emissions.

3.0 Wind Barriers

Currently, approximately 0.6 miles of 3-foot high wind fences have been deployed at strategic locations at the landfill. The fences are moved periodically and re-positioned to maximize their capture efficiency with respect to changing fill face and cell construction locations In addition, a vegetative barrier comprised of 2,800 feet of 6-foot high Oleander bushes are positioned atop the screening berm located parallel to the northern property boundary. The fences and Oleanders are positioned downwind of the prevailing wind direction (northeast).

The topographic setting of the landfill also provides natural advantages with respect to reducing potential dust emissions. For example, the site is located in a natural depression with steep sidewalls located on three of its four sides (to the west, east and south). The initial waste deposits were placed near the north property line, and this disposal area was filled to final grade and closed in 1993 (the Closed Area). The current landfill cells (Cell 1 – Cell 10A) are located south of and behind the Closed Area. Future cells (Cell 10B through Cell 3.1) will be located south of and behind waste deposits in Cell 9 and west of deposits in Cells 4 Down, 5A, and 5B. The positioning of current and future cells increases the distance particulates must travel prior to exiting the site. The Closed Area and Cells 1 through 8 represent a barrier between landfill operations and the north perimeter. The surrounding natural sidewalls and the man-made barrier allow most activities to take place below-grade. Existing and proposed landfill operations are set back from the north property line by over 1,000 feet.

I. Waste Hauling and Transportation

1.0 Loading of Haul Trucks

Most waste delivery vehicles entering the site are enclosed, and it is the landfill’s standard operating practice to require non-enclosed waste delivery vehicles to be covered prior to entry. For open-top vehicles, tarps are required to cover the waste contents. In the event a vehicle is not covered, tarps can be purchased at the Gate House for a nominal fee.

2.0 Minimization of Vehicle Trackout

The site location receives approximately 9 inches of rain annually, and the on-site roads are constructed of a combination of caliche, on-site silty sands/sandy silts, and suitable construction and demolition debris. Because of the site’s dry setting and lack of cohesive road materials, concerns associated with vehicle trackout are minimal.

3.0 Limiting Vehicle Speed

Signs installed along landfill roads (disposal route and access roads limit) vehicle speeds to 15 miles per hour.

4.0 Public Convenience Station

Since October 2001, Camino Real Landfill has operated a Public Convenience Station (located approximately 300 feet west-southwest of the Gate House) for residents of Sunland Park, NM. The Convenience Station consists of two, side-by-side, 40-yd^3 roll-off boxes accessed by an elevated, paved ramp. The purpose of the Convenience Station is to provide a convenient location for residential self-haul customers to dispose of waste, and to reduce the amount of fugitive dust emissions generated by these vehicles on the disposal route.

V. WIND EVENT CONTROL MEASURES

A. Dust Generating Operations

1.0 High Wind Events

During high wind events, the rate of water application is increased, and certain non-essential landfill operations are either restricted or terminated. For example, cell preparation or routine road maintenance would likely be restricted or terminated during high winds. On rare occasions, the landfill has closed due to high winds. As necessary, the application rate and frequency of watering are increased to minimize potential dust emissions.

2.0 Wind Barriers

Wind barriers are discussed in Section IV.D.3.

B. Temporary Disturbed Surface Areas

1.0 New Cell Construction

Areas subject to excavation for preparation of a new cell are routinely scheduled for when high winds are less likely. Excavation of a new cell area is performed on a daily basis and conducted as expeditiously as possible in order to deploy the composite liner system. Once the liner material is installed, potential dust emissions from the new cell approach zero.

2.0 Temporary and Permanent Access Roadways

Temporary access roadways and parking lots are maintained with gravel base course material, crushed aggregate, and/or select C & D debris. Recycled asphalt and on-site caliche are also used for road construction and maintenance. The locations of temporary roadways are placed below surrounding grade to the extent practical in order to minimize the effects of wind erosion.

3.0 Operational Requirements Using the Area Fill Landfill Method

The area fill method is the most common landfill method employed today. This method allows excavation of new cells to the desired depth, followed by construction of liners and leachate collection systems. Once the liner and leachate collection systems are installed, waste placement commences. Construction of new cells using the area fill method necessarily requires the disturbance of up to eight acres at a time at the Camino Real Landfill. During excavation of new cells, potential dust emissions are controlled by watering the area subject to excavation, watering access roads, and confining soil stockpiles to the smallest area practicable. The elevations of the landfill cell floors are all below the surrounding terrain, minimizing dust dispersion.

ATTACHMENT 7.12

SITE-SPECIFIC HYDROGEN SULFIDE ANALYSIS

ANALYTICAL SOLUTION, INC. **(AnSol)**

5/8/17

Analytical Report

Sample log # : **S0427a**

Sample Description :	*Bio Gas*	Customer Project:	*Camino Real LF*
Number of Samples :	*2*	Received Date :	*4/27/17*

Note: This report is submitted to the requester through E-mail only. Please let us know if your need this document security signed, or a hard copy report by mail or fax.

Results:

All results are attached in following pages.

The unit conversion is based on standard conditions at 60°F and 14.73 psia, where applied

Submitted by: Sherman S. Chao, Ph.D.
Tel: (630) 230-9378, Fax: (630) 230-9376

Disclaimer:

Analytical Solution, Inc., 7320 S. Madison, Unit 500, Willowbrook, Illinois 60527

5/8/17

Analytical Report

Sample log # : **S0427a**

GAS COMPONENT ANALYSIS

Sample ID:	**Conc. Unit**	**S0427a01**	**S0427a02**
	Description:	LFG, SKC Tedlar bag, 4/26/17, 1100	LFG, ESS Tedlar bag, 4/26/17, 1105
Methane	%	28.68	30.14
Carbon dioxide	%	26.56	28.29
Nitrogen	%	41.2	39.06
Oxygen	%	3.55	2.52
GHV, dry (14.73 psi) *	Btu/scf	291	306
NHV, dry (14.73 psi) *	Btu/scf	262	275
Relative density *		1.002	1.004
Hydrogen sulfide	ppmv	1.29	0.22
TNMOC, as methane **	ppmv	ND	ND

* Calculation based on major components listed.

Note: All major component concentrations were reported as a moisture, H2S and C_2 plus free basis and were normalized to 100%. Oxygen and Argon cannot be separated; therefore, the oxygen result may include a small amount of Argon. Some results may be reported with additional significance for reference.

** Total Non-Methane Organic Carbon, modified EPA 25