LANDFILL OPERATIONS

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PROCESS DESCRIPTIONS:

Landfills are emission sources of particulates and gases. Active sites conduct many activities that produce particulate emissions including, but not limited to; cover material quarrying, soil screening, rock crushing, open cover material storage piles, haul roads, solid waste compaction, cover application, composting, and green waste recycling. Particulate emissions from inactive landfills are usually limited to short term cover maintenance projects. Landfill gases containing methane, carbon dioxide, hydrogen sulfide, and a wide variety of organic compounds are released from the decomposition of waste at all sites. The quantity of landfill gas released depends primarily on the size, age, and moisture content of each disposal site. Additionally, combustion by-products are emitted from landfills equipped with flares and energy recovery systems. Emission estimation techniques used by the District are generally based upon methods and emission factors specified in AP-42. A brief discussion of each process is provided below;

COVER MATERIAL QUARRY OPERATIONS

All active landfills require substantial amounts of soil and clay for daily cover of the solid waste received. Cover material is almost always excavated from on-site quarries to minimize transport costs and increase disposal space. Landfill quarry operations in San Diego County typically involve minimal equipment (front end loaders, bulldozers, and transport vehicles). Particulate matter released from these activities is most accurately quantified using quarry emission factors from the mineral product facilities. Emissions from quarry activities are quantified separately from landfill emissions in the EASIER database.

SAND / SOIL SCREENING

Some landfills use sand / soil screening equipment to increase the amount of available cover material. Screening equipment is usually owned and operated by sub-contractors. Emissions from sand and soil screening equipment are quantified separately from landfill

emissions in the EASIER database.

ROCK CRUSHING

Some landfills use rock crushing equipment to either convert cobble into cover material or recover usable rock prior to depositing waste materials.. Like sand screens, the rock crushing equipment is typically owned and operated by sub-contractors. Emissions from rock crushing equipment are quantified separately from landfill emissions in the EASIER database.

HAUL ROADS

Haul road emissions include all onsite vehicle traffic except for tractors and front end loaders working the quarry and open storage areas. Typical vehicle traffic at active landfills which must be included in haul road emission estimates are solid waste transport vehicles, green waste transport vehicles, and cover material transport vehicles. Haul road emissions from both paved and unpaved surfaces are quantified separately from landfill emissions in the EASIER database.

GREEN WASTE DISPOSAL ACTIVITIES

Green waste disposal activities involving tub grinders are common at active landfills. These operations typically consist of segregating the green waste at the collection point and transporting the material to a designated area of the disposal site. Earth moving equipment is used to stockpile the green waste and feed the grinding equipment. The resulting mulch is either used for cover material or transported off-site. Particulate emissions from the composting and recycling activities are generated primarily from the earth moving equipment and are similar to those observed at open material storage piles. Note that fuel combustion emissions from diesel fired tub grinders are quantified separately from green waste emissions in the EASIER database.

COVER MATERIAL STORAGE AREAS

Open material storage piles and green waste mulching operations commonly exist near the quarry areas or on the top deck of the landfill. These storage areas are sources of particulate emissions caused by material drops, bulldozing, pile formation, wind erosion, and miscellaneous vehicle traffic (i.e.; scrappers, front end loaders, etc.). Default concentration values for trace metals in this dust are from mineral product facility test results obtained throughout San Diego County. An overall emission estimation technique for the open storage piles, previously published in Section 8.19.1 of AP-42, was apparently removed ~9/97 and replaced with estimation procedures for each specific activity. Open storage pile emissions are calculated separately from landfill emissions in the EASIER database.

COVER MATERIAL APPLICATION

The compaction of solid waste and application of daily cover material at active landfills results in particulate matter emissions. Active landfills typically receive solid waste at the working face of the disposal site and compact the trash with large bulldozers. Soil cover material is then spread over the compacted solid waste as the working face of the disposal

site expands. The activity level and associated particulate emissions from waste transport vehicles, bulldozers, and cover transport trucks at the working face is similar to quarry operations. Since published emission factors do not currently exist for cover material application, mineral industry quarry factors will be used for estimation purposes. Test results for haul roads at mineral product facilities throughout San Diego County will be used as default concentrations for trace metals in this dust.

Calculation of cover material application emissions is included in the landfill emissions estimates from the EASIER database. The following methods will be used by to estimate these emissions until more accurate information becomes available.

$Ea = Ua \times EF \times Ci / 10^6$

$Eh = Ud \times EF \times Ci / (H \times 10^6)$

Where:

Ea = Annual emissions of each contaminant, (lbs/year)

Eh = Maximum hourly emissions of each contaminant, (lbs/hour)

Ua = Annual amount of cover material used, (tons/year)

Ud = Maximum daily amount of cover material used, (tons/day)

H = Hours of operation, (hours/day)

EF = Particulate emission factor for cover application operations, (lbs/ton)

= 0.05 lbs TSP/ton

= 0.021 lbs PM10/ton

Ci = Concentration of each listed toxic substance in process dust, (ppmw)

LANDFILL GAS FUGITIVE EMISSIONS

Anaerobic decomposition of landfill waste may generate large amounts of landfill gas composed primarily of methane and carbon dioxide. This gas also contains hydrogen sulfide and a wide variety of trace organic constituents including many chlorinated compounds. The quantity of landfill gas generated is primarily dependent upon the amount, type, age, and moisture content of the disposed waste. While several methods have been developed to estimate landfill gas generation rates, procedures specified in Section 2.4 of AP-42 (9/97) most closely predict actual gas collection rates observed at sites in San Diego county. Most San Diego County landfills are best quantified as dry sites (landfill gas generation rate constant = 0.02 / yr). Some site specific circumstances warrant a lower constant (i.e.; Borrego) while other conditions are best quantified using a much higher generation rate (i.e.; NTC, Mission Bay, North Island, etc.).

Default values for landfill gas composition are from AP-42 which was most recently updated in September 1997. All San Diego County landfills have been evaluated as non-codisposal sites. Local SWAT test results support these EPA gas concentration values. The following methods will be used to estimate fugitive emissions of landfill gas.

$$\mathbf{Ea = [L_o \times R \times (e^{-kc} - e^{-kt}) - (Gf + Ger)] \times (Ci \times MW) / (385 \times 10^6)}$$

$$\mathbf{Eh = Ea / (365 \times 24)}$$

Where:

Ea = Annual emissions of each contaminant, (lbs/year)

Eh = Maximum hourly emissions of each contaminant, (lbs/hour)

L_o = Landfill gas generation potential, (ft^3 landfill gas/ton of waste)

R = Average annual refuse acceptance rate during active life, (tons waste/yr)

e = Base log, (unitless)

k = Landfill gas generation rate constant, (1/yr)

c = Time since landfill closure (c = 0 for active landfills),(yrs)

t = Time since initial refuse placement, (yrs)

Gf = Gas collection rate for flare systems on site, (ft^3/yr)

Ger = Gas collection rate for energy recovery equipment on site, (ft^3/yr)

Ci = Concentration of each listed substance in the landfill gas, (ppmv)

MW = Molecular weight of each listed substance in the landfill gas, (lbs/lbmole)

DEFAULT VALUES - LANDFILL GAS GENERATION RATE

Variable	Variable Description	Default Values and Ranges
L_o	Landfill gas generation potential	8020 ft^3 landfill gas / ton of waste
k	Landfill gas generation rate constant	0.01 / yr (for arid landfills)
k	Landfill gas generation rate constant	0.02 / yr (for dry landfills)
k	Landfill gas generation rate constant	0.03 / yr (for moist landfills)
k	Landfill gas generation rate constant	0.04 / yr (for wet landfills)

Default values for the composition of typical landfill gas are from AP-42. These values

closely agree with average results obtained from San Diego county landfills.

DEFAULT VALUES - LANDFILL GAS COMPOSITION

Concentration of listed substances	Default Values and Ranges
Acetone	7.01 (ppmv)
Acrylonitrile	6.33 (ppmv)
Benzene	1.91 (ppmv)
Carbon Disulfide	0.58 (ppmv)
Carbon Monoxide	141.00 (ppmv)
Carbonyl Sulfide	0.49 (ppmv)
Chlorobenzene	0.25 (ppmv)
Chloroethane (Ethyl Chloride)	1.25 (ppmv)
Chloroform	0.03 (ppmv)
Ethyl Benzene	4.61 (ppmv)
Ethylene Dichloride (1,2-Dichloroethane)	0.41 (ppmv)
Ethylidene Dichloride (1,1-Dichloroethane)	2.35 (ppmv)
Fluorocarbons (chlorinated)	0.76 (ppmv)
Hexane	6.57 (ppmv)
Hydrogen Sulfide	35.50 (ppmv)
Methyl Chloroform (1,1,1-Trichloroethane)	0.48 (ppmv)
Methylene Chloride (Dichloromethane)	14.30 (ppmv)
Methyl Ethyl Ketone (2-Butanone)	7.09 (ppmv)
Methyl Isobutyl Ketone	1.87 (ppmv)
Perchloroethylene (Tetrachloroethylene)	3.73 (ppmv)
Toluene	39.30 (ppmv)
Trichloroethylene	2.82 (ppmv)
Vinyl Chloride	7.34 (ppmv)
Xylene(s)	12.10 (ppmv)
Nonmethane Organic Cmpds (as hexane)	595.00 (ppmv)
Total Organic Cmpds (including methane)	500,000.00 (ppmv)

LANDFILL GAS FLARE EMISSIONS

Most landfills in San Diego County are equipped with gas collection and combustion equipment. Landfill gas fired flares are used on small disposal sites where energy recovery is not economical and on large sites as back-up controls for engines and

turbines. Flare emissions consist of NOx, SOx, CO, PM10, ROG, and TOG as well as trace toxic air contaminants. Several flares in San Diego County have been source tested to develop emission factors for criteria pollutants and destruction efficiencies for trace toxics. Standard District permitting requirements for stack temperature (1500 F to 1800 F) and retention time (minimum 0.3 seconds) have resulted in fairly consistent criteria pollutant emission factors calculated in units of lbs/mmBTU. Landfill gas fired flare emissions are quantified separately from landfill emissions in the EASIER database.

DEFAULT VALUES - LANDFILL GAS FLARE EMISSIONS

Variable	Variable Description	Default Values and Ranges
EF	Combustion by-product emission factor	0.08 lbs NOx / mmBTU
EF	Combustion by-product emission factor	0.030 lbs SOx / mmBTU
EF	Combustion by-product emission factor	0.003 lbs CO / mmBTU
EF	Combustion by-product emission factor	0.02 lbs PM10 / mmBTU
EF	Combustion by-product emission factor	0.01 lbs ROG / mmBTU
EF	Combustion by-product emission factor	0.01 lbs TOG / mmBTU
c_p	Average landfill gas BTU content	450 - 550 BTU/ft3
e	Average destruction efficiency	98% (ROG)
e	Average destruction efficiency	99.98% (TOG)

LANDFILL GAS ENERGY RECOVERY EQUIPMENT EMISSIONS

Three San Diego county landfills are currently equipped with energy recovery devices that are individually tested on a regular basis. Site specific emission factors exist for NOx and CO. Emissions from this equipment are quantified separately from landfill emissions in the EASIER database.

EMISSIONS INFORMATION:

Additional information regarding landfill gas generation rates and composition is available in section 2.7 of AP-42. Haul road estimation techniques are available in section 11.2 of AP-42. District flare emission factors are from source testing performed at multiple sites between 1992 and 1997. Particulate emission speciation is based on test results from extensive sampling performed at a dozen local mineral processing facilities. Actual landfill gas collection rates at controlled sites in San Diego County support the overall gas generation rate assumptions and calculations in AP-42.

The landfill gas TOG (mainly methane) destruction efficiency for flares is expected to be 99.9+%. While flare destruction efficiencies for ROG and trace toxic components of the landfill gas vary from 50 - 99+% for different compounds with an average destruction efficiency of 98% by weight for total NMOC's. Emissions of SOx and HCl are highly dependent upon gas composition values which may change over time at each site.

Emissions of formaldehyde and other PIC's are uncertain at this time as data is limited. Significant questions remain regarding both the published landfill gas ROG content and the recommended EPA ROG analytical procedure as it applies to landfill gas. The most recent revision to AP-42 (9/97) has revised the default concentration of NMOC from 1170 ppmv as hexane to 595 ppmv as hexane. Further revisions may occur as addition research is completed.

ASSUMPTIONS / LIMITATIONS:

- Site specific test data may be used instead of default values if appropriate. Most of the District default values are based on EPA values which are average results from multiple tests and sites. Since significant variations in test results are common throughout an individual site and over short periods of time, average default values from several sites may be more representative than a single grab sample from the reporting facility.

- Particulate emission factors for quarry operations, solid waste compaction, cover application, and green waste composting / recycling have been estimated using emission factors and methods for similar operations at mineral product industry facilities. These values may be updated when additional information becomes available.

- The composition of landfill particulate emissions is expected to be similar to typical road dust found at mineral processing facilities throughout San Diego County. Only minor variations in trace metal concentrations were detected for approximately a dozen relatively dispersed sites. Site specific sampling may be used instead of default values where necessary.

- The emission estimation technique for paved haul roads from AP-42 is based only on surface silt loading. Variables including truck size, speed, and number of wheels are not specifically considered (Average values appear to be empirically included in the constants). Further refinement of this estimation technique by EPA may be necessary to more accurately predict actual haul road emissions at landfills.

- Process data for quarry, open material storage, and haul road emissions at landfills equipped with sand mining equipment and / or rock crushing facilities may be operated by subcontractors. Process data from both the subcontractors and the landfill owners should be carefully reviewed to avoid double counting production rates and/or emissions.

FORMS:

Emissions from landfill operations are calculated separately from haul roads, rock processing operations, and combustion equipment. Care should be taken to properly define the "facility" and associated equipment at each landfill to avoid double counting process data and associated emissions. In many cases, the operation of multiple facilities

at a single site are interrelated resulting in difficulties "defining" individual processes. Operations which are commonly interrelated include multiple use quarries, shared open material storage piles, common gas collection systems, and multiple use haul roads.