Response to Comments on Draft Revisions to AP-42 Chapter 2, Section 4 – Municipal Solid Waste Landfills August 2024

On January 12, 2024, the EPA posted draft revisions to AP-42 Chapter 2, Section 4 - Municipal Solid Waste Landfills, which included new and updated emission factors.[1] The EPA provided a 60-day public review period of the revisions. The EPA received four comments, which are being referenced in the Response to Comments as shown below:

Commenter	Commenter Reference
The Environmental Integrity Project (EIP), Sierra Club, and the Chesapeake Climate Action Network	EIP
The National Waste & Recycling Association (NWRA) and the Solid Waste Association of North America (SWANA)	NWRA/SWANA
John Zink Company LLC	Zink
APTIM/LFG Specialties, LLC	APTIM

Comments were provided on three versions of AP-42 Chapter 2, Section 4. These versions are referred to as the "final 1998 Chapter," the "2008 draft Chapter," and the "2024 draft Chapter." The final version of AP-42 Chapter 2, Section 4 is referred to as the "final 2024 Chapter" in EPA's responses.

[1] Revisions are posted at Emissions Factors for AP-42 Chapter 2, Section 4 - Municipal Solid Waste Landfills | US EPA

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1.0 Default Factors for NMOC and VOC in Landfill Gas

Comment 1.1: Commenter EIP expressed disappointment that the NMOC/VOC values in Table 2.4-2 of the 2024 draft Chapter are essentially unchanged from their 1998 values. The commenter stated the EPA has access to and has reviewed a large amount of test data since publishing the 1998 final Chapter and that this more recent and robust data should have been used to update the NMOC and VOC default concentrations in Table 2.4.-2. The commenter stated the 1998 default NMOC/VOC values were based on a dataset consisting largely of at least 30-year-old data (collected between 1987 and 1996), a smaller set of speciated compounds, and fewer test reports (5 landfills for co-disposal sites and 18 landfills for sites with no or unknown co-disposal) compared to the newer dataset. Commenter EIP noted that in 2008, the EPA published a draft update to AP-42 Chapter 2.4, which included updated NMOC/VOC concentrations in LFG based on 44 test reports, more than double the number of tests that were available for the no/unknown co-disposal NMOC default concentration in the 1998 final Chapter. Commenter EIP stated that after the 2008 draft Chapter was released, landfill operators provided the EPA with additional test data (242 complete test reports from 116 landfills),[2] and that the EPA used this larger and more complete dataset for its 2019 Residual Risk Assessment for the NESHAP for MSW landfills rather than the dataset used to develop the 1998 final Chapter, finding that "the 1998 Final AP-42 is outdated and has very few hazardous air pollutant emission factors."[3] Commenter EIP stated the additional dataset contains 120 test reports that can be used to determine the average NMOC concentration, and 56 test reports that include both NMOC concentrations and speciated data, which can be used to determine the VOC portion of NMOC. Commenter EIP provided a spreadsheet citing the test reports, the data compiled from those reports, and their calculations, leading to summary findings presented in Tables 1 and 2.

EIP Table 1: NMOC Concentrations (ppmv as hexane) in Draft 2008 Chapter Dataset and Post- 2008 Dataset

	Draft 2008 Chapter Dataset	Post-2008 Dataset
Number of test reports used in analysis	44	120
Minimum NMOC concentration	31	14
Maximum NMOC concentration	5,387	11,667
Mean NMOC concentration	838	756
95% Confidence Interval	240	217

[2] The commenter cites Memo from Andy Sheppard to Docket ID No. the EPA-HQ-OAR-2002-0047 regarding Residual Risk Modeling File Documentation for the Municipal Solid Waste Landfill Source Category at Section 7 (May 20, 2019) [Included as Appendix 1 to the EPA, *Residual Risk Assessment for the Municipal Solid Waste Landfills Source Category in Support of the 2019 Risk and Technology Review Proposed Rule* (May 2019), *available at* https://www.regulations.gov/document/the EPA-HQ-OAR-2002-0047-0091]

[3] Id.

EIP Table 2: VOC as percent of NMOC in Draft 2008 Chapter Dataset and Post-2008 Dataset

	Draft 2008 Chapter Dataset	Post-2008 Dataset[]
Number of test reports used in analysis	34	56
Minimum % VOC	95%	0.00%
Maximum % VOC	100%	100%
Mean % VOC	99.7%	95.3%
95% Confidence Interval	0.3%	5%

Commenter EIP stated that the EPA's acknowledgement in footnote j to Tables 2.4-4 and 2.4-5 of the 2024 draft Chapter that VOC are the primary component of NMOC, with less than 50 ppmv difference between NMOC and VOC concentrations in landfill gas, is directly at odds with EPA's decision to retain the default VOC values in Table 2.4-2 of the 2024 draft Chapter. Commenter EIP urged the EPA to revise the NMOC and VOC default values in Table 2.4-2 using the more recent data.

Response**:** The EPA disagrees with the commenter's assertions. The EPA is not required to publish hazardous air pollutant data and emission factors under the Clean Air Act, section 130, 42 U.S.C. § 7430. Section 130's mandate is limited to review of volatile organic compounds (VOC), carbon monoxide (CO), and nitrogen oxides (NO_x) data, and, if necessary, revisions to those emissions factors. Given that landfill temperatures are not high enough to form NO_x, there can be no default emission factor for it. EPA therefore gathered and reviewed the existing test reports again, in accordance with our revised procedures for emission factor development, to review and, if necessary, revise the emission factors for VOCs and CO for municipal solid waste landfills. Many of the test reports used unsuitable test methods (e.g. South Coast method 25.1 and draft method 25.2). Of the remainder, only 53 test reports were suitable for scoring.

Twenty-seven of the 53 suitable test reports had values for at least one of the seven predominant non-reactive, non-methane organic compounds (NMOCs) found in MSW landfills – methyl chloroform, acetone, tetrachloroethylene, methylene chloride, chlorodifluoromethane, dichlorodifluoromethane, and ethane. Those values yield a Moderately representative NMOC emissions factor of 552 ppm (rounded to 550 ppm in the final 2024 Chapter) for landfills opened during and after 1992. No change has been made to the existing NMOC values for landfills that opened before 1992 because current landfills do not allow co-disposal, as some landfills did before 1992.

Four of the 53 suitable test reports had CO values. Those values yield a Minimally representative CO emission factor of 105 ppm (rounded to 110 ppm in the final 2024 Chapter).

EPA notes that emission factor development procedures differ from those used in rulemakings; therefore, it should not be surprising that AP-42 values, calculated as averages of the data submitted to the Agency, differ from emission limit values, typically determined as the average of the best performing units.

Comment 1.2: With regards to the 5 ppmv increase in the default NMOC concentration in Table 2.4-2 of the 2024 draft Chapter (the concentration changed to 600 ppmv compared to 595 ppmv in the 1998 final Chapter), Commenter EIP noted "…this change is unexplained, and it appears that this revision may be for purposes of rounding."

Response: As suggested by the commenter, the EPA rounded the NMOC value to two significant figures to be consistent with our emission factor development policy. Moreover, based on the commenter's suggestion, the EPA also rounded the remaining default values in Tables 2.4.1 and 2.4.2 to two significant figures, as well as the values in LandGEM. As discussed in Section 2.4.4.1 of the 2024 draft Chapter, LandGEM includes several concentrations for NMOC, including 2,420 ppmv (now rounded to 2,400 ppmv) for landfills with co-disposal; for landfills with no or unknown co-disposal default values from before 1992 use 600 ppmv but for default values from 1992 on, use 550 ppmv.

Comment 1.3: Commenter EIP noted discrepancies with the text about the VOC concentration at no or unknown sites in footnote c in Table 2.4-2 of the 1998 final Chapter and Table 2.4-2 of the 2024 draft chapter. The text in question reads "…at No or Unknown sites = 39% by weight 235 ppmv as hexane." Commenter EIP stated that 235 ppmv does not equate to 39% of the NMOC each table shows. EIP points out that the difference is unexplained.

Response: EPA thanks the commenter for bringing this inconsistency to our attention, however, this footnote has now been edited to remove the text in question in response to another comment. Therefore, no further explanation is necessary.

Comment 1.4: Commenter EIP stated that the EPA should continue to acknowledge the variability in measured NMOC and VOC concentrations and that operators should be encouraged to use site-specific test data when calculating emissions. The commenter noted that the 2024 draft Chapter appropriately retains statements of caution from the 1998 final Chapter and 2008 draft Chapter about using the AP-42 data.

***Response*:** EPA thanks the commenter for its support.

Comment 1.5: Commenter NWRA/SWANA commented on the discussion on page 2.4-3 of the 2024 draft Chapter, which states "volatile organic compound (VOC) emissions are equivalent to NMOC emissions minus the emissions from compounds with low to no photochemical reactivity," and that "recent data review shows that the contribution of these seven predominant compounds to be less than 0.005% of LFG and less than 0.25% of NMOC." The commenter stated the EPA presented no supporting data that VOC are equivalent to NMOC, and that this equivalency is only cited in Tables 2.4-4 and -5 in footnote j for combustion emissions. The commenter pointed out that the data in Table 2.4-1 and Table 2.4-2 show that certain non-reactive VOCs are commonly present in LFG and provide default concentrations for those chemicals. Lastly, despite this claim of equivalency, the EPA is not amending any concentration of the compounds listed in Table 2.4-1 or Table 2.4-2, which affirms the 39% VOC/NMOC ratio, nor is EPA amending footnote c of Table 2.4-2. Commenter NWRA/SWANA stated that, rather than assuming that VOCs are equal to NMOC, the EPA should maintain the 39% value as is set forth in the tables, which can be used as a default VOC concentration in the absence of site-specific data. Because non-reactive VOCs would include, but not be limited to, ethane, acetone, certain halogenated VOCs, siloxanes, and any other non-reactive VOCs, for which high concentrations may be present, the default value continues to be valid. The commenter stated there are landfills that contain much higher concentrations of non-reactive VOCs than the examples cited by the EPA; therefore, the assumption that VOCs equals NMOCs is not a conclusion that is appropriate for MSW landfills. The commenter suggested the EPA recommend that site-specific data be developed for this determination.

Response: The EPA agrees with the commenter that site-specific VOC to NMOC ratio data are superior to default averages provided by emission factors, and as mentioned in this and other sections, recommends development and use of such site-specific data. As the commenter points out, individual landfills may have varying constituents, which can lead to differing ratios among landfills. As a general matter, EPA disagrees with the commenter's suggestion that VOCs are equal to NMOCs is not a conclusion that is appropriate for MSW landfills. During our review of twenty-seven test reports that contained data suitable for emission factor development – meaning that heat input; output NMOC, NO_X, and CO; and air infiltration equation input values were available, as well as appropriate methods were used, and that input from NMOC and seven predominant NMOCs with negligible photochemical reactivity were used – we checked and affirmed that NMOC remains a good surrogate for VOC, using the relationship described on page 4-21 in the Emission Factor Documentation for AP-42 Section 2.4 Municipal Solid Waste Landfills, August 1997 (1997 Background Document) that photochemical reactive compounds (or VOC) equals NMOC minus negligible photochemical reactive NMOC. Note that some test reports contained more compounds than others; however, averages of the available data were used in calculations. More specifically, as shown in the test reports which are available in the background data (see footnote j in Tables 2.4-4 and 2.4-5), the average outlet NMOC expressed as hexane was 681 ppmv, while the sum of seven predominant negligible photochemical reactive NMOCs was 44 ppmv, yielding a VOC value of 637 ppmv; the VOC to NMOC ratio for this no or unknown co-disposal data sample is 637/681, or about 93.5 percent, which differs from the 39 percent ratio found earlier for this category of landfills, but affirms EPA's view that when the contribution of emissions from compounds with low to no photochemical reactivity is low, then NMOC emissions are a good surrogate for VOC emissions.

The apparent discrepancy between the older 39 percent ratio and the 99.7 percent ratio found by the recent review may be explained by incorrect or suspect ethane values. Indeed, the 1997 Background Document urges potential users of default VOC ratios to use "…extreme caution… since [those] values are driven in large part by the default value assumed for ethane."

Based on the data obtained by its review, the EPA is providing a revised default inlet CO concentration in Table 2.4-1 and a revised default NMOC concentration to be used on and after

1992 for landfills in the no or unknown co-disposal category in Tables 2.4-2; however, because site-specific concentrations of low and no photochemical reactive compounds can vary from landfill to landfill, the EPA is not amending any other concentration of the compounds listed in Table 2.4-1 or Table 2.4-2. Since extreme caution should be used when contemplating use of these default VOC ratios, footnote c to Table 2.4-2 was revised to remove mention of default ratio use; rather, as the commenter suggests, users should develop and use their own site-specific data for non-NSPS or non-Emission Guideline purposes.

Comment 1.6: Commenter NWRA/SWANA stated that the concept of co-disposal is discussed in the 2024 draft Chapter and includes emission factors associated with co-disposal landfills. However, the definition of co-disposal is not clear and can be misinterpreted to include typical MSW landfills, which may accept wastes other than household wastes, such as construction and demolition (C&D) materials that clearly are not hazardous wastes and are primarily inert. According to the commenter, since co-disposal only applied to very few MSW landfills that accepted hazardous waste at one time in California,[4] and does not represent the vast majority of MSW landfills, the commenter requested the EPA either remove the emission factors for co-disposal, or expressly clarify them as having very limited application within Chapter 2.4. If the latter, then the commenter suggested adding the following definition:

> *Co-disposal, as used within this Chapter 2.4, refers to only those facilities at which hazardous waste, as defined by RCRA, was accepted for disposal along with municipal solid waste. Only those sites that are known to have accepted hazardous waste should use the co-disposal factors listed in this Chapter.*

For additional clarification on the issue of co-disposal, Commenter NWRA/SWANA requested that the discussion of co-disposal in section 2.4.4.1 refer to "hazardous waste" instead of "non-residential waste," and that the EPA consider the following definition of MSW:

> *Municipal Solid Waste (MSW) Landfill is a landfill that has been permitted by a Local, State, or Federal agency to accept MSW and has MSW in-place. An MSW landfill may also accept other non-hazardous wastes; however, this is not co-disposal. Co-disposal is the acceptance of MSW and hazardous waste. A C&D landfill that is not permitted to accept MSW is not an MSW Landfill.*

***Response*:** The EPA agrees with the commenter that the characterization of municipal solid waste landfills as 'co-disposal' applies to just a few facilities that once accepted hazardous waste. In recognition that MSW landfills no longer accept hazardous wastes, emission factors for

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[4] The commenter cites EPA, Emission Factor Document for AP-42, Municipal Solid Waste Landfills (Revised) dated August 1997. Appendix B lists sites with known Co- Disposal – these landfills were sites that accepted hazardous waste and MSW waste, such as BKK Landfill and Palos Verdes. Sites in the list that accepted MSW waste with no hazardous waste were listed as "U" for unknown.

co-disposal and unknown characteristics remain for landfills operating before 1992; however, in response to this comment, the final 2024 Chapter of AP-42 was revised to contain an additional NMOC emission factor for MSW landfills operating during and after 1992. This emission factor was added in the final 2024 Chapter to Table 2.4-2. Because co-disposal of hazardous waste with municipal waste is prohibited, providing a definition for co-disposal is unnecessary.

2.0 Methodology for Estimating Methane Generation (Equation HH-1 and LandGEM)

Comment 2.1: Commenter EIP supported the EPA's proposal to incorporate by reference in Equation 1 of the 2024 draft Chapter the first order decay method for estimating methane generation from subpart HH (Municipal Solid Waste Landfills) of the Mandatory Greenhouse Gas Reporting Rule (40 CFR Part 98 subpart HH). The commenter noted that incorporation of subpart HH's methane generation method (also referred to as Equation HH-1) into Equation 1 results in two significant improvements. First, it establishes methodological consistency with the EPA's greenhouse gas reporting program (GHGRP) and some state regulations for landfill methane control.[5] Second, it allows for the updates to the GHGRP methods to be incorporated into the AP-42 approach to methane generation.

***Response*:** The EPA appreciates the commenter's support.

Comment 2.2: Commenter EIP stated the 2024 draft Chapter does not incorporate the adjustment factor of 1.3, which was added to Equation 1 in the 2008 draft Chapter. The commenter stated this factor should be incorporated into Equation 1 in the 2024 draft Chapter.

Response: The EPA disagrees with the commenter's suggestion. Equation HH-1, which is shown below and is used in the 2024 draft Chapter, already incorporates the 1.3 factor by including the molecular weight ratio of methane (16) to that of carbon (12). This ratio, identified as $\frac{16}{12}$ in Equation HH-1, was conveyed as 1.3 when rounded to two significant figures in the 2008 draft Chapter. Incorporation of this ratio allows emissions to be reported on an 'as carbon' basis. Note that an additional 1.3 factor added to Equation HH-1 would be redundant.

Equation HH-1

$$G_{CH_4} = \left[\sum_{x=S}^{T-1} \left\{ W_x \times MCF \times DOC \times DOC_F \times F \times \frac{16}{12} \times \left(e^{-k(T-x-1)} - e^{-k(T-x)} \right) \right\} \right]$$

[5] The commenter cites, e.g., COMAR 26.11.42.11(D)(1)(a) (Maryland landfill methane regulations incorporating Equation HH-1 by reference as part of threshold for installing controls).

Comment 2.3: Commenter EIP requested the EPA develop a rating for Equation HH-1 describing its representativeness of actual methane generation at MSW landfills. In developing a rating, the commenter suggested the EPA review methane generation and emission estimates using first order decay to other methods including the multivariate analysis conducted in support of the proposed revisions to the greenhouse gas reporting program (GHGRP) as well as comparisons of reported emissions to observed emissions from airborne measurements of landfill emissions. The commenter referenced four studies for the EPA to review when evaluating a rating.

Response: The EPA disagrees with the commenter's suggestion, as emission factors, not equations, are characterized by their representativeness in accordance with the emission factor development procedures. The EPA does not rate equations in the GHGRP, nor does the EPA rate equations in AP-42. The emission factor representativeness rating is a function of the test data, the number of data points in relation to the size of a source category, and the completeness of a test report. For more information on the rating process, the commenter may refer to the Introductory Chapter of AP-42.

Comment 2.4: Commenter NWRA/SWANA noted that Section 2.4.4.1 of the 2024 draft Chapter states Equation (1) is for estimating "methane generation and not methane emissions to the atmosphere" and LandGEM is used for estimating "emissions rates for total landfill gas, methane, carbon dioxide, NMOCs, and individual air pollutants from municipal solid waste landfills." The commenter stated this distinction is not accurate since LandGEM, like Equation (1), calculates methane generation. The commenter stated that the EPA's update of LandGEM (Version 3.1) to be consistent with Equation (1) and the EPA's statement that LandGEM Version 3.03 depicts "methane production" (p. 2.4-3) confirm that these methodologies should be considered consistently. Accordingly, Commenter NWRA/SWANA requested the EPA amend the language in this section to state that LandGEM is also used to determine "generation rates" of methane, CO_2, NMOC, and individual pollutants. For similar reasons, the commenter stated the use of the term "uncontrolled emissions" in the first paragraph of Section 2.4.4.1 is not appropriate and requested the paragraph be revised as follows:

> *To estimate generation rates ~~uncontrolled emissions~~ of the various compounds, present in landfill gas, ~~total landfill gas emissions~~ methane generation must first be estimated. ~~Uncontrolled CH4 emissions~~ Methane generation may be estimated for individual landfills by multiplying the result of Equation HH-1, found at 40 CFR 98.343(a)(1), by 1474.83 to obtain methane generation for the reporting year for ~~which emissions~~ generation rates ~~are~~ calculated in terms of cubic meters per year.*

Response: While the EPA notes that the sentence in the second paragraph of Section 2.4.4.1 (which states that LandGEM can be used to estimate emissions rates) is similar to the text on the homepage of LandGEM (which states "The Landfill Gas Emissions Model (LandGEM) is used to estimate emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds, and individual air pollutants from municipal solid waste (MSW) landfills"),[6] the EPA understands the commenter's view that the language could be viewed as inconsistent. Therefore, given that Equation HH-1 estimates methane generation and is now incorporated into the model, the EPA has edited the text of Section 2.4.4.1 of the final 2024 Chapter to state LandGEM can be used to estimate generation or emission rates. The language in the first paragraph of Section 2.4.4.1 of the final 2024 Chapter has also been edited to provide greater clarity on the use of methane generation to estimate uncontrolled emissions of a pollutant in landfill gas. Should Equation HH-1 change over time, EPA intends to revise the AP-42 section to be consistent.

Comment 2.5: Commenter EIP supported the EPA's update of the Landfill Gas Emissions Model ("LandGEM") tool to include relevant default values consistent with the EPA's proposed revisions to the 2024 draft Chapter. The commenter stated changes to LandGEM are particularly important as this is the tool that is used by practitioners, who need the adjusted default values in order to estimate emissions for purposes of, among other things, permit applications.[7]

Response: The EPA appreciates the commenter's support.

Comment 2.6: Commenter EIP stated the updated LandGEM model incorporates the degradable organic carbon (DOC) value for the bulk waste option but does not provide the DOC values for the modified bulk MSW option or waste composition option. The commenter stated that alternatives to the bulk waste option are frequently used by facilities when reporting to the GHGRP. Fewer than half (46%) of the landfills that reported waste placement in 2022 used the bulk waste option to report the composition of waste accepted at the facility.[8] The commenter requested the EPA incorporate the additional DOC values in LandGEM.

Response: The EPA disagrees with the commenter. The purpose of LandGEM is to aid in the calculation of methane generation. The bulk value represents the most generic approach to estimate methane generation at a landfill. Users can select DOC values from Table HH-1 to meet their needs. Generally, the concentration of NMOC (CNMOC) reflects the measurement of the landfill's waste mass, rather than any one specific waste stream.

3.0 Revision of the Default Collection Efficiency

Comment 3.1: Commenter EIP requested the EPA revise the method of estimating controlled emissions using a default collection efficiency of 75% with a site-specific collection efficiency calculated using the equation in Table HH-3 of subpart HH of the greenhouse gas reporting rule

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[6] https://www.epa.gov/land-research/landfill-gas-emissions-model-landgem#Background

[7] The commenter cites, *e.g.*, Texas Commission on Environmental Quality, Air Permit Reviewer Reference Guide, Municipal Solid Waste Landfills (MSWLF) And Transfer Stations, APD-ID 14 (April 2021) p. 7, https://www.tceq.texas.gov/assets/public/permitting/air/Guidance/NewSourceReview/mswlf guide.pdf ("TCEQ prefers using the LandGEM (landfill gas emission model) for determining emissions.")

[8] The commenter cites EPA, *Envirofacts GHG Query Builder: Subpart HH – Municipal Solid Waste Landfills: Table hh_waste_qty_details*, accessed on February 21, 2024, https://enviro.epa.gov/query-builder/ghg.

(GHGRP). The equation is a weighted average of collection efficiencies based on cover type. The commenter noted that the EPA has proposed revisions to subpart HH which would incorporate lower default collection efficiencies in the Table HH-3 equation for unregulated landfills that do not conduct regular surface methane concentration monitoring (the revisions would require these landfills to use default collection efficiencies that are 10% lower for all cover types).[9] The commenter stated that the EPA should adopt these same revisions when incorporating the Table HH-3 equation into the 2024 draft Chapter.

Response: Since this comment was received, final revisions to the GHGRP were published on April 25, 2024 in the Federal Register (see Federal Register :: Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule). In the finalized revisions to subpart HH, collection efficiencies associated with cover types are provided in Table HH-3. As the emission factors in AP-42 strive to be consistent across landfill programs, if a user lacks site-specific collection efficiencies, determined by a comparison of measured methane collected to predicted methane generation, she or he may use the appropriate values in Table HH-3 for calculations.[10] See section III.T.2 of the preamble of the GHGRP final rule for more information on the finalized collection efficiencies in Table HH-3 and default collection efficiency.

4.0 Source Classification Codes (SCCs)

Comment 4.1: Commenter EIP stated the EPA should explain MSW landfill-related SCCs and clarify the distinction between the government, industrial, commercial, and institutional categories. The commenter noted the inclusion of SCCs in the 2024 draft Chapter is helpful for mapping the included emission factors to SCCs to be used in emission inventory reporting. However, the list is incomplete and does not clarify whether there is a distinction between government, institutional, industrial, and commercial devices, as indicated in the SCC database but not in the listed emission factors. For example, the SCC database designates four codes for fugitive emissions according to these categories (50100402 [Government], 50600601 [Commercial], 50700601 [Institutional], and 50300603 [Industrial]),[11] but the Draft Revised Chapter includes only two (50100402 and 50300603).[12] Similar examples are:

- There are SCCs for turbines (as well as microturbines) in each of these categories along with a separate SCC for turbines powered by landfill gas but classified at SCC level one

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[9] Commenter cites EPA, Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule, Proposed Supplemental Rule, 88 Fed. Reg. 32852, 32861(May 22, 2023); Memo from Liz Goodiel, U.S. EPA/ORD to Docket ID. No. EPA-HQ-OAR-2019-0424 regarding Technical Support for Supplemental Revisions to Subpart HH: Municipal Solid Waste Landfills at 6 – 8 (Nov. 21, 2022) *available at* https://www.regulations.gov/document/EPA-HQ-OAR-2019-0424-0256.

[10] Subpart HH allows the use of a default collection efficiency when information on area by cover type is unknown (when the latter is available, the Table HH-3 equation must be used).

[11] The commenter cites EPA, *Source Classification Codes (SCCs)*, accessed March 12, 2024, *available at* https://sor-scc- api.epa.gov/sccwebservices/sccsearch/; EPA, *Introduction to Source Classification Codes and their Use for EIS Submissions* at 8, *available at* https://sor.epa.gov/sor_internet/registry/scc/SCC-IntroToSCCs_2021.pdf.

[12] The commenter points to the Draft Revised Chapter at Section 2.4.5.

as "Internal Combustion Engine" rather than "Waste Disposal." For all of these potential turbine categories, the Draft Revised Chapter lists only one (for the Solid Waste Disposal – Government category).

- The database also includes four SCCs for internal combustion engines and the chapter includes only one (for the Solid Waste Disposal – Government category).

Commenter EIP stated that, to avoid possible confusion for landfill operators, EPA should add explanations regarding (1) the distinction between the sector categories; and (2) how operators are to use the codes provided in the chapter when reporting to the Emissions Inventory System.

Response: The SCC database[13] contains 95 SCCs which reference a municipal solid waste landfill or a solid waste landfill, and which have additional classifications including government, commercial, institutional, and industrial, as well as energy recovery (internal combustion engine, turbine, boiler); landfill management; and other landfill descriptors. The 2024 draft of Chapter 2.4 listed 8 of these 95 SCCs.[14] In response to this comment, the EPA revised Section 2.4.5 of the final 2024 Chapter to include all 95 SCCs, however, it is beyond the scope of AP-42 to provide guidance on which SCC should be used. For specific SCC questions, contact the Air Emissions Inventories help desk.[15]

Comment 4.2: Commenter EIP stated the EPA should incorporate by reference information for landfill-associated SCCs that are provided in other AP-42 Sections. The commenter stated the list of SCCs in the 2024 draft Chapter does not include at least one source type associated with landfills and for which the EPA has developed an emission factor: 20300801 (Internal Combustion Engines – Electric Generation – Landfill Gas – Turbine).[16] The commenter noted the EPA should correct this omission and provide guidance on the distinctions between 20300801 and SCC 50100420 (Waste Disposal; Solid Waste Disposal – Government; Municipal Solid Waste Landfill; Landfill Gas (LFG) Energy Recovery: Turbine), which is included in the 2024 draft Chapter.

Response: While SCCs 20300801 and 50100420 both represent the conversion of LFG to energy via a turbine, they represent different sectors. As noted in the SCC database, SCC 20300801 represents the sector "Fuel Comb - Comm/Institutional - Other" while SCC 20300801 represents the "Waste Disposal" sector, which is why these SCCs are in different AP-42 Chapters (SCC 20300801 is part of Chapter 3.1). The EPA reviewed the data from Chapter 3 to see if they could be included in Chapter 2.4. The EPA found one complete test report that could be included in the calculation for the CO and NO_X LFG turbine factors; however, it did not change the measured values of the existing turbine factors in Chapter 2.4 of AP-42. There are emission factors for

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[13] Source Classification Codes (epa.gov).

[14] Note that SCC 20300802 was inadvertently added to the list of SCCs in the 2024 draft Chapter and has since been removed

[15] Help with SCCs

[16] The commenter cites AP 42 Section 3.1 at 3.1-10 and 3.1-16.

other pollutants for LFG in AP-42 Chapter 3.1. Note that the final 2024 Chapter refers readers to AP-42 Chapter 3.1 in Section 2.4.1.

5.0 Emission Factors for Secondary Pollutants Exiting Control Devices (Tables 2.4-4 and 2.4-5)

Comment 5.1: Commenter EIP stated that the EPA reviewed, but did not revise, the default concentrations for secondary pollutants emitted by reciprocating internal combustion engines (RICE). The commenter stated that the spreadsheet the EPA provided of the review gave the following reason for not updating the concentrations: "NOx emissions vary by engine type (which was not noted in the test reports), the sample size is too small for engines, there are variations in landfill waste composition and quantity, and weather characteristics." The commenter noted that the spreadsheet does not specify the test reports reviewed. The commenter stated that standards for RICE used at landfills were established during the 2008 update of the NESHAP for RICE and that the docket for that rule making (EPA-HQ-OAR-2008-0708) contains test reports from more than 30 sites operating RICE powered by landfill gas. The commenter noted these test reports could be used to review the concentrations of pollutants from RICE in the 2024 draft Chapter.

Commenter EIP requested the EPA propose emission factors for VOC emissions associated with the combustion of LFG in turbines and internal combustion engines. The commenter noted that in the AP-42 chapter on Stationary Combustion Sources (Chapter 3), the EPA acknowledges that VOC are produced as secondary products of combustion by turbines and RICE.[17] VOC are emitted as a result of inefficient combustion regardless of the fuel burned – when the fuel is not burned or only partially burned during the combustion process – and may be unreacted, trace constituents of the gas or byproducts of the combustion process.[18] The commenter noted that to quantify VOC emissions associated with these types of sources, Chapter 3 of the AP-42 compendium incorporates default concentrations for VOC emissions from turbines and RICE in Tables 3.1-2a, 3.2-1, 3.2-2, and 3.2-3 based on evaluations of source test reports.[19]

***Response*:** Based on the commenter's request, the EPA further examined the internal combustion (IC) engine data, learned that the test data were from similar engines and found additional, complete test reports, suitable for grading. As a result of this new information and data, the EPA developed an emission factor for NMOC and NO_x and revised the CO EF for IC Engines (see Tables 2.4-4 and 2.4-5 for the new/updated factors in the final 2024 Chapter, updated since the 2024 draft Chapter).

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[17] The commenter cited AP 42 Section 3.1 at 3.1-2; the EPA, *AP 42, Fifth Edition, Volume I, Chapter 3, Section 3.2: Natural Gas-fired Reciprocating Engines* at 3.2-2 (Aug. 2000), *available at* https://www.epa.gov/sites/default/files/2020- 10/documents/c03s02.pdf

[18] The commenter cited AP 42 Section 3.1 at 3.1-4; AP 42 Section 3.2 at 3.2-3.

[19] The commenter noted that references used in development of emission factors are detailed in the EPA, *Emission Factor Documentation for AP- 42 Section 3.1 Stationary Gas Turbines* at Section 3.2 (Apr. 2000) available at https://www.epa.gov/sites/default/files/2020-10/documents/b03s01.pdf and the EPA, *Emission Factor Documentation for AP-42 Section 3.2 Natural Gas-fired Reciprocating Engines* at Section 3.2 (July 2000) available at https://www.epa.gov/sites/default/files/2020-10/documents/b03s02.pdf.

With regard to turbines, the EPA did not create a VOC turbine emission factor for this section because only one test report was found to be complete upon review. However, the final 2024 Chapter refers readers to AP-42 Chapter 3.1 for additional LFG turbine factors in Section 2.4.1.

Comment 5.2: Commenter NRWA/SWANA expressed disappointment that the 2024 draft Chapter still includes emission factors for combustion emissions from IC engines and gas turbines. The commenter stated emissions from these devices are highly variable based on the make, model, site conditions where they are deployed, and whether additional controls have been installed on the engines or turbines. Therefore, it is impossible to establish one set of emission factors that will be representative of such units. The commenter recommended that no emission factors for LFG-fired IC engines and turbines be listed in AP-42, and that they be removed from Tables 2.4-3, 2.4-4 and 2.4-5. Instead, the commenter stated the EPA should direct the use of vendor information for the establishment of emission factors for these sources as presently it is vendor information that is most used in permitting of landfill gas-fired engines and turbines across the United States.

Response: The EPA disagrees with the commenter. The EPA has no data, nor did the commenter provide data, to refute the control efficiencies and emission factors for gas turbines and IC engines in Tables 2.4-3 through 2.4-5. Should one believe uncertainty exists in using the AP-42 data, the EPA recommends seeking out other information, including but not limited to site-specific emissions testing, emissions measurement, or vendor guarantees if available, as EPA notes in the disclaimer at the beginning of the final 2024 Chapter. Note that, where required, this information must be found acceptable by the regulatory authority with jurisdiction over the program that would allow the use of emission factors.

Comment 5.3: Commenter EIP stated that the EPA must develop a default concentration for formaldehyde emissions from devices combusting MSW landfill gas. The commenter noted that formaldehyde is among the VOC emitted as byproducts of combustion and has been documented as a pollutant of particular concern from engines used in landfill gas-to-energy projects. The commenter added that formaldehyde is not only a VOC, but it is also a hazardous air pollutant.

Response: The EPA disagrees with the commenter. The EPA does not have the data to develop a default concentration for formaldehyde since there were only a small number of test reports with formaldehyde data; moreover, the test method used to collect the data was flawed (therefore no emission factors can be developed from values obtained via use of that test method). The EPA will consider adding a formaldehyde concentration to Chapter 2.4 during the next revision if appropriate data are received and processed using our emission factor development procedures.

Comment 5.4: Commenter EIP stated that the EPA must account for VOC, NO_X, and CO emissions from combustion devices operating at low loads and low temperatures. The commenter noted that the 2024 draft Chapter contains single emission factors for NO_X, CO, and PM for all operating conditions for internal combustion engines (SCC 50100421), boiler/steam turbines (SCC 50100423), and gas turbines (SCC 50100420) in Tables 2.4-4 and 2.4-5. In the

AP-42 chapter on Stationary Combustion Sources, Chapter 3, Section 1, the EPA acknowledges that the operating load for turbines and reciprocating internal combustion engines, as well as ambient temperature and humidity, affect the emission rates from the engines.[20] For reciprocating engines, the observed effect of operating load on NO_x and CO emissions was sufficient for the EPA to incorporate two load-based emission factors for these pollutants in Section 3.2.[21] Commenter EIP stated that the EPA must provide emission factors to account for variability in emissions based on operating conditions or should specify the operating conditions for which the emission factors apply.

Response: The EPA does not have the data to evaluate NMOC (as a surrogate for VOC), NO_X, or CO emissions under different operating conditions for turbines. However, the EPA was able to locate suitable data at differing engine loads. These factors have been added to Tables 2.4-4 and 2.4-5 in the final 2024 Chapter. To the extent that commentors or the public provide other variability data, including low load or low temperature conditions, the EPA will consider such data during the next revision.

Comment 5.5: Commenter EIP stated the EPA must clarify the effect of the proposed new enclosed flare emission factors in the 2024 draft Chapter on existing emission factors. The commenter noted the EPA has proposed to add new emission factors for secondary compounds from enclosed flares (SCC 50300601) but does not explain the effect of this on its existing emission factors for devices that include flares.[22] Instead, the existing emission factors remain designated for both waste gas flares (SCC 50100410) and destruction devices (SCC 50300601). Additionally, footnote c to Table 2.4-4 notes that "where information on equipment was given in the reference, test data were taken from enclosed flares."[23] The commenter stated that if the emission factors are, in fact, based on data from another source type (enclosed flares), the EPA should assess whether they should be applied to open flares. Commenter EIP further stated that if the EPA finalizes the new emission factors for enclosed flares, the Agency should clarify whether the existing emission factors are intended to apply only to open flares. It should also revise the emission factors, as appropriate, to clearly state that they should be used for open flares.

Response: The EPA appreciates the commenter pointing this out this discrepancy. In response to this comment, to provide clarity, the EPA replaced the "Flare" designation with the "Enclosed

[20] The commenter cited AP-42 Section 3.1 at 3.1-2 to 3.1-4; EPA, *Emission Factor Documentation for AP-42 Section 3.1 Stationary Gas Turbines* at 3.6 (Apr. 2000); AP -42 Section 3.2, at 3.2-3 and Tables 3.2-1, 3.2-2, 3.2-3. The discussion addresses the impacts of these conditions on NO_X and CO. The same processes that affect CO emissions (inefficient combustion) also affect VOC emissions (see AP 42 Section 3.1 at 3.1-4 and AP-42 Section 3.2 at 3.2-3), and VOC emissions would therefore be impacted by these conditions as well.
[21] The commenter points to AP-42 Section 3.2, August 2000, p 3.2-3 and Tables 3.2-1, 3.2-2, 3.2-3, the EPA, *Emission Factor Documentation for AP-42 Section 3.2 Natural Gas-fired Reciprocating Engines* at 3.8 (July 2000).
[22] The commenter cites the 2024 draft Chapter at 2.4-13 and 2.4-14.
[23] The commenter cites *id*.

Combustor/Flare" designation in Tables 2.4-4 and 2.4-5. There are now four pollutants associated with the Enclosed Combustor/Flare designation including PM, NO_X, NMOC, and CO. Note, the latter has a revised EF based on the addition of new data with existing CO data. For additional clarity, the EPA included a footnote in Tables 2.4-4 and 2.4-5 of the final 2024 Chapter to the Enclosed Combustor/Flare designation (footnote d) which states "Test data were taken from enclosed flares. Control efficiencies are assumed to be equally representative of open flares."

6.0 New Emission factors for Enclosed Flares (Tables 2.4-4 and 2.4-5)

Comment 6.1: Commenter APTIM stated that the proposed emission rates in Table 2.4-5 for Enclosed Flare/Combustor (50300601) for NOx, NMOC, and CO are inaccurate for enclosed flares as a single class. A review of the data provided include facilities that have both enclosed and ULE flare design and construction. The ULE flares have lower NOx and CO emission rates by their design and operation and were developed to meet the more stringent emission limits in select states and/or air districts. As way of example, Commenter APTIM provided their guaranteed emission rates for enclosed and ULE flares:

Parameter	Enclosed Flare	ULE Flare
NOx	0.06 lb/MMBTU	0.025 lb/MMBTU
CO	0.2 lb/MMBTU	0.06 lb/MMBTU
NMOC	98% destruction or 20 ppmv	98% destruction or 20 ppmv

Commenter APTIM requested that EPA provide separate emission factors for enclosed and ULE flares operating at landfills.

Commenter Zink stated that the current diffusive combustion technology employed in conventional biogas enclosed flares is highly unlikely to produce emissions as low as the values presented in Table 2.4-5, over the complete range of operations that typical enclosed flares experience. Diffusive combustion entails the interaction of the hydrocarbons (typically methane) in landfill gas, with the air (oxygen) required for combustion at the burner tip, facilitated by an ignition source. However, this combustion mechanism presents a limitation regarding the extent of mixing that is achievable at the burner tip, impeding the contact between hydrocarbons (methane) and the necessary amount of oxygen for optimal clean combustion. Consequently, the commenter stated, only partial combustion (i.e., sub-stoichiometric) occurs at the burner tip, while the remaining combustion takes place as the gas traverses the stack. Additionally, a substantial portion of thermal NO_X generation occurs at the burner tip itself, at temperatures above 3000°F. During the sub-stoichiometric conditions, at the burner tip during diffusive combustion, a high portion of the flame front reaches temperatures above 2600°F. The commenter said that, as partial combustion occurs at the burner tip, achieving the NO_X emissions listed in Table 2.4-5 becomes unattainable with higher methane concentration landfill gas. This theory is supported by a publication authored by John Zink, presented at SWANA's 21st Annual Landfill Gas Symposium and titled "Ultra-Low Emission Enclosed Landfill Gas Flare." The publication contains the results of extensive research done on enclosed flare emissions performance, and its findings show that landfill gas with methane concentrations surpassing 55%

produce NO_X emissions that exceed the proposed emissions factors. The commenter stated that the findings establish that the methane concentration of landfill gas to each unit significantly impacts emission generation, thereby, warranting its consideration when defining emission limits. The commenter stated that the source tests included in AP-42 Factor data do not show the inlet landfill gas conditions at each test, and that without that inclusion, the emissions data points presented are not comparable.

Commenter Zink stated the source tests used in determining the emission factors in the 2024 draft Chapter, Table 2.4-5 present emissions data without providing insight into the specific operating conditions and inlet gas conditions of each tested unit. There are several variables that impact the emissions of an enclosed flare such as inlet gas composition, flowrate, ambient air conditions, operating temperature, dimension of the stack, etc. Typically, the inlet gas composition plays a significant role in the emissions performance of the unit; the higher the hydrocarbon (methane) composition in the inlet landfill gas stream, the higher the NO_X formation. The commenter stated that, when a landfill gas has lower hydrocarbon (methane) concentrations, it has been found to generate lower NO_X. Additionally, as found in the "Ultra-Low Emission Enclosed Landfill Gas Flare" publication, previously referenced, there is also a correlation between the inlet flowrate and the amount of NO_X generated.

Commenter Zink stated that out of 40 test report data used for emissions values determination, 24 of those were John Zink systems, and 10 of the 24 John Zink Systems were Zink Ultra Low Emission (ZULE®) Flares, a different type of premix combustion technology. The commenter stated that including emissions data from different combustion technologies can skew the emissions averages for conventional enclosed flares.

Commenter NWRA/SWANA also expressed concerns with the updated emission factors proposed for combustion emissions from enclosed flares, noting the EPA appears to have combined stack test data from ultra-low emission (ULE) flares with that of conventional enclosed flares to create these factors, particularly with respect to NOx and CO. The commenter stated this has resulted in emission factors that most conventional enclosed flares cannot meet. Since it is common for regulatory agencies to use AP-42 factors in permitting, these non-representative factors would result in emission limits that are not attainable and result in flares being in non-compliance with site permits, the commenter said. Commenter NWRA/SWANA stated they reviewed stack test data from conventional enclosed flares across the country and found a wide range of tested values, many of which would not comply with the proposed factors if they were imposed as permit limits. Furthermore, the commenter noted NOx and CO emission rates can work counter to each other during combustion of landfill gas in conventional enclosed flares. As such, efforts to meet lower NOx emission limits can result in increased CO (and vise-versa), making it additionally problematic when both NOx and CO are set at very low level. Commenter NWRA/SWANA requested the EPA remove the stack test data from ULE flares from the emission factor dataset and then recalculate the emission factors for enclosed flares. The commenter stated that ULE flares are not in common use across the country and thus do not belong in a dataset being used to create nationally recognized factors. Further, these flares may not be appropriate for all landfills, depending on the quality of the landfill gas and the more limited turndown ratio of ULE flares.

Response: The EPA disagrees with the commenters. During the review of the flare data, the EPA was unable to identify whether flares were ULE flares or conventional enclosed flares, nor did commenters provide data to distinguish between the different flare types. The EPA intends to consider evaluating whether these different flare types warrant separate emission factors during the next revision to this chapter if identifying information is provided. It is expected that some enclosed flares will have emissions below the factors in Tables 2.4-4 and 2.4-5, since the values in Tables 2.4-4 and 2.4-5 are averages. The EPA reminds potential users that emission factors may not be appropriate for setting regulatory limits or evaluating regulatory compliance; the EPA recommends site-specific emissions testing or measurement whenever available. This is reiterated in the disclaimer added at the beginning of the final 2024 Chapter.

Comment 6.2: Commenter NRWA/SWANA stated AP-42 should be consistent with the Landfill NSPS and Landfill NESHAP emission standards in terms of NMOC emissions from LFG combustion devices. The commenter noted that based on observations from their members, at facilities with very high concentrations of inlet NMOCs, combustion devices are unlikely to meet the outlet concentration of 20 parts per million by volume (ppmv) as hexane at 3% oxygen. Similarly, the commenter stated that landfills with very low NMOC concentrations in the raw LFG are unlikely to demonstrate a 98% destruction efficiency because laboratories cannot get low enough detection limits to prove this fact. Because of these considerations, which the commenter stated are highly dependent on the site-specific variability in gas quality, the commenter requested that NMOC emissions be stated as 98% destruction efficiency or 20 ppmv.

Commenter Zink stated the emission of NMOC in biogas enclosed flares exhibits a strong reliance on the concentration of NMOC in the inlet gas. In cases where the inlet NMOC concentration surpasses the typical values found in landfill gas, the destruction efficiency (DRE) requirement may need to be much higher than 98% to achieve the outlet concentration of 20 ppm as hexane at 3% oxygen stated in the draft. The attainment of destruction efficiency exceeding 98% consistently proves to be impractical for conventional enclosed combustors. Conversely, facilities characterized by very low inlet NMOC concentrations face considerable challenges in achieving a DRE of 98%. Hence, Commenter Zink recommends that the NMOC emission limit be expressed as either 98% DRE or 20 PPM as hexane at 3% oxygen.

Response: While the EPA recognizes that the NSPS and NESHAP contain provisions that express the NMOC emission limit as a 98 percent destruction efficiency or an outlet concentration of 20 ppmv, the EPA disagrees with the commenters that the emission factor program be used as the basis to adjust regulatory emission limits. The emission factors in AP-42 are based on stack test data submitted to EPA, and data from these tests include control efficiencies and concentrations; such data can and often differ in stringency from what is contained in rules. As emission factors represent the average of actual data, as opposed to regulatory limits, and are developed through a different process than regulatory limits, the EPA will continue to rely on the actual data and the emission factor development procedures, not on regulatory limits, to ensure creation of the most representative NMOC emission factors as possible. More information on the emission factor procedure process can be found here:

https://www.epa.gov/air-emissions-factors-and-quantification/procedures-development-emissions-factors-stationary.

7.0 Emission Factors for Open-Flame Flares (Tables 2.4-4 and 2.4-5) and Control Efficiency for Open-Flame Flares (Table 2.4-3)

Comment 7.1: Commenter Zink stated that biogas-elevated flares typically use diffusive and natural draft technology like industrial flares that do not employ steam assistance. The NOx emission factor for industrial flares reported in AP-42 Section 13.5 Industrial Flares is 0.068 lbs/MMBtu, the commenter notes. Because of the similarity between biogas-elevated flares and industrial flares, and based on previous discussion on diffusive combustion, achieving the NOx emissions listed in Table 2.4-5 for an elevated flare becomes impractical and therefore the commenter recommends continued use of AP-42 section 13.5.

Commenter APTIM also requested that the emission factors for open flares be based on AP-42 Section 13.5 Industrial Flares. Specifically, Table 13.5-1 identifies an emission factor of 0.068 lb NOx/MMBTU fired and Table 13.5-2 identifies an emission factor of 0.31 lb CO/MMBTU fired. The commenter requested that these emission factors continue to be applicable to open flares that are operated on landfills.

Commenter NWRA/SWANA stated that Table 2.4-5 contains emissions from flares/non-enclosed flares and that these emission factors remain the same as in the 1998 final Chapter. These non-enclosed flares are closely related to the Industrial Flares in Section 13.5 of AP-42. In April of 2015, the emission factors for Industrial Flares were updated based on tests of non-enclosed flares. This testing is much newer information than the basis of the non-enclosed flares in Section 2.4, the commenter said, and represents the most up-to-date data on non-enclosed flares. Commenter NWRA/SWANA recommended that EPA use the testing from Section 13.5 and have the emission factors for the non-enclosed flares in Section 13.5 and 2.4 match based on the most recent testing, including emission factors of 0.31 lb/MMBtu for CO and 0.068 lb/MMBtu for NOx. The commenter stated these factors are already in common use for landfill permitting across the United States, so this change would be consistent with what is already happening in the industry.

Response: The EPA agrees with the commenters that emissions from open flares may be estimated using the NO_x and CO emission factors for industrial flares in Chapter 13.5. This is referenced in Section 2.4.1 of the final 2024 Chapter.

Comment 7.2: Commenter APTIM stated that Table 2.4-3 should include control efficiencies for open flares as a separate control device and corresponding Source Code. The commenter noted that footnote c of Table 2.4-3 states "…test data were taken from enclosed flares. *Control efficiencies are assumed to be equally representative of open flares*" (emphasis added). Based on operating temperatures, Commenter APTIM stated the control efficiency of enclosed flares would generally be higher than the control efficiency of open flares for NOx, CO, and NMOC.

Commenter EIP stated the EPA must account for the lower performance (destruction efficiency) of open flares. The commenter stated that the 2024 draft Chapter maintains the existing approach of relying on data from enclosed flares to characterize the destruction efficiency of all flares, including open flares.[24] The commenter stated this is inappropriate because the performance of open and enclosed flares is different. A technology review conducted by Eastern Research Group in 2019 in support of updates to the NESHAP for landfills found that there are several factors that can reduce the destruction efficiency of open flares. A 2012 technical report on the design and operation of open flares recommended that controlling operating parameters such as the heating value of the flared gas and the exit velocity be controlled to optimize destruction efficiencies.[25] However, the NESHAP technical review noted that this report focused on air-assisted and steam-assisted flares and did not include non-assisted flares, which are typically in use at landfills.[26] Commenter EIP noted that a study conducted at University of Alberta, which evaluated non-assisted flares, such as those used at landfills, found that, while the assumed 98% destruction efficiency can be achieved, operating conditions including wind, ambient pressure, and the methane content of the gas impact the destruction efficiency that is achieved in practice.[27]

Response: The EPA disagrees with the commenters, noting that it has long held the position that properly operated flares achieve at least 98 percent destruction efficiency in the flare plume. This position is discussed in Section 13.5 (Industrial Flares) of AP-42 and is supported by data collected in the development of the emissions factors in that section. Additionally, it is very possible that a well-operated flare can exceed 98% destruction efficiency, as is evidenced by many test runs in the data included in the emissions factor development in Section 13.5. AP-42 Section 13.5 states that for flares to be properly operated, dilution from assist gas must be taken into account. For example, oversteaming is not an example of proper flare operation, and a flare that is oversteamed will not likely achieve 98% destruction efficiency. However, these dilution effects do not generally extend to unassisted flares. While environmental conditions can affect the performance of an unassisted flare, the EPA expects that owners and operators who properly operate their flares will account for site-specific conditions that affect performance. Changes in ambient pressure and feed methane content are expected to affect flare performance equally for open and enclosed flares. Additionally, the dataset for enclosed flares that was used to create the emissions factors included units meeting a variety of destruction efficiencies, including some percentages in the low to mid-90s. The EPA has no reason to believe that the variability provided by the enclosed flare testing is not representative of the destruction efficiency achieved by open flares burning similar streams, and is therefore not adjusting the language of the final 2024 Chapter on this point.

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[24] The commenter points to 1998 Chapter, Table 2.4-3; Draft Revised Chapter, Table 2.4-3.
[25] The commenter cites EPA, *Parameters for Properly Designed and Operated Flares: Report for Flare Review Panel (Draft)* (Apr. 2012).
[26] The commenter cites ERG NESHAP Memo at 32.
[27] The commenter cites *id*; Kostiuk et al., University of Alberta Flare Research Project Final Report, September 2004, pp 236-237

8.0 Miscellaneous Comments

Comment 8.1:

Commenter NWRA/SWANA stated that, as currently written, the 2024 draft Chapter appears to distinguish between fugitive emissions and uncontrolled emissions, with "fugitive" referring primarily to dust and roadway emissions (e.g. Section 2.4.4) while "uncontrolled" refers to uncollected landfill gas (e.g. Section 2.4.4.1). The commenter requested that EPA clarify that uncollected landfill gas represents fugitive, rather than uncontrolled, emissions. The commenter expressed that the EPA should provide clarification that not all landfill gas can reasonably be collected within a landfill gas collection system, and that Chapter 2.4 acknowledges this by stating that on average, only 75% of the generated landfill gas can be collected. The remaining uncollectable 25% of generated gas would have the potential to be generally released from any area of the landfill. Consequently, the related emissions should be characterized as fugitive rather than uncontrolled. Commenter NWRA/SWANA stated there is a presumption that uncontrolled emissions could be controlled while fugitive emissions are not, which is the case for landfills with landfill gas collection and control systems. This description is consistent with the definition of fugitive emissions as set forth in Parts 51, 52, and 70 (relating to New Source Review and Title V) as those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening.[28] Moreover, as the result of EPA determinations over time, it is well understood for purposes of these programs that uncollected landfill gas would be treated as fugitive in nature, whereas the portion of landfill gas that can be collected would not.[29] Having these emissions correctly classified as fugitive instead of uncontrolled is likewise important within AP-42 Chapter 2.4, to ensure that they are treated consistently across the applicable regulatory programs.

***Response*:** In this context, the EPA believes that uncontrolled emissions are also uncollected as well as fugitive emissions**.** We have added clarifying language in Section 2.4.4.1 of the final 2024 Chapter. Additionally, EPA notes that the language in Section 2.4.4.2 of the final 2024 Chapter has been clarified to direct users that do not determine their collection system efficiencies may choose to use the defaults in Table HH-3 to Subpart HH of Part 98 - Landfill Gas Collection Efficiencies. Instead, the use of a model such as LandGEM could be more appropriate for annual emission inventory development as it incorporates parameters such as landfill freshness and meteorological conditions.

Comment 8.2: Commenter NWRA/SWANA stated it is unclear why the discussion of k and L_0 values was removed from the 2024 draft Chapter and requested the EPA include them again. The commenter noted these values are cross-referenced within the Landfill NSPS (40 C.F.R. Part 60, Subparts WWW and XXX) and Landfill NESHAP (40 C.F.R. Part 63, Subpart AAAA) as an alternative to the NSPS/NESHAP default values, which are notably conservative in light of their

[28] The commenter cites, *e.g.* §40 CFR 70.2.

[29] The commenter cites Memo from John Seitz, OAQPS, to Director, Air Pesticides and Toxics Management Division, Regions I and IV, Director, Air and Waste Management Division, Region II, Director Air, Radiation and Toxics Division, Region III, Director Air and Radiation Division, Region V, Director, Air, Pesticides and Toxics Division, Region VI, Director, Air and Toxics Division, Regions VII, VIII, IX and X entitled *Classification of Emissions from Landfills for NSR Applicability Purposes.*

purpose in that context, which is to determine when gas collection and control systems should be installed.[30] The commenter noted that without these values, regulatory agencies are likely to require the use of the NSPS/NESHAP values that significantly overestimate methane and landfill gas generation from MSW landfills. In particular, the NSPS/NESHAP L_0 value of 170 Mg/m^3 is extremely inflated, according to the commenter, and is not appropriate for other Clean Air Act (CAA) purposes, such as emission estimation supporting permitting applicability actions for New Source Review or Prevention of Significant Deterioration. Further, as states implement organics diversion programs, the commenter said that L_0 values will decrease, exacerbating the inaccuracy of using 170 Mg/m^3. For example, recent data in California suggests that L_0 values are between 85-90 Mg/m^3 for waste being disposed of today. In addition, under the Landfill NSPS and Landfill NESHAP, the k value increases from 0.02 to 0.05 when annual rainfall reaches 25 inches per year, the commenter said. Data suggests that decay rates do not increase this abruptly at 25 inches of rainfall. For example, the LFG model developed by the California Air Resources Board, based on information from the Intergovernmental Panel on Climate Change, utilizes k values of 0.02 up to 20 inches of rain, 0.037 from 20-40 inches of rain, and 0.057 over 40 inches of rain. Based on these considerations, the commenter requested the EPA reinstate the k and L_0 values from the previous version of AP- 42 for use in inventories and other CAA purposes outside of the Landfill NSPS and Landfill NESHAP rules.

Response: The EPA does not agree with this comment. Now that the estimated methane generation rate in Equation 1 in Chapter 2.4 has been revised to be congruent with Equation HH-1 from 40 CFR part 98 subpart HH, Equation HH-1's inputs are also available for use. Note that those inputs include a range of values for k and the parameter DOC, which is analogous to L_0, in Table HH-1 of the Greenhouse Gas Reporting Rule.

More specifically, in this revision of AP-42, DOC replaces L_0, the methane generation potential of waste. The DOC can be considered a direct measurement of biodegradable carbon in a waste sample. The amount of methane produced is proportional to the amount of biodegradable carbon in the sample (see Krause et al. 2016).[31] The approach to translate DOC to L_0 is adapted from Equations 3.2 and 3.3 from the Solid Waste Disposal chapter of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

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[30] The commenter pointed out that 40 CFR §60.765(a)(1) and §63.1960(a)(1) state that "... The methane generation rate constant (k) and methane generation potential (L_o) kinetic factors should be those published in the most recent *Compilation of Air Pollutant Emission Factors* (AP-42) or other site-specific values demonstrated to be appropriate and approved by the Administrator; and 40 CFR §60.764(c) states "When calculating emissions for Prevention of Significant Deterioration purposes, the ...MSW landfill...must estimate the NMOC emission rate...using Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources (AP-42) or other approved measurement procedures."

[31] See https://www.tandfonline.com/doi/full/10.1080/10643389.2016.1204812

$$L_0 = DOC \times DOC_f \times F \times MCF \times \frac{16}{12} \div 6.67x10^{-4}$$

See Table HH-1 in 40 CFR 98 Subpart HH for default values.

Comment 8.3: Commenter NWRA/SWANA commented on the single percentages currently used in the 2024 draft Chapter to characterize the composition of LFG, specifically, 40% CO_2, 55% CH_4, 5% N_2 and trace amounts of NMOC. The commenter stated these values should instead be represented by ranges to reflect the diversity of landfills rather than single percentages. The commenter also requested the EPA clarify that in-situ LFG differs from as-collected LFG because when a vacuum is applied, there can be air intrusion that would alter the gas composition. The commenter recommended changing the chapter language to state that, under static conditions, in-situ LFG typically has a composition of approximately 40% CO_2, 55% CH_4, 5% N_2 and trace amount of NMOC, while as-collected LFG typically consists of 45-55% CH_4, 35-45% CO_2, 2-10% N_2, and 0-4% O_2.

***Response*:** The EPA disagrees with the commenter's suggestion for including LFG composition ranges in AP-42. While the EPA recognizes that LFG composition can vary and can be determined via measurement, the EPA disagrees with using values obtained after a vacuum is applied to the collection system because that practice changes the quality of collected LFG. The use of a vacuum applies air that can skew the results. The EPA is not making changes in the final 2024 Chapter based on this comment.

Comment 8.4: Commenter NWRA/SWANA stated that carbon monoxide (CO) is listed as a constituent of LFG in Table 2.4.1 of the 2024 draft Chapter with a corresponding footnote stating the following:

> *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.*

The commenter stated that since CO is not normally found in landfill gas, it should be removed from the Table as a listed constituent of LFG, however, the footnote should remain for the case of underground combustion. The commenter stated that many air agencies use AP-42 without examining footnotes, and therefore agencies may require CO emissions to be calculated from the landfill even when there is no underground combustion occurring, simply because it is in the default list. This can impact the air permitting of landfills and when landfills must use this Table 2.4.1 in determining emissions. Therefore, commenter NWRA/SWANA requested the EPA remove CO from the list of LFG constituents in Table 2.4.1.

Response: The EPA disagrees with the commenter's suggestion to remove default values for

CO, but the footnote will be revised because CO can be a constituent of LFG.[32] The new footnote in the final 2024 Chapter is as follows: "Carbon monoxide can exist in LFG, typically in small quantities. This default value should be used with caution. Just 2 of 18 sites showed detectable levels of CO. Note that large values – on the order of 1,000 ppm and greater – can indicate underground combustion or other atypical conditions."

With regard to potential misuse of emission factors in permitting programs, the EPA recommends throughout the final 2024 Chapter 2.4 of AP-42, and in other chapters, against emission factor use for those programs.

Comment 8.5: Commenter NWRA/SWANA stated while they support the incorporation of a method for correcting samples of landfill gas for air infiltration (citing p. 2.4-4), several clarifications are necessary. First, the commenter said, total pollutant concentrations from EPA Reference Method 25C already have a correction related to air, specifically for nitrogen or oxygen. Correcting an already corrected concentration compounds the calculation, yielding an erroneous result. Therefore, the commenter requested that only uncorrected concentrations be corrected for air. Concentrations already corrected should be allowed to skip Equation 2. In addition, the commenter stated, the term "infiltration" does not adequately describe the mechanisms put forth by EPA. The commenter stated the dictionary definition of infiltration is the "permeation of a fluid into something by filtration." Air can be present in a landfill gas sample due to a variety of mechanisms, including leaks in sampling equipment, air pulled into the landfill from applied vacuums, air present in area of a landfill waste with low gas production, etc. As such, it is more accurate to reference air "present" in the sample rather than using the term infiltration. Considering these comments, commenter NWRA/SWANA recommended the following changes to page 2.4-4, paragraph 2:

> *If an uncorrected site-specific total pollutant concentration is available ~~(i.e., as measured by EPA Reference Method 25C)~~, it must be corrected for air ~~infiltration~~ in the sample (if present) which can occur by two different mechanisms: LFG sample dilution, and air intrusion into the landfill. Corrected concentrations can skip to Equation 3.*

Commenter NWRA/SWANA also requested that the EPA clarify that air intrusion or the presence of air in a sample is not purely a function of collection system operations. The commenter noted there are many natural causes including biological and biochemical reactions related to waste age, type, moisture, barometric changes, and other factors that influence oxygen and nitrogen content in a landfill gas sample. These factors are most notable in arid areas. For these reasons, the commenter recommended the EPA add a precipitation caveat like EPA

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[32] See, for example https://link.springer.com/article/10.1007/s00203-008-0382-6, https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2015.01275/full, and https://academic.oup.com/femsec/article/44/2/271/548585.

Reference Method 25C allowing a landfill to skip the correction requirement if annual rainfall is less than 20 inches per year and is not attributed to sample dilution from an air leak.

Lastly, Commenter NWRA/SWANA clarified that source test reports do not typically include raw landfill gas concentrations, and therefore, recommended the following revision to the text in Section 2.4.4-1:

> *Values for CCO2, CCH4, CN2, and CO2, can usually be found in the ~~source~~ laboratory test report or handheld meters for the landfill along with the total pollutant concentration data.*

Response: The EPA disagrees with the commenter's suggestion to skip the instructions and Equation 2 for those users who choose to use the process provided in AP-42 for estimating landfill pollutant emissions. The commenter's view that Method 25C corrects every pollutant with regard to air infiltration is incorrect and irrelevant for AP-42 purposes. Method 25C includes an infiltration adjustment to NMOC concentrations only, based on either an oxygen or nitrogen correction. In contrast, AP-42 yields estimates for all default pollutant values – including NMOC – provided the instructions and inputs to Equation 2, which include oxygen, nitrogen, carbon dioxide, and methane, are followed. Of course, users who choose to use direct measurement of NMOC via Method 25C are welcome to use and report those values instead of relying on the process given in AP-42.

The EPA disagrees with the commenter's suggested edits to existing language in AP-42 concerning air infiltration. As mentioned earlier and in section 2.4.4.1 of AP-42, users who choose to use the process in AP-42 and who have site-specific total pollutant concentrations as measured by EPA Reference Method 25C must review those concentrations for potential air infiltration correction; the EPA finds that the suggested edits would serve to confuse, rather than offer clarification for, users. Note that as mentioned earlier, users with direct measurements of their pollutants would not need to skip Equation 2, rather, they would supply their measured values in relevant units, as opposed to forcing their site-specific measured emissions into the generic AP-42 estimation process.

While the EPA agrees with the commenter that air, including nitrogen and oxygen, can be pulled artificially into the landfill, the EPA notes that the volume of this naturally produced oxygen, including that produced by rainfall and its effect on waste characteristics, is negligible compared with the volume of oxygen provided artificially through the collection system. Therefore, this negligible volume does not warrant discussion or clarification in the existing language.

While the EPA is familiar with handheld instrumentation for oxygen, methane, and carbon dioxide, it is unfamiliar with handheld instrumentation for nitrogen, and the commenter provided no information on such a product. The EPA notes that to the extent other instrumentation can provide relevant information necessary to complete the AP-42 emissions estimation process and that other instrumentation meets EPA method requirements, then such instrumentation can be used. As this ability to use other EPA approved methods is universally accepted except where specifically barred, the EPA sees no need to modify the existing language.

Comment 8.6: Commenter NWRA/SWANA stated Equation 3 in the 2024 draft Chapter utilizes a correction factor that assumes 55% methane and 45% CO_2 and other constituents. The commenter noted that landfill gas compositions vary over a wide range for each constituent, therefore, including a constant in the formula that is representative of a single composition (1.82) does not provide a mechanism to address the diverse site-specific concentrations. The commenter therefore recommended the EPA adopt a new variable (CF_{LFG}) to replace the 1.82 factor to calculate the pollutant generation rate more accurately: $CF_{LFG} = 1 + (C_{CO2} + C_{N2} + C_{O2})/C_{CH4}$.

Response: The EPA agrees with the commenter that Equation 3 could be made more consistent by replacing the default value of 1.82 (which represents 55% methane) with the variable 1/F. As directed by 40 CFR part 98 subpart HH, users should provide a value of F that represents the fraction by volume of CH_4 in landfill gas from measurement data for the current reporting year, if available (fraction, dry basis, corrected to 0% oxygen). Revised Equation 3 in the final 2024 Chapter will now appear as:

$$Q_P = \frac{1}{F} Q_{CH_4} \times \frac{C_P}{(1 \times 10^6)} \quad (3)$$

where:

Q_P	=	Emission rate of pollutant P (e.g., NMOC), m^3/yr;
F	=	Fraction by volume of CH_4 in landfill gas from measurement data for the current reporting year, if available (fraction, dry basis, corrected to 0% oxygen); otherwise, use the default of 0.5;
Q_{CH_4}	=	CH_4 generation rate, m^3/yr (from equation 1 or LandGEM); and
C_P	=	Concentration of P in landfill gas, ppmv.

Comment 8.7: In addition to their proposed definitions for co-disposal and MSW landfills (see Comment 2.5), Commenter NWRA/SWANA requested the EPA consider a definition for gas treatment prior to a beneficial use project that is consistent with the definition included in the Landfill NSPS and Landfill NESHAP rules. The commenter noted that these treatment systems are considered as a control system for MSW Landfills and are often the first step prior to the gas being processed for the creation of renewable natural gas or prior to being used as fuel in engines/turbines/boilers to create energy. The intent of the definition of treatment is to describe the minimum steps for preparation of landfill gas for beneficial use via filtration, de-watering, and compression. While some beneficial use projects may require additional processing, the minimum treatment system criteria are set forth in the Landfill NSPS and Landfill NESHAP, along with an example list of these beneficial uses. The commenter therefore recommended that EPA incorporate the Landfill NSPS and Landfill NESHAP definitions of treated landfill gas into Chapter 2.4 as follows:

- *Treated landfill gas means landfill gas processed in a treatment system as defined in this subpart.*

- *Treatment system means a system that filters, de-waters, and compresses landfill gas for further processing, sale, or beneficial use. A treatment system that processes the collected gas for subsequent processing, sale, or beneficial use such as fuel for combustion, production of vehicle fuel, production of high-British thermal unit (Btu) gas for pipeline injection or use as a raw material in a chemical manufacturing process. Venting of treated landfill gas to the ambient air is not allowed. If the treated landfill gas cannot be routed for subsequent processing, sale, or beneficial use, then the treated landfill gas must be controlled according to either enclosed or non-enclosed combustor.*

Response: The EPA disagrees with the commenter. The EPA does not have any treated landfill gas data, and it is unclear that these definitions would be useful. Because the commenter did not indicate how the definitions would promote the goals of AP-42, no definitions are being provided in AP-42 at this time. Should such data become available, the EPA may consider incorporating these definitions during future reviews.

Comment 8.8: Commenter APTIM noted the introduction section of AP-42 states that emission factors presented "are neither EPA-recommended emission limits…nor standards. Use of these factors as source specific limits and/or emission regulations compliance determinations is NOT recommended by EPA." In addition, the Introduction states "if representative source specific data cannot be obtained, emissions information from equipment vendors…is a better source of information for permitting decisions than an AP-42 emission factor." Commenter APTIM stated they endorse this approach; however, they noted they've experienced instances where this is not the case and AP-42 emission factors have been incorporated into air permit limits. To highlight EPA's intent to users that may not read the Introduction, Commenter APTIM requested that a footnote be added to Tables 2.4-3, 2.4-4, and 2.4-5 restating this stance or at a minimum referring the user to the AP-42 Introduction section on the appropriate use of emission factors.

Commenter NRWA/SWANA also recommended the EPA clarify in the 2024 draft Chapter that vendor supplied emission factors for flares should be used ahead of the AP-42 factors in the hierarchy of emission factors for use in permitting.

Response: The EPA agrees with the commenter regarding reiterating the caveats provided in AP-42's Introduction and has included a disclaimer to the beginning of the final 2024 Chapter regarding the intended use of AP-42 emission factors instead of footnotes to Tables 2.4-3, 2.4-4 and 2.4-5. The hierarchy of emission factors for use is described in the AP-42 Introduction, which is linked in the disclaimer.

Comment 8.9: Commenter EIP stated the EPA should consider establishing methods in AP-42 Chapter 2 Section 4 to account for periods when flares are not operating or are operating poorly, as it does in subpart HH of the GHGRP. The commenter noted that in its supplemental proposed revisions to subpart HH, the EPA acknowledged that flares do not always operate at optimal conditions, such as when temperatures are below design values, and that the Agency clarified these impacts should be accounted for in the subpart HH estimates of controlled emissions from landfills with Gas Collection and Control Systems (GCCS). To do so, the EPA proposed revising the definition of fDest,n (the fraction of hours during the year that the nth destruction device is operating) in subpart HH Equations HH-6 and HH-8, which estimate controlled emissions.[33]

Response: This comment is out of scope for AP-42. To the extent that relevant changes are made to Greenhouse Gas Reporting Program equations that can impact AP-42, EPA intends to revise AP-42 accordingly during future reviews.

[33] The commenter cited 88 Fed. Reg. 32852, 32878 (May 22, 2023); Memo from Liz Goodiel, U.S. EPA/ORD to Docket ID. No. the EPA- HQ-OAR-2019-0424 regarding Technical Support for Supplemental Revisions to Subpart HH: Municipal Solid Waste Landfills at 4 (Nov. 21, 2022*) available at* https://www.regulations.gov/document/the EPA-HQ-OAR-2019-0424- 0256.