Summary of Expert Review Comments and Responses:
Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*

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U.S. Environmental Protection Agency
Office of Atmospheric Programs
Washington, D.C.

Responses to Comments Received during the Expert Review Period on the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*

Preface

EPA thanks all reviewers and commenters for their interest and feedback on the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks. To continue to improve the estimates in the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks, EPA distributed draft chapters of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017* for a preliminary Expert Review of estimates and methodological updates prior to release for Public Review. The Expert Review was 30 days by sector and included charge questions to focus review on methodological refinements and other areas identified by EPA as needing a more in-depth review by experts. The goal of the expert review is to provide an objective and independent review of the Inventory to ensure that the final Inventory estimates, and document reflect sound technical information and analysis.

EPA received 54 unique comments on as part of the expert review process. The verbatim text of each comment extracted from the original comment letters is included in this document, arranged by sectoral chapters. No comments were received on the Draft Land Use, Land-Use Change, and Forestry Chapter. EPA's responses to comments are provided immediately following each comment excerpt. The list of reviewers, dates of review and all charge questions distributed to reviewers are included in the Appendix to this document.

Chapter 3. Energy

Comment 1: Clarity and Transparency of the Energy Chapter
Within the source categories, the information is generally clear and adequately sourced. However, missing from the chapter draft is a front-end section outlining the specific source categories to be discussed.

Response: As discussed in the Expert Review draft chapter and review memo, only some emission sources were updated for the Energy chapter. The remaining source categories of the Energy chapter were updated later. The sections that were not updated were removed from the Expert Review draft report for purposes of facilitating review. The front section was updated and included for Public Review as well as for the Final Report.

Comment 2: Completeness and/or Accuracy of the Energy chapter
Previous versions of the Sinks and Sources report have had a high-level summary at the front of the chapter that significantly improved readability and laid a general framework around which to think about emissions from energy, pulling forward some of the high-level findings and general discussion about the impact of energy use on emissions. It is not clear why that is removed from this draft chapter, but I would recommend the Agency continue to include those high-level findings before diving into the source categories.

Response: As discussed in the Expert Review draft chapter and review memo, only some emission sources were updated for the Energy chapter. The remaining source categories of the Energy chapter were updated later. The sections that were not updated were removed from the Expert Review draft report for purposes of facilitating review. The front section was updated and included for Public Review as well as for the Final Report. A linked Table of Contents was provided in the Expert Review draft for ease of review and to allow expert reviewers to focus on only their specific areas of interest.

3.1 Fossil Fuel Combustion

Comment 3: Monthly Vehicle Sales – Methodology for Estimating Electricity Use by On-Highway Electric Vehicles
The available monthly data from hybridcars.com is a reasonable estimate for data to-date and comes from Baum and Associates. However, that data is no longer being updated as of June 2018. The Alliance of Automobile Manufacturers also maintains its own public database (AAM 2018), using data from Polk/IHS-Markit. The only other public dataset of which I'm aware is that of insideevs.com; however, that data is extrapolated based on public information and may not necessarily represent an accurate accounting of current year sales data.

If the Alliance continues to update its data, EPA should avail themselves of it. Or, in the future EPA could consider acquiring an industry dataset to ensure reliable current year sales data, such as Polk-IHS or WardsAuto. One benefit of utilizing Polk-IHS data is that by examining current registration data, it would help solve one of the major sources of error in the Agency's current assessment—survivability.

The Agency's assumption of the electric fleet is that no vehicles sold since 2010 have been scrapped (p. 2). This is not a reasonable assumption. The National Highway Traffic Safety Administration (NHTSA)

has previously estimated survivability data using the Polk National Vehicle Population Profile (NHTSA 2006). A recent paper on scrappage used a slightly narrower subset of that data in its own scrappage analysis (Jacobsen and van Benthem 2015). Using these sources, I estimate that the Agency's current process yields in 2017 an overestimated fleet size of 2.3-3.7% Car PHEVs, 2.0-3.3% Car BEVs, 1.2-1.4% LT PHEVs, and 1.4-1.6% LT BEVs. Correcting this issue well before 2025 (according to the cited 15-year lifetime) is highly recommended. While these national estimates of scrappage may not be perfect estimates of EV scrappage, it is likely that for early generations of EVs the scrappage rate could be even higher given the rapidly advancing technology and large number of leases offered for these products.

Response: We agree that the use of hybridcars.com has been a good data source for the 1990-2017 inventory, but given that this data source is no longer available, EPA intends to use data from insideevs.com for future Inventories. We will continue to assess availability of improved hybrid cars monthly vehicles sales information.

With regards to vehicle scrappage, we agree that a scrappage formula based on literature data will need to be applied in future inventories. We are still exploring studies related specifically to the scrappage of EVs. Any updates to reflect scrappage will be included in future expert reviews when completed.

Comment 4: Include Transportation as an end-use sector

Within the section on the Electric Power Sector (beginning on p. 3-9), it would be appropriate for the Agency to now include Transportation as an end-use sector in addition to Industrial, Commercial, and Residential, to reflect its new apportioning of "upstream" emissions from electric vehicles to the Transportation sector.

Response: Transportation is not included as an electricity end-use sector in Chapter 3 (e.g., Figure 3.9) because the amount of electricity allocated to Transportation is very small (even with the addition of electric vehicles), compared to the residential and commercial sectors. EPA does, however, report electricity emissions broken out by Economic End-Use Sector, including Residential, Commercial, Industrial and Transportation, in the report's Executive Summary and Chapter 2 (see, for example, Table 2-5 and Figure 2-8). Electricity use by end-use sector is also listed in Annex 2, Table A-43: Electricity Consumption by End-Use Sector (Billion Kilowatt-Hours), where it can be seen that electricity use in the transportation sector represents less than 1% of electricity sales in 2017. However, we acknowledge this is a category with changing trends, and will consider further disaggregation of electricity end-use sectors in future reports as growth trends continue.

Comment 5: VMT Statistics – Methodology for Estimating Electricity Use by On-Highway Electric Vehicles

As described in NHTSA 2006, it is generally true that newer vehicles travel more miles than older vehicles, in which case one would expect that using the national average VMT would result in a significant underestimate. On the other hand, one could expect that limitations on BEV range and different regional distribution of EV sales could depress that mileage estimate

For BEVs, a study of EVs in Arizona (EPRI 2018) yielded a wide range of results, with vehicles like the Focus and Smart Fortwo showing annual VMT much less than the assumed 11,300, while Tesla's EVs, which have a much larger range, showed average VMT significantly higher (nearly 15,000 miles). This is consistent with the idea that range plays some role in annual VMT and suggests that as more and more

models achieve ranges on par with Tesla, BEVs would be expected to achieve annual VMT more similar to their gasoline-powered counterparts, which would be higher than the Agency's estimate (since the EV fleet will skew newer).

PHEVs should not suffer from range limitations, and that is borne out in the data. A detailed study of the PHEV Chevy Volt (Smart et al. 2013) showed VMT consistent with what one would expect for a brand-new vehicle (median = 31.6 miles/day → 11,500 annual; average = 40.7 miles/day → 15,000 annual). Similarly, EPRI 2018 showed a median mileage of over 12,000 miles, again higher than the Agency's estimate.

Importantly, relying upon the SAE utility factor (UF) likely underestimates the annual electric miles traveled by PHEVs. A study of early model Chevy Volts showed utilization 7-8% higher than would be expected based on the EPA charge-depletion range (Smart et al. 2014). EPRI 2018 showed utilization for its PHEVs at or well-above the SAE value (40% for a C-MAX Energi but 68% for a Fusion Energi and an average of 83% for the 23 Chevy Volts in the study, both well above the SAE UF). The SAE standard assumes only one charging event per day, while many Volts exhibited multiple charging events per day—it is unknown at this time how much of this behavior may be dependent upon unique characteristics of early adopters, but it is suggestive that the SAE UF represents a lower bound and therefore a conservative estimate of electric miles traveled by PHEVs.

Response: We acknowledge that both BEVs and PHEVs may have VMT that differ from the FHWA average VMT, however VMT from electric vehicles is not well studied or documented. While we agree with the literature that newer cars travel further than older cars, as an average with believe using the FHWA average is appropriate.

Comment 6: 85/15 Percent Allocation to Residential/Commercial Sectors – Methodology for Estimating Electricity Use by On-Highway Electric Vehicles

This is approximately consistent with EPRI 2018, which showed 83% of GPS-identified electric charging (by kWh) occurring at the home.

However, one fundamentally incorrect issue with the approach taken by EPA relates to the location of the charging event itself, i.e. the grid used. Electric vehicles are not uniformly distributed throughout the country and will not charge on the average national grid. More than half of the electric vehicles sold are sold in California (AAM 2018), which has a grid that is significantly cleaner than average (EPA 2018). Using data on EV sales through 2017, including losses related to transmission and distribution, I estimate that the average EV is charged at a rate of 355 g/kWh, compared to a national average of 477 g/kWh, a 25.5 percent reduction.[1]

EPA must consider regional distribution of electric vehicles in its assessment of emissions from these vehicles. This can be achieved by combining its latest eGRID data with sales information already recommended EPA obtain.

[1] To be more consistent with the EPA sinks and sources methodology, while these values include losses related to transmission and distribution, it ignores upstream emissions from the plants themselves, which the Union of Concerned Scientists includes in analyses such as Reichmuth 2018.

References

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Response: We agree that there are regional differences in the distribution of electric vehicles and the sources of electricity and agree as this increases, this will be important to consider. We have started looking into data sets that would facilitate accounting for these differences within this category but also other end-use sectors for methodological consistency. However, at this time, given the current level of activity and as this is a national inventory, we believe that applying a national average for emissions from charging electric vehicles is appropriate. See also response to comment 4.

Chapter 4. IPPU

4.1 Cement Production

Comment 7: Clarity of cement/clinker production process description in Cement Production Chapter

Specific comments [as page (line number)]:
4-8 (19-31): as in past years, there is an initial impression that calcination is the only thing going on in the kiln and that the kiln is producing cement. It would be clearer to state:

(20) … (CO_2) from both the energy consumed in making the **clinker precursor to** cement and the chemical process itself **to make the clinker**. Emissions from fuels…

(22-26) During the **clinker** production process, **the key reaction (and, apart from preheating to reach calcination temperatures, the major heat-consuming step) is where** calcium carbonate ($CaCO_3$), **in the form of limestone or similar rocks**, is heated in a kiln at a temperature range of about 700 to 1000 degrees Celsius (**about 1,300 to 1,800** degrees Fahrenheit) to form lime (i.e., calcium oxide or CaO) and CO_2 in a process known as calcination or calcining. The quantity of CO_2 emitted during **clinker** production is directly proportional to the CaO content of the clinker. During calcination, each mole of **$CaCO_3$** heated forms one mole of **CaO** and one mole of **CO_2**. **The CO_2 is vented to the atmosphere as part of the kiln line exhaust**.

Comment: Emphasis has been given to clinker (not cement). We should not equate limestone and $CaCO_3$, as many limestones used to make clinker are not especially high purity (in contrast to the lime industry, which does require very high purity limestone). I rounded the degrees F (and can't you just use °C, °F for brevity?) because the °C were rounded. I prefer "CaO" to "lime" as the latter is a vague term (do we mean free-lime content; the product lime; and which type of lime…?)—a better chemical term for CaO would be "calcia".

(28-31) Next, **over a temperature range of 1000 to 1450°C, the CaO combines with alumina, iron oxide, and silica, that are also present in the clinker raw material mix to form hydraulically reactive compounds within white-hot semifused (sintered) nodules of clinker**. **Because one of these "sintering" reactions is highly exothermic, very little extra heat energy is required, and these sintering reactions have essentially no associated process emissions of CO_2.** The clinker is then rapidly cooled to maintain quality, and then **very finely interground** with a small amount of gypsum and potentially other materials (e.g., **ground granulated blast furnace** slag, etc…) to make portland **and similar cements**.

Comment: It is important to stress that, although the clinker is taken to 1450°C, the process emissions of CO_2 (and the vast bulk of the fuel combustion emissions of CO_2) stem from preheating and calcination, NOT from the subsequent sintering reactions to form clinker.

(35-37): I am not sure which USGS data you used for clinker; in general, reliance should be on the Minerals Yearbook chapters and the monthly data and not the Mineral Commodities Summaries (MCS); the MCSs are written before full-year data are available—sadly, this affected botht eh 2016 and 2017 data in the so-called 2018 MCS. I have appended the most recent available data below from the monthly (D16) and annual (D15) surveys. For 2017, only the monthly data are as yet available and they

indicate an approx. 1.3% increase in clinker production in 2017, not the approx. 2% that you stated. It is unclear why you state that "Although trend information is available from the USGS…" when, in fact, clinker production data (NOT mere trend data) are published monthly by the USGS (see table 4 in the monthly reports).

4-9 (1-3) you state (likely referring to an earlier USGS estimate) that the USGS reported 75,800 kilotons (citing EPA 2018…) but the table that I have provided below with updated data has the 2017 output as 76,984 kmt. Your table 4-3 should be updated; however, if you retain your 2017 estimate (merely a repeat of 2016), the 2017 emissions should be rounded (in the kt column)—you cannot justify 5-significant figures!

USGS data: U.S. production of clinker
(Metric tons, includes Puerto Rico)

		D16	D15	D15 - D16	
Year	EPA (kt)	Monthly	Annual	mt	% D15
2013	69,900	69,892,088	69,900,170	8,082	0.012%
2014	**75,800**	75,044,961	75,011,532	-33,429	-0.045%
2015	**76,700**	76,603,356	76,578,773	-24,583	-0.032%
2016	**75,800**	75,997,022	76,022,179	25,157	0.033%
2017*	**75,800**	76,984,145	NA		

*2017 monthly data as of 10/2018 cycle.
"EPA" data used USGS for 2013 & EPA GHG surveys thereafter.

4-9 (6): "…(2009 emissions **were** approx.. 28% lower…)"
(9) "In 2017, **estimated** emissions from cement production **were about 1% lower than those in 2015.**" Comment: 2017 emissions are estimated; the 2017 emissions didn't decrease from 2015 levels—they were lower than 2015 levels. You could say that 2016 emissions decreased from 2015. In any case, the USGS clinker data above suggest that the emissions likely increased in 2017 from 2016 levels and likely were slightly higher than those of 2015.

4-9 (23-25): **During clinker production, some of the raw materials, partially reacted raw materials, and clinker enters the kiln line's exhaust system as dust, here collectively referred to as cement kiln dust (CKD). To the degree that the CKD, like the raw materials, contains carbonate raw materials which then get calcined, there is an associated emission of CO_2. At some plants, essentially all CKD is directly returned (insufflated) to the kiln, becoming part of the raw material feed, or is likewise returned to the kiln after first being removed from the exhaust by an electrostatic precipitator or filtration baghouse. In either case, the returned CKD becomes a raw material, thus forming clinker, and the associated CO_2 emissions are simply a component of those calculated for the clinker overall. At some plants, however, the CKD cannot be returned to the kiln at all because it is chemically unsuitable as a raw material, or chemical issues limit the amount of CKD that can be so reused. Any clinker that cannot be returned to the kiln is either used for other (non-clinker) purposes or is landfilled. The CO_2 emissions associated with this non-returned clinker are thus "lost" to the system in that they are not covered by the clinker emissions factor**. The IPCC recommends….

Comment: as originally stated, the key CKD argument—that the "lost" CKD's emissions are not accounted for in the clinker emissions factor—was not made; instead, it seemed like CKD remaining in the kiln somehow was not being counted, which is incorrect. CKD, by definition, does not "remain" in the kiln, but it can be returned to the kiln (becoming part of the raw material feed). Only the CKD that is not returned to the kiln is of interest with respect to "lost" (unaccounted for) emissions. The 2% addition pertains to the likelihood of there being some "lost" CKD.

Table 4-4: apart from comments below regarding the preferred sourcing of the clinker data, it appears that the 2014-2017 data are all rounded (2013 is actually not rounded—except to the nearest 1,000 tons) and while this is ok, such rounding would call for similar rounding in table 4-3.

4-10 (12): Unclear if by "CKD loss can range from 1.5 – 8%" you mean the CKD itself, or the CO_2 emissions associated with CKD "lost" to the system (i.e., not returned to the kiln).

(16): "….the outer 0.2 **inch** of the **total thickness**." A thickness effect, not a surface area effect; carbonation favors high surface area applications—a stucco may carbonate fairly thoroughly & quickly, a thick concrete slab likely will not.

(28-32) Yes, there is a difference between the USGS and EPA data—I would trust the USGS data on clinker production.

Response: EPA appreciates the expert review comments received to help clarify and provide a more accurate description of the cement and clinker production process. The EPA has also performed outreach with the commenter to better understand the comments received. As a result, the Final Inventory report includes an updated description to better reflect the production process per the comments received.

Comment 8: Datasets and data comparison of Clinker Production data

4-9 (34-37) and 4-10 (1-6). You have used the USGS data (I presume from the Minerals Yearbook) for 1990-2013, as you should. It remains unclear why the EPA has switched to its own clinker data thereafter. In discussing data quality, it should be made clear that the USGS has surveyed clinker production data both annually (USBM 1925-1994; USGS thereafter) and monthly (starting 1/1998). For both the monthly and annual surveys, the clinker production data are collected to the nearest ton and are so published in the monthly data; the annual data are presented in units of thousand tons for brevity. The data are rigorously checked: Beginning with the 1998 data, all individual plants' monthly data have been compared with the plants' subsequent annual reporting. Where an annual difference (monthly vs. annual surveys) of 5,000 short tons or more is evident for an individual plant, the plant is queried to resolve the discrepancy (usually resulting in the revisions of some monthly data). For most plants (85%+), the two surveys match exactly for the year or differ by just a few single tons—representing a rounding error from various short to metric ton (or vice versa) conversions. In a few other cases, differences will amount to a few hundred or a few thousand tons but be below the resolution threshold. Fewer than 5% of the forms will have discrepancies of 5,000 short tons or more; these differences get resolved. If the error was indeed with monthly data, the relevant month(s) will be corrected ASAP as revisions in a subsequent monthly report. Of course, this checking is, really, a check on consistency. However, the USGS also collects data on the consumption of raw materials for clinker production vs. those (i.e., additions into the finish mill) for finished cement production. The raw material for clinker data are ratioed to the clinker production as a further check on the data quality or to

detect major shifts in "recipes". Likewise, we collect fuel (energy) data and ratio these to the clinker production to see if things look reasonable.

In the table submitted above, the USGS monthly data for the years shown can be compared with what was published in the USGS annual cement chapters—the agreements are extremely close (in part courtesy of the resolution process!); for the years shown, the two USGS surveys differ by a mere 0.045% (2014) or even less. The data represent 100% reporting of clinker production and are reliable. It is unlikely that the EPA-collected data can match the quality and quality checking of the USGS clinker data—the EPA data are from a single survey only, so it is likely that only the most egregious reporting errors will be evident to the EPA analysts. Do not be surprised if some of the "reasonable" production data reported are really clinker consumption data for the year. Also, do not be surprised if there are short-ton vs. metric ton issues—most U.S. cement plants are owned by foreign companies and some of these do their (U.S.-based) internal accounting in metric tons. It is common for plants to report metric tons when they are supposed to be reporting short tons; inadequate attention is paid by some respondents to the requested reporting units. Anyway, the table above also shows the EPA data for 2014-2017; I view the EPA data as less reliable than the USGS data. By the EPA's admission, the EPA does not have complete data for 2017—why not then at least use the USGS data for 2017 (albeit that only the monthly data are as yet available) instead of simply repeating the EPA 2016 number?

Response: EPA appreciates the expert review comments received regarding the clinker production data utilized in the estimation of cement production process for the Inventory. The Final Inventory report reflects updated data for 2017 based on EPA's GHGRP data, as well as an updated comparison of this data with clinker production values reported by the USGS. At the time of the IPPU expert review period, 2017 GHGRP data was not yet available as this data follows the GHGRP data production cycle. EPA conducted outreach with the commenter to discuss available data, differences in data sets including where errors may occur, and provided additional information regarding the EPA's GHGRP data and verification processes: https://www.epa.gov/sites/production/files/2017-12/documents/ghgrp_verification_factsheet.pdf. EPA was unable to provide additional comparison to the Cement Production chapter between GHGRP data and the various reports published by the USGS due to the timing of Final Inventory publication but will include this information in the QA/QC and Verification section in the April 2020 Inventory submission.

Chapter 5. Agriculture

Comment 9: Clarity and Transparency of the Agriculture Chapter

In general, the methodology and explanation of emissions is clear and appropriate. The analysis is rigorous and comprehensive. In some cases, there is room for improvement (most of which EPA also recognizes):

- The exact source of activity data could be clearer. For example, noting in the text, in a table, or a footnote which survey was used to obtain the data for specific livestock types may be helpful.
- Similarly, including tables depicting changes in activity data overtime would help readers better understand the rationale behind emissions changes.
- Diet characteristics for dairy cattle and some WMS activity data are outdated—recognizing that there are planned improvements in this area.
- The maximum methane generating capacity factor (B_0) is based on ~40 year old research and should be revisited—recognizing there are planned improvements in this area.

Response: EPA appreciates the comment received regarding potential improvements to the overall Agriculture Chapter of the Inventory. EPA notes that many of these improvements are currently reflected in the Planned Improvements sections of the Agriculture Chapter source categories. The EPA plans to consider making changes that would present additional information regarding data sources, as well as changes in data. In the Final Inventory report, Annex 3b does include tables which reference sources of data. For example, Table A-171 provides the source of DE values and Table A-185 provides sources of waste characteristics data for manure management. Additional detail on the specific sources of data for each animal population can be found in the methodology text descriptions within Annex 3b: https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-annex-3-additional-source-or-sink-categories-part-b.pdf. EPA will assess further updates to the text for future reports.

Comment 10: Clarity and Transparency of the Agriculture Chapter
Generally, it appears to be done well with consideration of the intake of digestible energy driving GHG production, as is the most reliable variable. I did wonder about what changes in feed ingredients caused the recent increase in beef cattle methane emissions. The impact of the ethanol industry on the emissions from cattle should be considered. The major byproduct of ethanol production is distillers grains which are fed to beef cattle. I believe these grains may decrease emissions from cattle for a given level of digestible energy. If there is any effect, it might be considered as an aspect of the impact of ethanol-distillers grain production.

Response: EPA appreciates the commenter's support on clarity and transparency of the chapter in describing GHG emissions from enteric fermentation. The underlying diet characterization data used in the Cattle Enteric Fermentation Model (CEFM) to calculate enteric fermentation emissions have not been updated for several years due to prioritization of resources and lack of available data. The recent increases seen in enteric fermentation emissions are resulting from changes to the animal population data, which are updated annually. As resources allow, EPA is working to incorporate updated diet characterization data into the CEFM as noted in the Planned Improvements section of Chapter 5.1; these updated data when incorporated should reflect the use of distillers' grains.

5.1 Enteric Fermentation

Comment 111: Typo on pg. 5-3
P 5-3 line 1. Typo. Should read "but increased from 2015 to 2017"

Response: The description of the Enteric Fermentation chapter has been updated for the Final Inventory publication.

5.2 Manure Management

Comment 12: Adding detail on cattle and swine populations
Page 5-11, line 1. Could give more detail on how often cattle and swine populations are updated (see annex page A-25). Also, swine is not mentioned in this paragraph. Should be included.

Response: EPA notes that information on annual animal populations, including swine, are obtained from the USDA-NASS. Additional detail on methodology for Manure Management is included in Annex 3.11.

Comment 13: Clarity change on pg. 5-8
1. page 5-8, line 4. For clarity, change "produce little or no CH_4" to "produce CO_2 and little or no CH_4"

Response: EPA agrees with this suggested edit and has reflected this change in the Final Inventory report.

Comment 14: Unclear phrase on pg. 5-8
2. page 5-8, line 8. It is unclear what the following phrase refers to: including the animal's digestive system

Response: EPA agrees with this suggested edit and has incorporated changes to make the discussion clearer in the Final Inventory report.

Comment 15: Remove the word 'organic' on pg. 5.8
3. page 5-8, line 13. Remove the word 'organic', organic nitrogen is not denitrified

Response: EPA agrees with this suggested edit and has reflected this change in the Final Inventory report.

Comment 16: Grammar error on pg. 5-8
4. page 5-8, lines 17-18. These clauses are not parallel. For clarity, change the first instance of 'to' to 'into', and change the next two instances of 'in' to 'into"

Response: EPA agrees with this suggested edit and has reflected this change in the Final Inventory report.

Comment 17: Categorization of manure on pg. 5-8
5. page 5-8, line 19. Manure includes urine, either remove urine here or change manure to fecal matter

Response: EPA notes that not everyone assumes that manure includes urine, so this differentiation has been made in the past to clarify this point. However, EPA agrees that this description could be made clearer and has incorporated changes in the Final Inventory report.

Comment 18: Factual error on pg. 5-8
6. page 5-8, line 21. This is factually wrong, organic N is not converted to N_2O. Organic N is first mineralized or decomposed to NH_4 which is then nitrified to NO_3 (producing some N_2O as a byproduct), and the nitrate is then in turn denitrified to N_2O and N_2. NOx can also be produced during denitrification.

Response: EPA appreciates the comment received regarding updates to clarify the text description of manure management emissions within the Agriculture Chapter of the Inventory. The text description at the time of the expert review draft explains the aerobic and then anaerobic conditions that must exist for manure N to process through the N cycle. EPA agrees that this point could be reworded, also to reflect expert review comment, and has incorporated changes into the Final Inventory report.

Comment 19: Better reference on pg. 5-8
7. page 5-8, line 24. A better reference for this is:
Robertson, G. P. and P. M. Groffman. 2015. Nitrogen transformations. Pages 421-446 in E. A. Paul, editor. Soil Microbiology, Ecology, and Biochemistry. Academic Press, Burlington, Massachusetts, USA.

Response: EPA agrees with this suggested edit and has reflected this change in the Final Inventory report.

Chapter 7. Waste

Comment 20: Clarity and Transparency of the Waste Chapter
Comments specifically regarding EPA request for reviewers: "Please provide your overall impressions of the clarity and transparency of the Waste chapter. Please provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the Waste chapter."

First, the cited literature accompanying the updated methodology was brief, outdated and extremely disappointing with an emphasis on old literature and outdated concepts. There are literally dozens of articles in the refereed literature during the last two decades which were not cited and, thus, apparently not considered. See, for example, the literature cited in NASEM (2018), Scheutz et al. (2009), and Spokas et al., (2011, 2015). Especially, this literature includes: a) discrete field campaigns quantifying landfill methane emissions [field measurements + statistical analysis], as well as b) advances in field-validated process-based modeling for improved quantification of site-specific landfill methane emissions inclusive of site-specific climate. Moreover, in addition to the paucity of recent refereed literature, the current document under review lists a number of internal contractor memos without apparent online availability via EPA—this strategy (internal discussions without linkage to refereed literature) lacks transparency and is disappointing from such a reputable agency as EPA with historically strong internal technical expertise. Thus it would be helpful if EPA professionals would 1) take advantage of their extensive in-house technical expertise while also overseeing contractor tasks; 2) improve the credibility of methodological analysis via consultation of appropriate refereed literature; 3) more closely collaborate with international colleagues via the IPCC Taskforce for National GHG Inventory Methodologies to insure that U.S. landfill methane emissions are realistically quantified and reported to the UNFCCC; and 4) collaboratively improve, expand, and unify efforts under their own GHGRP and GHGI with other Federal agencies (NASA, NOAA, DOE) to work toward providing the necessary "landfill methane" input for an annually-updated gridded U.S. inventory for anthropogenic methane emissions.

This goal (item #4)—namely, a gridded U.S. inventory—is a major recommendation from a new National Academies of Science, Engineering, and Medicine (NASEM) consensus report on "Improving Inventories for Anthropogenic Methane Emissions in the U.S." (NASEM, 2018). Methane emissions are "complicated" with many anthropogenic and natural sources having spatial and temporal variability spanning orders of magnitude. Certainly, all four of the National Academies' (NASEM, 2018) major recommendations (NASEM, 2018) deserve consideration, encouragement and collaborative implementation by EPA, NASA, NOAA, and DOE—those recommendations are:

1) Continue and enhance current atmospheric methane observations and advance models and assimilation techniques used by top-down approaches.

2) Establish and maintain a fine-scale, spatially and temporally explicit (e.g., gridded) inventory of U.S. anthropogenic methane emissions that is testable using atmospheric observations, and update it on a regular basis.
3) Promote a sustainable process for incorporating the latest science into the GHGI, and regularly review U.S. methane inventory methodologies [see landfill methane-related discussion].
4) Establish and maintain a nationwide research effort to improve accuracy, reliability, and applicability of anthropogenic methane emissions estimates.

Finally, it must be recognized that there are fundamental problems with the current methodology for landfill methane emissions. Use of the IPCC (2006) first order model methodology results in a fundamental dependence for emissions on WIP with the largest sites (largest WIP) having the highest emissions. This is simply not true: literature during the last 2 decades refutes this dependency: rather, emissions are directly related to a) site operational factors (i.e., thickness and composition of site-specific cover materials, presence and operation of engineered biogas recovery) and 2) site-specific climate (affecting temporal variability in emissions over an annual cycle in site-specific soils). [Spokas et al., 2015, 2011; Scheutz et al., 2009] Certainly, temporal soil moisture and temperature changes drive temporal variability in gaseous transport and methanotrophic oxidation rates in individual cover soils. Therefore, credible inventory methods for landfill methane emissions must incorporate consideration of these site-specific operational factors and climate.

However, the current IPCC (2006) methodology assigns a k value for methane generation based on climate but excludes any rigorous consideration of site-specific climate effects on emissions. In contrast, it can be shown via published metadata analysis that, perhaps surprisingly, methane [generation + recovery] from highly-engineered U.S. landfills (i.e., California) is relatively constant across 129 [California] sites irregardless of climate and age of waste (approx. 125 Nm^3 CH_4 per hour per million Mg WIP) [Spokas et al., 2015]. Since much of the further details of this discussion rely on previously published literature, I have attached a relatively large .pdf file [Bogner Nov18 landfill methane GHGI methodology review FINAL.pdf] with more detailed graphs of field data, modeling outcomes, and discussion of:

- the shortcomings of the current methodology;
- one example of a process-based, freely-available model [CALMIM] with independent international field validation for site-specific landfill methane emissions estimates and an example of an inventory application [California landfills, 2010 inventory];
- published comparisons of measured emissions to CALMIM estimates;
- suggestions for advanced CALMIM implementation for site-specific research and engineering strategies to mitigate emissions, and
- bibliography/references cited [NOTE: This bibliography also includes the landfill references cited in these comments—see last 2 pages in pdf file].

Briefly, as discussed above, we now know that there are many fundamental problems with the IPCC (2006) methodology as the basis for inventory reporting for landfill methane—realistically, method abandonment should be a strong consideration based on current science unavailable in 1990's when this methodology was first developed (IPCC, 1996). Instead, an inventory methodology for methane emissions should directly model/estimate emissions based on the known drivers for emissions. Recognizing that EPA must also address backcasting to a 1990 benchmark, I realize that these recommendations for GHGI and GHGRP reporting represent a radical departure from the status quo. However, based on extensive literature during the last 20+ years, and recognizing that the method is

largely based on 40-year old science (first order modeling for landfill biogas generation) and a 20+-year old understanding of emissions prior to a critical mass of field data on measured emissions, there should be serious consideration of an alternative methodology. It is also important to point out that the additional methodological complexity added to the GHGRP protocols over historic GHGI methods is not scientifically astute and was never field-validated; rather, the current range of "assigned" emission and oxidation factors for the GHGRP, which are scaled very loosely to ranges of values taken from literature only add complexity without reducing uncertainties or adding any additional value. (For example, on p. 10, it is stated that "There is less uncertainty in the GHGRP data because this methodology is facility-specific, uses directly measured CH_4 recovery data (when applicable), and allows for a variety of landfill gas collection efficiencies, destruction efficiencies, and/or oxidation factors to be used.") Certainly, facility-specific data are needed—however, it is important to incorporate the measurable site-specific parameters which impact directly on site-specific emissions: i.e., areal extent of various cover materials; thickness and composition of each cover material; physical extent of engineered biogas extraction under each cover material [i.e., % of cover area or WIP in each cell]; and, finally, average or annual site-specific climate data (daily pcp, daily min/max temperature). The current "assigned" emission, oxidation, and climate factors incorporated in the GHGRP protocols do not have direct linkage to the site-specific drivers for emissions as discussed above.

I would respectfully suggest that EPA: (1) for each year of the GHGRP annual reports to date, plot site-specific measured methane recovery (Mg methane) vs. measured WIP (Mg waste); and (2) separately plot each of the various HH- "emission" values (Mg CH_4) vs. measured WIP (Mg). Please compare those plots with the plots in the first slides of the attached .pdf file. With regard to 1), this is likely to be a nominally linear relationship with scatter that can be largely attributed to a "known unknown", namely the % of WIP which has installed biogas recovery. This conclusion is based on a parallel plot using 2010 data for California only [also shown in the attached] where it was independently determined by CalRecycle that >90% of the WIP in place in California landfills was "welled" and this plot using California data alone yielded a robust linear relationship (see also Spokas et al., 2015: approx. 125 Nm^3 /hr measured methane recovery per million Mg WIP). With regard to 2), when I did this using averaged 2010- 2014 GHGRP data for 201 sites for 2010-2014, there were no obvious relationships and wide scatter for all the plots using the various HH-values—not promising for the current GHGRP method where the scaling factors were never independently field-validated. As discussed extensively in historic documentation for IPCC (1996, 2006) and the U.S. GHGI and GHGRP, the discussion in previous paragraphs above, as well as in the attached .pdf, the current FOD methodology in its classic application results in estimated emissions that are directly related to measured WIP. As discussed in more detail in the attached .pdf, this is not true and skews site-specific emissions with regard to this misleading assumption [especially note the differences between site-specific emissions for California landfills using IPCC (2006) and the CALMIM model, Spokas et al., 2015]. In contrast (Spokas et al., 2015 and attached .pdf), a revised 2010 site-specific California landfill methane emissions inventory, demonstrated a strong dependency for emissions on cover soils (>90% of emissions from large areas of thinner intermediate cover soils in California) and climate (MAP, MAT: i.e., lower emissions from sites with >500 mm MAP due to increased oxidation rates).

Finally, when using the IPCC (2006) FOD model as a basis for estimated emissions, there is no mechanism for quantitatively crediting the effect of known mitigation strategies on site-specific emissions (i.e., greater density of biogas recovery wells, thicker cover materials w/ alternative physical characteristics, leaving a thin intermediate cover in place prior to vertical expansions, i.e., Cambaliza et al., 2017). This remains a major shortcoming of the current method wherein emissions are incorrectly

assumed to be directly related to WIP. This also means that, for localized GHG mitigation strategies, there is no linkage between the estimated emissions and the specific strategy employed.

For all these reasons, consideration should be given to alternative methods such as CALMIM. Even with the need to adjust/backcast values to a 1990 baseline, the use of a science-based, internationally field-validated methodology should be strongly considered at this point in time. This becomes especially important if and when the recommendations of NASEM (2018) are implemented, especially regarding the proposed 0.1 X 0.1 deg. gridded inventory for anthropogenic methane emissions for the U.S. At that point, realistic values for individual methane sources really DO matter and are needed to guide mitigation strategies from multiple localized sources to further reduce emissions.

Response: Regarding recent scientific studies relevant to these estimates, a key part of the QA/QC and verification process for generating the estimates is conducting literature reviews to evaluate the appropriateness of country-specific emission factors (e.g., DOC values, precipitation zones with respect to the application of the k values) given findings from recent peer-reviewed studies. To maintain transparency, references cited in the Inventory are those used in the Inventory. A broader range of studies is reviewed and considered. EPA has posted the memos to which the commenter is referring on the same site at which the final Inventory report was posted (now posted under Waste Chapter of current Inventory). However, the commenter is correct that we did not distribute these memos, nor post them, with the expert review draft. In future Inventory preparation cycles we will be more transparent by either including such memos with the expert review distribution or indicate where they may be readily found online for additional technical context.

Regarding gridding CH_4 estimates in the GHG Inventory, in 2016, to improve the ability to compare the national-level inventory with measurement results that may be at other scales, a team at Harvard University along with EPA and other coauthors developed a gridded inventory of U.S. anthropogenic methane emissions with 0.1° x 0.1° spatial resolution, monthly temporal resolution, and detailed scale-dependent error characterization. The gridded methane inventory is designed to be consistent with the 2016 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014 estimates for the year 2012, which presents national totals. Please see https://www.epa.gov/ghgemissions/gridded-2012-methane-emissions. An update to the gridding, using the latest GHG Inventory is in progress.

Regarding the methodology used for the Inventory, please note that the IPCC Guidelines and the FOD model with country specific DOC and k values is used for years 1990-2004 as no directly reported facility specific data is available for those years. We agree with the limitations of the FOD model. Data submitted to the GHGRP is used beginning in 2005 (data submitted for 2010 – 2017 are backcasted to 2005). While landfills without gas collection that report to the GHGRP do use the FOD as the source of their methane generation and emissions, landfill with gas collection also provide actual measurements of landfill gas flow and methane concentration.

We have reviewed CALMIM and other methods and approaches in the past and at the time our assessment was that the current method is the most appropriate, though we will again review CALMIMM and continue reviewing new data for potential future updates. If resources allow, we will also compare the GHGRP data to the 125 Nm3 CH_4/hr/MT WIP value that the commenter describes.

Comment 21: Improving the Waste Chapter
Provide overall impressions of the clarity and transparency of the Waste chapter.

Generally the chapter is clearly written. While there are numerous areas of potential improvement to keep the chapter in line with current scientific findings, such challenges are noted elsewhere. However, the 2nd paragraph on p. 7-2 that opens the chapter states "After being placed in a landfill, organic waste (such as paper, food scraps, and yard trimmings) is initially decomposed by aerobic bacteria. After the oxygen has been depleted, the remaining waste is available for consumption by anaerobic bacteria, which break down…". While this statement is true, greater transparency could be achieved by including information related to the relative time frame that the waste is under aerobic versus anaerobic conditions. As written, a reader unfamiliar with landfills could interpret this statement to mean that landfills function aerobically for substantial periods of time, which is not the case. If the initial description could refer to the fact that aerobic conditions subsist over very short durations, this would be more transparent.

Response: EPA appreciates the commenters feedback regarding transparency. Please note that in a later paragraph on that same page we state, "Methane production typically begins within the first year after the waste is disposed of in a landfill." This addresses the short duration during which aerobic conditions exist after which time anaerobic bacteria begin to break down the waste. Having said that we agree that include similar text in the 2nd paragraph would increase transparency. We will include such text in the subsequent Inventory report (i.e. April 2020).

7.1 Landfills

Comment 22: Paper Recycling Figure

p. 16 Fig. 7.3. Figure shows almost 80% paper recycling in 2015... That seems unrealistically high even with the (now much diminished) shipping of paper discards to China in that year—please discuss data sources, including international shipping to China and other countries in Asia, and provide further explanation. More specifically, could your "total" for paper discards that year be too low, so that the % of recycled paper [including known tonnage from international shipping/trading] might be correspondingly too high…

Response: The source for the data used in this figure is EPA's Sustainable Materials Management Facts and Figures Report 2015, which may be found at: https://www.epa.gov/sites/production/files/2018-07/documents/smm_2015_tables_and_figures_07252018_fnl_508_0.pdf; specifically, the amount of food scraps and yard trimmings recycled and composted, and the amount of paper and paperboard recycled and composted are located in Table 25 (yard trimmings and food scraps are under 'other waste', paper and paperboard were simply the total % for that category). The methodology document for this report does note that in terms of MSW generation, production data are adjusted by imports and exports from the U.S. where necessary (page 2, paragraph 4 https://www.epa.gov/sites/production/files/2015-09/documents/06numbers.pdf), however, it does not go into specifics as to which source categories these adjustments are made for, therefore it is difficult to discern whether it accounts for shipments to China.

Comment 23: Degradable Organic Carbon (DOC)

A comprehensive Internet search by state was conducted to identify waste characterization studies published as of July 2018. We plan to conduct analyses to generate DOC values specific to the time frame of 1990 to 2004. This time frame is specified because the Inventory uses directly reported GHGRP net emissions, which incorporate the DOC values allowed under the rule, in years beyond 2004. Please

comment and provide information on any additional studies that have not been published on the Internet from 1990 to date that may further these efforts.

For a lot of reasons, this is not a productive use of EPA's resources. First, there are major issues with the current IPCC (2006) FOD model methodology as discussed above. It is highly unrealistic to expect that a few updated "DOC values" can have any field credibility across the many U.S. sites. In general, such data may be appropriate for and add value to site-specific LCA's with site-specific interpretations, but it is inappropriate for broader state or national applications. Importantly, in Spokas et al., (2015) and also discussed in NASEM (2018) and the attached .pdf, it can be shown that, using 2010 data (NOT modeling) for the 129 full-scale California landfills with biogas recovery, there is a robust linear relationship (r^2 =0.82-0.90 depending on inclusion of the very large Puente Hills site) between site-specific measured annual average methane recovery rate and the measured Waste in Place (WIP). That measured field rate (126 Nm^3 /hr methane recovered per million Mg WIP) implies steady state methane generation without any assumed first order kinetic relationship as traditionally based on the estimated degradable organic carbon content of the waste. The broader implication, of course, is that methane generation in landfills can proceed at "relatively" steady rates over many decades, since the California sites include a wide variety of ages, status (open/closed many years ago), climate regions, and site-specific practices where, unlike for emissions, [generation + recovery] appears to proceed at a quantifiable rate. It is ironic, perhaps, that recent field data have indicated that simpler perceptions of obtainable methane recovery from landfilled waste are valid, whereas our understanding of climatic and site-operational drivers for residual methane emissions have only gotten more complex.

Response: EPA appreciates the commenter's feedback on the usefulness of examining waste characterization studies. As EPA begins preparation of future Inventory emissions estimates, and depending on resources, we will consider this feedback as we investigate any changes to our methodology.

Comment 24: Decay Rate Values
An analysis is being conducted on decay rate values reported by developed countries (e.g. UNFCCC Annex 1 countries) in their annual National Inventory Reports, as well as decay rate values used as defaults in first order decay models, as compared to the U.S. Greenhouse Gas Inventory defaults used in the U.S. Waste model. This analysis is specific to the 1990 to 2004 time frame, because the Inventory uses directly reported GHGRP net emissions, which incorporate the decay rate values allowed under the rule, for years beyond 2004. Please comment and provide information on any additional studies and models that have not been published on the Internet from 1990 to date if any stakeholders have this information available to share.

What is meant by "directly reported GHGRP net emissions"? As there are several HH- values within the GHGRP protocols —which one of the several HH- values is used? It is also a misnomer to infer that these "reported" emissions have any relationship except by serendipity, to actual field-measured emissions at U.S. landfills. As in the previous question, this is not a productive use of EPA resources. Metadata analysis showing a relatively consistent rate of biogas recovery per unit mass of landfilled WIP (see attached .pdf) refutes the use of the FOD model where biogas production rate peaks in the year of disposal and declines exponentially thereafter.

To conclude, I would recommend consultation of:

NASEM (National Academies of Science, Engineering, and Medicine), 2018, Improving Characterization of Anthropogenic Methane Emissions in the United States, Washington, DC: The National Academies Press.doi:https://doi.org/10.17226/24987.

As well as the following literature:
Abichou, T., J. Clark, S. Tan, J. Chanton, G. Hater, R. Green, D. Goldsmith, M. A. Barlaz, and N. Swan. 2010. Uncertainties Associated with the Use of Optical Remote Sensing Technique to Estimate Surface Emissions in Landfill Applications. Journal of the Air & Waste Management Association 60(4):460-470. DOI: 10.3155/1047-3289.60.4.460.

Bogner, J., K. Spokas, and M. Corcoran. 2014. International field validation of CALMIM: A site-specific process-based model for landfill methane (CH_4) emissions inclusive of seasonal CH_4 oxidation. Raleigh: EREF. Available at https://erefdn.org/wp-content/uploads/2015/12/IPCC_Final_Report.pdf, accessed July 24, 2017.

Bogner, J. E., K. A. Spokas, and R. P. Chanton. 2011. Seasonal greenhouse gas emissions (methane, carbon dioxide, nitrous oxide) from engineered landfills: Daily, intermediate, and final California cover soils. Journal of Environmental Quality 40(3):1010-1020. DOI: 10.2134/jeq2010.0407.

Cambaliza, M. O., J. Bogner, G. R., P. B. Shepson, T. A. Harvey, K. A. Spokas, B. H. Stirm, and M. Corcoran. 2017. Field measurements and modeling to resolve m^2 to km^2 CH_4 emissions for a complex urban source: An Indiana landfill study. Elementa--Science of the Anthropocene 5(36). DOI: http://org/10.1525/elementa.145.

Cambaliza, M. O. L., P. B. Shepson, J. Bogner, D. R. Caulton, B. Stirm, C. Sweeney, S. A. Montzka, K. R. Gurney, K. Spokas, O. E. Salmon, T. N. Lavoie, A. Hendricks, K. Mays, J. Turnbull, B. R. Miller, T. Lauvaux, K. Davis, A. Karion, B. Moser, C. Miller, C. Obermeyer, J. Whetstone, K. Prasad, N. Miles, and S. Richardson. 2015. Quantification and source apportionment of the methane emission flux from the city of Indianapolis. Elementa: Science of the Anthropocene 3(37). DOI: 10.12952/journal.elementa.000037.

Chanton, J., and K. Liptay. 2000. Seasonal variation in methane oxidation in a landfill cover soil as determined by an in situ stable isotope technique. Global Biogeochemical Cycles 14(1):51-60. DOI: 10.1029/1999gb900087. Chanton, J., T. Abichou, C. Langford, G. Hater, R. Green, D. Goldsmith, and N. Swan. 2011. Landfill Methane Oxidation Across Climate Types in the U.S. Environmental Science & Technology 45(1):313-319. DOI: 10.1021/es101915r.

Chanton, J., T. Abichou, C. Langford, G. Hater, R. Green, D. Goldsmith, and N. Swan. 2011. Landfill Methane Oxidation Across Climate Types in the U.S. Environmental Science & Technology 45(1):313-319. DOI: 10.1021/es101915r.

Chanton, J. R., D. K. Powelson, and R. B. Green. 2009. Methane oxidation in landfill cover soils, is a 10% default value reasonable? Journal of Environmental Quality 38(2):654-663. DOI: 10.2134/jeq2008.0221.

de la Cruz, F. B., R. B. Green, G. R. Hater, J. P. Chanton, E. D. Thoma, T. A. Harvey, and M. A. Barlaz. 2016. Comparison of Field Measurements to Methane Emissions Models at a New Landfill. Environmental Science & Technology 50(17):9432-9441. DOI: 10.1021/acs.est.6b00415.

Foster-Wittig, T. A., E. D. Thoma, R. B. Green, G. R. Hater, N. D. Swan, and J. P. Chanton. 2015. Development of a mobile tracer correlation method for assessment of air emissions from landfills and other area sources. Atmospheric Environment 102:323-330. DOI: 10.1016/j.atmosenv.2014.12.008.

Goldsmith, C. D., J. Chanton, T. Abichou, N. Swan, R. Green, and G. Hater. 2012. Methane emissions from 20 landfills across the United States using vertical radial plume mapping. Journal of the Air & Waste Management Association 62(2):183-197. DOI: 10.1080/10473289.2011.639480.

Liptay, K., J. Chanton, P. Czepiel, and B. Mosher. 1998. Use of stable isotopes to determine methane oxidation in landfill cover soils. Journal of Geophysical Research Atmospheres 103(D7):8243-8250. DOI: 10.1029/97jd02630

Maasakkers, J. D., D. J. Jacob, M. P. Sulprizio, A. J. Turner, M. Weitz, T. Wirth, C. Hight, M. DeFigueiredo, M. Desai, R. Schmeltz, L. Hockstad, A. A. Bloom, K. W. Bowman, S. Jeong, and M. L. Fischer. 2016. Gridded National Inventory of US Methane Emissions. Environmental Science & Technology 50(23):13123-13133. DOI: 10.1021/acs.est.6b02878.

Miller, S. M., S. C. Wofsy, A. M. Michalak, E. A. Kort, A. E. Andrews, S. C. Biraud, E. J. Dlugokencky, J. Eluszkiewicz, M. L. Fischer, G. Janssens-Maenhout, B. R. Miller, J. B. Miller, S. A. Montzka, T. Nehrkorn, and C. Sweeney. 2013. Anthropogenic emissions of methane in the United States. Proceedings of the National Academy of Sciences of the United States of America 110(50):20018-20022. DOI: 10.1073/pnas.1314392110.

Scheutz, C., J. Samuelsson, A. M. Fredenslund, and P. Kjeldsen. 2011. Quantification of multiple methane emission sources at landfills using a double tracer technique. Waste Management 31(5):1009-1017. DOI: 10.1016/j.wasman.2011.01.015.

Scheutz, C., P. Kjeldsen, J. E. Bogner, A. De Visscher, J. Gebert, H. A. Hilger, M. Huber- Humer, and K. Spokas. 2009. Microbial methane oxidation processes and technologies for mitigation of landfill gas emissions. Waste Management & Research 27(5):409-455. DOI: 10.1177/0734242X09339325.

Spokas, K., J. Bogner, and J. Chanton. 2011. A process-based inventory model for landfill CH_4 emissions inclusive of soil microclimate and seasonal methane oxidation. Journal of Geophysical Research--Biogeosciences 116(G4). DOI: 10.1029/2011JG001741. Spokas, K., J. Bogner, M. Corcoran, and S. Walker. 2015. From California dreaming to California data: Challenging historic models for landfill CH_4 emissions. Elementa: Science of the Anthropocene 3(51). DOI: 10.12952/journal.elementa.000051.

Spokas, K., J. Bogner, M. Corcoran, and S. Walker. 2015. From California dreaming to California data: Challenging historic models for landfill CH4 emissions. Elementa: Science of the Anthropocene 3(51). DOI: 10.12952/journal.elementa.000051.

Spokas, K. A., and J. E. Bogner. 2011. Limits and dynamics of methane oxidation in landfill cover soils. Waste Management 31(5):823-832. DOI: 10.1016/j.wasman.2009.12.018.

Streese-Kleeberg, J., I. Rachor, J. Gebert, and R. Stegmann. 2011. Use of gas push-pull tests for the measurement of methane oxidation in different landfill cover soils. Waste Management 31(5):995-1001. DOI: 10.1016/j.wasman.2010.08.026.

Taylor, D. M., F. K. Chow, M. Delkash, and P. T. Imhoff. 2016. Numerical simulations to assess the tracer dilution method for measurement of landfill methane emissions. Waste Management 56:298-309. DOI: 10.1016/j.wasman.2016.06.040.

Response: EPA appreciates the commenter's feedback on the relationship between reported GHGRP data and field measurements. As EPA begins preparation of future Inventory emissions estimates, and depending on resources, we will consider this feedback as we investigate any changes to our methodology. EPA also appreciates the list of literature provided by the commenter.

Comment 25: The Scale-Up Factor for MSW Landfills

Recognizing that the GHGRP does not include every MSW landfill in the country – (MSW landfills that ceased taking waste prior to 1980 or have potential emissions less than 25,000 tons CO_2e) – we continue to support EPA's decision to use a scale-up factor to estimate emissions from non-reporting landfills in the draft 1990-2017 Inventory. As part of the expert review of the draft 2018 Inventory, the landfill sector reviewed the largest of the Agency's list of potential landfills not reporting emissions to the GHGRP. We found that the Agency overestimated Waste in Place (WIP) by more than 60 percent and recommended adjusting the scale-up factor to 5 percent from 12.5 percent. We were pleased that EPA adjusted the factor for the 2018 Inventory and employed a lower scale-up factor of 9 percent; however, **we do recommend that EPA revisit using an even lower factor of five percent in the 2019 Inventory. EPA should evaluate and revise the scale-up factor on a routine basis to account for the additional WIP for sites reporting to GHGRP which is likely to significantly exceed non-reporting facilities that have closed and are no longer receiving waste.** The Agency can reasonably anticipate a downward trend in WIP at landfills outside the GHGRP, and the scale-up factor should reflect these changing landfill demographics.

Response: EPA appreciates commenter's support of the scale-up factor approach to account for landfills that do not report to the GHGRP. EPA also appreciates and agrees with the commenter's feedback that the scale-up factor should be evaluated on a routine basis. EPA plans to reexamine the scale-up factor with each inventory cycle to determine if there are additional landfills reporting to the GHGRP such that the WIP assumed for those landfills can be removed from the scale-up factor. At the same time, EPA will also account for those landfills that have stopped reporting to the program because they were able to exercise the off-ramp provisions.

Comment 26: Methane Oxidation Factor

For the period 1990 – 2004 in the inventory time series, EPA calculates a national estimate of methane generation and emissions using a combination of secondary data sources that detail the annual quantity of waste landfilled and the annual quantity of methane recovered from facilities with landfill gas collection and control systems. EPA applies a 10% oxidation factor to all facilities for the years 1990 to 2004. This ten percent default factor contrasts significantly with the average methane oxidation factor of 19.5 percent applied through use of GHGRP data, to the later years of the time series (2005 to 2016). Importantly, the 19.5 percent average oxidation rate incorporated in the GHGRP, subpart HH emissions data is premised on a more detailed and up-to-date estimation approach than is the default value of 10 percent. It is also a conservative average value, as the GHGRP methodology restricted the maximum oxidation rate to 35 percent.

In its work to review and revise the method for calculating methane oxidation under subpart HH of the GHGRP, EPA acknowledged the need to update the default 10 percent oxidation value. The default value was based on only one field study, at a landfill without gas collection and control, and did not reflect the

much higher oxidation values found in numerous subsequent, peer-reviewed field studies. **Given the plethora of scientific studies showing methane oxidation to be several times higher than the EPA and IPCC default value, we strongly recommend EPA apply a revised value (perhaps the average oxidation value from the GHGRP) to the earlier years of the time series.**

Response: EPA appreciates commenter's feedback on the oxidation factor as applied to estimating emissions from MSW landfills in Chapter 7 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. As stated in the Planned Improvements section of Section 7.1 of the Inventory, EPA is continuing to review new literature and investigate options to adjust the oxidation factor from the 10 percent currently used for 1990 to 2004 to another value or approach such as the binned approach used in the GHGRP (e.g., 10 percent, 25 percent, or 35 percent based on methane flux). The oxidation factor currently applied in the later portion of the time series (2005 to 2017) averages to 19.5 percent due to the use of the GHGRP data while the earlier portion of the time series applies the default of 10 percent.

Comment 27: Degradable Organic Carbon (DOC)
Chapter 7 of the draft inventory explains that EPA uses one DOC value of 0.20 to calculate emissions for the years 1990 through 2004, and uses emissions reported through the GHGRP for years 2005 through 2017. The GHGRP allows landfills to use 0.20 for bulk MSW or allows a landfill to further delineate waste streams by accounting for separate shipments of C&D waste, which uses a DOC of 0.08, and separate shipments of inert wastes, which may use a DOC of 0.0. If a landfill delineates in this way, it must use a DOC of 0.31 for its MSW waste volumes, which applies an artificially high DOC to MSW, and inappropriately overestimates emissions. The required DOC value of 0.31 fails to account for the significant volumes of C&D and inert wastes that are incorporated in MSW, and which cannot be separated from the MSW or accounted for distinctly, as can discrete shipments of inert wastes from industrial or C&D recycling facilities.

While we are pleased to learn that EPA plans to revisit the DOC value of 0.20, we question why the Agency is focusing first on the early years of the inventory rather than the later portion of the time series. We believe that the fundamental shifts in the characterization of waste disposed in landfills has occurred in the later portion of the time series and that the research conducted thus far by state agencies and the Environmental Research and Education Foundation (EREF) are illustrative of those changes. **We strongly recommend that EPA instead focus on the second half of the time series and reevaluate the DOC values incorporated in subpart HH of the GHGRP, which underpins the data used for those years of the inventory.**

In 2016, the Environmental Research and Education Foundation (EREF) undertook a state-based study of DOC values for both landfills receiving only MSW (MSW Only Landfills) and for Non-MSW Material going to MSW Landfills. The DOC guideline recommended by EPA for MSW Only Landfills is 0.31 and the recommended guideline for Non-MSW material going to MSW landfills is 0.20. EREF concluded both of these guidelines over-estimate the amount of organic waste deposited in landfills, which results in inaccurate estimates of landfill gas generation and methane emissions. Furthermore, neither of the EPA-recommended DOC guidelines have been reviewed in many years. We therefore support EPA's view that it is time to update the DOC values and believe that the most valuable focus would be to reassess the DOC values incorporated in the GHGRP used for inventory years 2005 forward.

EREF reviewed recent waste composition studies for MSW Only Landfills conducted by 13 states and confirmed that waste composition has and continues to change over time, as fewer organic materials

are sent to MSW landfills. In fact, the EREF results show that the percent of the MSW-only stream that is organic waste ranged from 50.1% to 69.4%, with an average of 60.2% (Table 1).[1] EPA data also indicate that the fraction of organics going to landfills generally declined from the earliest studies through 2013. Since EPA cites the EREF research as a rationale for reassessing DOC values for 1990-2004, the following quotes from EREF clearly suggest that the data strongly suggest reevaluating DOC values used in the GHGRP for years 2005 and later:

> Subsequent analyses were performed using both state characterization study data and EPA Facts and Figures data to compute DOC values for MSW (DOC_{MSW}). An average DOC_{MSW} of 0.184 was computed from the state study data, with values ranging from 0.142 – 0.209. All characterization studies had DOC_{MSW} values significantly less than the default value of 0.31, which suggests this value is not representative of real-world conditions for MSW (Table 2; Figure 4). Analysis of U.S. EPA data … also results in a significantly lower DOC_{MSW} value compared to the U.S. EPA guideline of 0.31, with DOC_{MSW} values ranging from 0.218 in 1994 to a minimum of 0.165 in 2011 (Figure 4; Appendix B). Both the state characterization studies and U.S. EPA Facts and Figures data independently suggest that a DOC guideline value of 0.31 for MSW is not representative of the landfilled MSW stream. …
>
> The use of a single DOC value as a guideline for all U.S. landfills makes the implicit assumption that waste composition does not change over time or due to location. The results presented here suggest these are not valid assumptions and that, collectively, the use of a static DOC value of 0.31 may lead to inaccurate estimates of landfill gas emissions for landfills that only accept MSW. Because this specific analysis is focused only on MSW materials, one would expect the inclusion of non-MSW materials going to a landfill to impact DOC estimates even more.[2]

With respect to Non-MSW going to MSW Landfills, EREF finds "a common assumption is that all waste materials entering MSW landfills consist only of MSW materials. As noted previously, MSW Landfills rarely accept MSW exclusively. Rather, most MSW Landfills (landfills in 45 states) are authorized to accept other Subtitle D wastes in addition to MSW."[3] In addition, EREF notes:

> Given that a third of incoming waste to MSW Landfills consists of non-MSW materials, there is significant potential for non-MSW materials to impact the relative fraction of organics and degradable organic carbon (DOC) of the MSW Landfill waste stream.[4]
>
> The amount and types of non-MSW Subtitle D organic wastes impact the DOC value for the landfilled waste since it consists of both MSW and non-MSW streams. This combined DOC value (DOC_{SubD}) incorporates degradable organic carbon from all Subtitle D wastes accepted at MSW Landfills (both MSW and non-MSW). … State waste characterization studies were used to estimate the relative fraction of each organic constituent for C&D and industrial waste … and DOC for each waste type was calculated using Equation 1b. Based on this analysis the DOC_{SubD} value of landfilled waste is 0.161 (Table 6)."[5]

EREF also highlights that the DOC_{SubD} value:

> … is lower than the guideline value of 0.20 for bulk waste. It is also lower than the average DOC_{MSW} value of 0.184 computed in the prior section, indicating the inclusion of non-MSW decreases overall DOC. Using the same approach as for the DOC_{MSW} analysis, state-specific organics content and DOC_{SubD} values for all fourteen states with sufficient data were determined

> and presented in Table 7, below. … The results, all for 2013, highlight differences in DOC_{SubD} based on locale and suggest the use of a static 0.20 guideline for bulk waste may lead to inaccurate estimates of methane generation and emissions, especially in some areas.[6]

Thus, EREF concludes as follows:

> The average computed DOC value for MSW using state data was 0.184, or roughly three-fifths of the MSW guideline value. The average computed DOC value for bulk waste using state data was 0.161, or roughly four-fifths of the bulk waste guideline. This analysis suggests that the U.S. EPA's guideline DOC values of 0.31 for MSW-only landfills and 0.20 for facilities accepting non-MSW Subtitle D wastes overestimate DOC at these landfills and may result in inaccurate estimates of landfill gas generation and methane emissions.[7]

Based on this review of the DOC values for MSW landfills, the waste sector concludes that the long-standing DOC values developed in the past are inaccurate and are likely to over-estimate both landfill gas generation and methane emissions. The data provided by EREF confirms that two trends are driving the changes at MSW Landfills. First, many MSW Landfills are handling less organic matter now, and this trend is anticipated to continue due to state and local organics diversion goals. Second, the increase of Subtitle D non-MSW waste disposed has altered the DOC for all waste deposited in MSW Landfills. EPA validates these trends in the Inventory's Chapter 6 discussion of carbon sequestration of harvested wood products, yard waste and food waste, which shows a significant reduction in sequestered carbon since 1990 due to reduced volumes of organic wastes disposed in landfills.

Based on EREF's research, **we urge EPA to update the DOC values to reflect significant changes in the amounts and types of organic materials being landfilled over recent years.** The values now in use are inaccurate and should not be used going forward. **We recommend that EPA review and update the DOC values for the entire time series for the 2019 version of the GHG Inventory, and as a priority update the DOC values used in calculating GHG emissions under Subpart HH of the GHGRP.** Further, as EPA clearly recognizes that the composition of the waste at MSW Landfills has changed and continues to change, we suggest the Agency add an additional factor, "(5) the composition of the waste" to the sentence on line 42, page 7-2 of the waste chapter that begins: "Methane generation and emissions from landfills are a function of several factors."

[1] Staley, B.F. and Kantner, D.L., *Estimating Degradable Organic Carbon in MSW Landfills and the Impact of Non-MSW Materials*, EREF – Environmental Research and Education Foundation, 2016, Table 1, p. 4.
[2] Ibid., pp. 6 - 7.
[3] Ibid., p. 8.
[4] Ibid., p. 10.
[5] Ibid., p. 11.
[6] Ibid., p. 12.
[7] Ibid., p. 13.

Response: As stated in the Planned Improvements section of Section 7.1 of the U.S. Greenhouse Gas Inventory of Emissions and Sinks, EPA currently uses one value of 0.20 for the DOC for years 1990 to 2004. With respect to improvements to the DOC value, EPA developed a database with MSW characterization data from individual studies across the United States. EPA will review this data against the Inventory time series to assess the validity of the current DOC value and how it is applied in the FOD method. Waste characterization studies vary greatly in terms of the granularity of waste types included and the spatial boundaries of each study (e.g., one landfill, a metro area, statewide).

EPA also notes the recommendation from the commenter regarding the DOC values used in the GHGRP, in the context of new information on the composition of waste disposed in MSW landfills; these newer values could then be reflected in the 2005 and later years of the Inventory. EPA is continuing to investigate publicly available waste characterization studies and calculated DOC values resulting from the study data.

Comment 28: The k Factor (Methane Generation Rate Constant)
On page 7-13 EPA notes that it began investigating using k-values based on climate. The waste sector strongly supports EPA's plans to review these k values against new data and other landfill gas models, as well as assess the uncertainty factor applied to these k values in the Waste Model. We have been concerned that these k-values are outdated and rife with uncertainty, as confirmed by the *Draft AP 42.2.4 Municipal Solid Waste Landfills*, which states:

> There is a significant level of uncertainty in Equation 2 and its recommended default values for k and L_o. The recommended defaults k and L_o for conventional landfills, based upon the best fit to 40 different landfills, yielded predicted CH_4 emissions that ranged from ~30 to 400% of measured values and had a relative standard deviation of 0.73 (Table 2-2). The default values for wet landfills were based on a more limited set of data and are expected to contain even greater uncertainty.[8]

The waste sector has previously highlighted the significant issues with the k values used in the Draft AP-42 Section 2.4: Municipal Solid Waste Landfills. In fact, EPA has never finalized AP-42 for MSW landfills, despite the k-value issues identified <u>by EPA</u> in both AP-42 and the Background Information Document. With uncertainties in CH_4 emissions ranging from -30% to 400% under EPA's assessment of the LandGEM model, it is difficult to rely on these data. For this reason, we support EPA's plan to review and resolve the significant problems in the k value data set.

[8] U.S. EPA, *Draft AP 42.2.4: Municipal Solid Waste Landfills*, October 2008, p. 2.4-6.

Response: As stated in the Planned Improvements section of Section 7.1 of the U.S. Greenhouse Gas Inventory of Emissions and Sinks, EPA began investigating the k values for the three climate types (dry, moderate, and wet) against new data and other landfill gas models, and how they are applied to the percentage of the population assigned to these climate types. EPA will also assess the uncertainty factor applied to these k values in the Waste Model. Like the DOC value, the k values applied through the Waste Model are for the years 1990 to 2004; the k values for 2005 to 2017 are directly incorporated into the net methane emissions reported to EPA's GHGRP. EPA will continue investigating the literature for available k value data to understand if the data warrant revisions to the k values used in the Waste Model between 1990 to 2004.

Comment 29: Industrial Food Processing Waste Datasets
Please comment on datasets that detail the quantities of industrial food processing waste that is disposed of in industrial waste landfills.

The waste sector does not have datasets on food processing waste disposed at industrial waste landfills.

Response: EPA appreciates commenter's feedback on lack of available data on industrial food processing waste.

Comment 30: Waste Characterization Studies
A comprehensive Internet search by state was conducted to identify waste characterization studies published as of July 2018. We plan to conduct analyses to generate DOC values specific to the time frame of 1990 to 2004.

The waste sector shared the list of waste characterization studies evaluated by EPA with EREF to see if the research foundation might have information on additional waste characterization studies. In comments above we also strongly recommended that EPA reevaluate the default DOC values and focus first on the values used in the GHGRP and applied to emissions estimates for 2005-2017.

Response: EPA appreciates commenter's feedback on the availability of additional waste characterization studies and the list of studies provided. EPA notes that review and update of the DOC values are part of the ongoing Planned Improvements outlined in section 7.1 of the U.S. Greenhouse Gas Inventory of Emissions and Sinks. See responses to comments 27 and 33.

Comment 31: Methane Emissions from Pulp and Paper Landfills
NCASI notes that the revisions to US paper, paperboard, and market pulp production also reduced the estimates of mass of solid waste from pulp and paper facilities entering landfills that would contribute to methane emissions (Table A-1). It is our understanding that this revision in mass loading does not reduce methane emissions from pulp and paper landfills in the inventory because EPA is now using directly reported EPA Greenhouse Gas Reporting Program (GHGRP) information with a scale-up factor to calculate these emissions for the pulp and paper industry. NCASI would appreciate confirmation that this is indeed the approach being used to characterize current methane emissions from pulp and paper landfills.

Response: EPA appreciates commenter's feedback on the contribution of solid waste from pulp and paper facilities to the estimated emissions from industrial waste landfills in the U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2017. However, the commenter appears to misunderstand how emissions from industrial waste landfills are accounted for in the Inventory. The methodology currently uses production values for pulp and paper from the Lockwood-Post Directory (and USDA derived values for food and beverage), not data submitted to the GHGRP. In the Inventory, EPA does discuss recent analysis of data submitted to Subpart TT (Industrial waste landfills) of the GHGRP to determine if production values from other sectors that generate organic waste which could be disposed of in industrial landfills should be included in the Inventory estimates. However, no changes have been made to date as a result of this analysis.

Comment 32: Methane Oxidation from Landfill Cover Soils
The document notes (page 7-9) that the amount of methane oxidized by the landfill cover at MSW landfills was assumed to be 10% of the methane generated that was not recovered from 1990 to 2004. Note that at this point, there have been numerous studies conducted by academic researchers documenting methane oxidation over a variety of cover and climatic conditions that suggest methane oxidation is substantially higher than 10% in most circumstances. While the "Planned Improvements" section notes that the methane oxidation value used between 2005 to 2016 averages at 19.5%, this value appears to be applied across all landfills and is not adjusted based on geospatial differences and cover conditions. Given the substantial body of knowledge on methane oxidation from landfill covers that documents a higher and more variable range of methane oxidation values, consideration should be given to revising the 10% assumption to be more aligned with current scientific findings and values used

should more accurately reflect geospatial differences in oxidation values. The studies listed below provide a few examples. Note that a link to the final report for each project can be found at the bottom of the web page. Peer-reviewed articles are also published for most of these projects and can be provided if necessary.

1) Methane Oxidation: Field-scale test sections experiment https://erefdn.org/methane-oxidation-field-scale-test-sections-experiment/

2) International Field Validation of a New IPCC Model for Landfill Methane Emissions https://erefdn.org/international-field-validation-of-a-new-ipcc-model-for-landfill-methane-emissions/

3) Constraining the Effects of Secondary Porosity on CH_4 Oxidation https://erefdn.org/constraining-the-effects-of-secondary-porosity-on-ch4-oxidation/

Response: EPA appreciates commenter's feedback on the oxidation factor as applied to estimating emissions from MSW landfills in Chapter 7 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017. As stated in the Planned Improvements section of Section 7.1 of the Inventory, EPA is continuing to review new literature and investigate options to adjust the oxidation factor from the 10 percent currently used for 1990 to 2004 to another value or approach such as the binned approach used in the GHGRP (e.g., 10 percent, 25 percent, or 35 percent based on methane flux). The oxidation factor currently applied in the later portion of the time series (2005 to 2017) averages to 19.5 percent due to the use of the GHGRP data while the earlier portion of the time series applies the default of 10 percent. EPA further appreciates the source references provided by the commenter.

Comment 33: Degradable Organic Carbon (DOC)
In the "Planned Improvements" section of the chapter (page 7-13), it is noted that for the years from 1990 to 2004, a DOC value of 0.20 is used to calculate emissions. Recent research conducted by EREF using waste characterization studies to compute DOC entering landfills suggest that DOC values have been changing over time and in recent years are lower than the guideline value of 0.20. This appears to be due to an increasing fraction of non-MSW material being placed into MSW landfills, which in some cases, represents a substantial portion of received tonnage. Additionally, another factor attributed to lower DOC values is due to less organics entering landfill compared to prior years. Collectively, these results suggest that the guideline value of 0.20 may overestimate DOC, resulting in subsequent errors in estimated landfill gas emissions. A copy of the report is attached for reference and the "Conclusions" section of the report provides key findings that would be useful for review in EPA's effort to update the DOC values.

However, it should be stressed that the data aggregated in the EREF report suggest that DOC values are changing and, over the past 10-15 years, the DOC is significantly lower than the guideline value. DOC values prior to this time frame were not included in the analysis performed by EREF and data was not analyzed prior to the year 2000. Based on the changing waste composition to landfills over time, DOC values determined should be used to compute emissions that are aligned and within the same time frame. In other words, the data suggest it would not be appropriate to use a DOC value computed from 1990, for example, to estimate emissions for 2015. This is a key consideration when using waste characterization studies to estimate DOC values and apply said values to an emissions inventory.

Response: As stated in the Planned Improvements section of Section 7.1 of the U.S. Greenhouse Gas Inventory of Emissions and Sinks, EPA currently uses one value of 0.20 for the DOC for years 1990 to

2004. With respect to improvements to the DOC value, EPA developed a database with MSW characterization data from individual studies across the United States. EPA will review this data against the Inventory time series to assess the validity of the current DOC value and how it is applied in the FOD method. Waste characterization studies vary greatly in terms of the granularity of waste types included and the spatial boundaries of each study (e.g., one landfill, a metro area, statewide). EPA also notes the recommendation from the commenter regarding the DOC values used in the GHGRP, in the context of new information on the composition of waste disposed in MSW landfills; these newer values could then be reflected in the 2005 and later years of the Inventory. EPA is continuing to investigate publicly available waste characterization studies and calculated DOC values resulting from the study data. EPA also appreciates commenters assessment that it is important to consider the timeframe when making changes to the DOC value used in the Inventory calculations. Changes for the later portion of the time series (e.g. 2005-2017) may not be appropriate for the earlier part of the timeseries (e.g. 1990-2005).

Comment 34: Industrial Food Processing Waste Datasets
Please comment on datasets that detail the quantities of industrial food processing waste that is disposed of in industrial waste landfills.

We are not aware of any significant database that exists and the level of effort to ascertain a reasonably accurate estimate would be significant.

Response: EPA appreciates commenter's feedback on lack of available data on industrial food processing waste and agrees that obtaining this data would require significant effort.

Comment 35: Degradable Organic Carbon (DOC)
A comprehensive Internet search by state was conducted to identify waste characterization studies published as of July 2018. We plan to conduct analyses to generate DOC values specific to the time frame of 1990 to 2004. Please provide any additional information on studies from this time frame.

A study performed in 2009 by Staley and Barlaz aggregated a number of robust statewide characterization studies to ascertain variability in waste composition for the purpose of looking at methane yield and carbon sequestration. The paper may provide some insight relative to computing DOC values in the time frame referenced.

Staley, B.F. and M.A. Barlaz (2009). Composition of MSW in the U.S. and Implications for Carbon Sequestration and Methane Yield. Journal of Environmental Engineering, p. 901-909.

Response: EPA appreciated commenter's feedback to the charge question. EPA had reviewed the study reference by the commenter in preparing the U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2017 and will retain this study part of ongoing review of the DOC value per planned improvements. See also responses to comments 27 and 33.

Comment 36: Decay Rate Values

An analysis is being conducted on decay rate values reported by developed countries relative to US GHG Inventory defaults from 1990 to 2004. Please provide any additional information on studies from this time frame.

We are not aware of additional studies that the EPA would not already be aware of.

Response: EPA appreciated the commenter's feedback on the lack of additional studies available on decay rates.

Comment 37: MSW Landfills Emission Calculations
Page 7-3, line 1&2: How was it calculated that MSW landfills accounted for approximately 95% of total landfill emissions and industrial waste landfills accounted for the remainder? (CC)

Response: This percentage was calculated by comparing the U.S. Waste Model results for MSW landfills and industrial landfills when estimating emissions for the 2017 Inventory year.

Comment 38: Operating MSW Landfills Source
EPA/ORCR has an estimate of the number of operating MSW landfills, which is 1738. The source is Advancing Sustainable Materials Management Facts and Figures: 2015 Tables and Figures, Table 34, page 35. This can be inserted on page 7-3, line 2. (HP)

Response: EPA has noted commenter's feedback and has incorporated this information and citation within Section 7.1 of Chapter 7 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.

Comment 39: MSW Data Source
On page 7-3, line 17, it says 205 MMT MSW was landfilled in 1990; 226 MMT MSW was landfilled in 2000; and 206 MMT MSW was landfilled in 2017. What is the source of this data? (HP)

Response: These quantities are calculated quantities within the solid waste inventory framework for the years listed, they are arrived at by using the U.S. Waste Model which is based on the Waste Model within the 2006 IPCC Guidelines.

Comment 40: Nationwide Municipal Solid Waste Data Sources
Page 7-6, line 20- mentions EREF's MSW management data but not EPA's Facts & Figures? (CB)

Response: EPA appreciates the commenter's feedback and will review this portion of the report to determine if it is appropriate to include EPA's Facts and Figures report.

Comment 41: Nationwide Municipal Solid Waste Data Sources
Page 7-14: The correct title of EPA's report is **Advancing Sustainable Materials Management Facts and Figures report.** We also have the following website to the report if that is of interest: Facts and Figures (SG)

Response: EPA appreciates the commenter's feedback and has made this correction to the title of the EPA report.

Comment 42: Biocycle/SOG reports
The report notes that the Biocycle/SOG reports are no longer published. I would recommend calling Biocycle to see if they still want their publication name included as it been several years since they stopped published the SOG. Also, in the third paragraph, the authors of this paper use the present tense to describe SOG's report (e.g. The SOG surveys, now EREF, collect state-reported data…). This sentence seems to indicate that SOG is still being published. (SG)

Response: EPA appreciates the commenter's input on how Section 7.1 of Chapter 7 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks characterizes the Biocycle/SOG reports. EPA will review the tense used to describe the SOG survey and make any necessary corrections in subsequent Inventory reports.

Comment 43: Adding a Footnote for Advancing Sustainable Materials Management Report
On page 7-16, line 4, Data for years 2012 and 2013 are from EPA's Advancing Sustainable Materials Management: 2014 Tables and Figures Report (Table 4) published in December 2016. This should be added to the footnotes. (HP)

Response: EPA appreciates the commenter's input. Proper citations have been included in the final Inventory report.

Comment 44: Industrial Waste Landfill Estimates
Page 7-3, line 21&22: "The estimated quantity of waste placed in industrial waste landfills (from the pulp and paper, and food processing 21 sectors) has remained relatively steady since 1990, ranging from 9.7 MMT in 1990 to 10.2 MMT in 2017 (see 22 Annex 3.14, Table A-254)." (CC)

- Can we see Annex 3.14, Table A-254. I'm very curious about these estimates and what additional estimates there are on industrial waste. (CC)

Response: Annex 3, which includes Annex 3.14 is posted to EPA's website at
https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017

Comment 45: Generation and Disposal Data
Page 7-6, line 16&17: why is the SOG surveys used for generation and disposal data instead of the Facts and figures Report? (CC)

Response: When the SOG survey data was first used for preparation of the emissions estimates for the U.S. Greenhouse Gas Inventory of Emissions and Sinks, the EPA Facts and Figures report was not yet in publication. The SOG survey data are only used for the years 1990-2004 of the Inventory time series, pre-dating the years for which the Facts and Figures values are available. Therefore, SOG data estimates remain the most accurate account of waste generation and disposal for those early years of the Inventory time series.

7.2 Wastewater Treatment

Comment 46: Paper, Paperboard, and Market Pulp Production
Based upon discussions between EPA and NCASI in early 2018 regarding methane emissions from pulp and paper waste water treatment operations, EPA determined that updates to US paper, paperboard, and market pulp production were appropriate, which resulted in changes to the production time series (Table 7-10) and the methane emissions attributed to pulp and paper wastewater treatment facilities (Table 7-9). NCASI has reviewed section 7.2 Wastewater Treatment, finds the results to be in accordance with NCASI calculations, and thanks EPA for implementing the changes.

Response: EPA appreciates the commenter's feedback supporting the changes made to the production time series and the methane emissions attributed to wastewater treatment at pulp and paper facilities.

7.3 Composting

Comment 47: Compost Emission Factor
In ideal conditions, the composting process occurs at a moisture content of between 50 and 60%, but the moisture content of feedstocks received at composting sites varies and can range from 20% to 80%. It is common for moisture to be added to dry feedstocks prior to the start of composting to optimize the biological process. In the calculation of emissions from composting in the draft chapter, it appears that all incoming wastes were assumed to have a moisture content of 60%. If 60% is not reflective of the actual weighted average of all feedstocks, this will introduce errors in the inventory calculation that could be significant.

We recommend that the calculations be based on waste subcategories (i.e., leaves, grass and garden debris, food waste) and category-specific moisture contents, or ask that further information be provided on the rationale for assuming 60% as the average moisture content of all inbound materials

Response: EPA notes commenter's feedback on the moisture content levels used in the calculation of emissions from composting. The calculations for composting are based on IPCC Tier 1 methodology defaults. Under this methodology, the emission factors for CH_4 and N_2O assume a moisture content of 60% in the wet waste. (IPCC 2006). EPA has added this detail to the Methodology section of Section 7.3 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 so that the source of the moisture content is more transparent. In addition, EPA has added to the Planned Improvements section of Section 7.3 that EPA is looking into the possibility of incorporating more specific waste subcategories and category-specific moisture contents into the emissions estimates for composting in the United States to improve accuracy. However, to date the EPA has not been able to locate substantial information on the composition of waste at U.S. composting facilities to do so. As additional data becomes available on the composition of waste at these facilities, EPA will consider using this information to create a more detailed calculation of U.S. composting emissions.

Comment 48: Datasets Available on Industrial Composting Facilities.
Please comment on datasets available on industrial composting facilities.

Currently, to our knowledge no comprehensive database exists for composting facilities. With this said, EREF has an effort currently underway that aims to develop a reasonably complete facility list for composting facilities. However, the project is moving slowly and it will likely be 2020 before this list is available.

Response: EPA appreciates commenter's feedback on the current lack of a comprehensive database of composting facilities. EPA notes the work underway at EREF to develop a list of composting facilities. We look forward to reviewing that work, when it is complete, for potential incorporation into the subsequent Inventory report as appropriate.

Comment 49: Datasets Available on Industrial Composting Facilities.
Please comment on datasets available on industrial composting facilities.

We are not aware of a comprehensive list of all industrial composting facilities in the U.S. and U.S. territories; however, the US Composting Council (USCC) has a list of facilities. It is not complete as not all facilities in the US are members of USCC. https://compostingcouncil.org/participants/

Biocycle Magazine runs this listing site: http://findacomposter.com/

Response: EPA appreciates commenter's feedback on the current lack of a comprehensive database of composting facilities. EPA has reviewed the Biocycle Magazine listing site and has found it to be incomplete as the commenter noted.

Comment 50: Industrial Composting Datasets
[actually, a composting question…]"Please comment on datasets available on industrial composting facilities located in the U.S. territories of Puerto Rico, Guam, U.S. Virgin Islands, Northern Mariana Islands, and American Samoa. We are aware of composting facilities in Puerto Rico. In order to accurately estimate GHG emissions from these facilities, data are needed on the first year of operation, approximate annual quantities processed or number of households serviced, and whether the amount of waste composted is consistent from year to year. "

Other than composting information available in: Goldstein, N., C. Coker, and S. Brown. 2014. State of Composting in the U.S.: What, Why, Where & How. Washington, DC: Institute for Local Self-Reliance. I am not aware of any such datasets. As discussed in more detail below in comments pertaining to Question 2. below, apart from issues raised above regarding an improved methodology for landfill methane emissions, there is a critical need to NATIONALLY develop an improved, annually updated, statistically-astute database to track the various waste streams in the United States (source, physical and chemical characteristics, mass, treatment and/or disposal strategy, imports & exports). For several decades, the EPA methodology for tracking waste in the U.S. related back to a 1970's era "material flow model" first developed by Franklin & Associates. There wasn't any comprehensive publically-available updated information on this methodology beyond the first few years of its application—most certainly, societal "material flows" have varied greatly in the intervening years. Importantly, the reported EPA annual numbers for total U.S. waste or landfilled waste over a number of years using the "material flow" approach typically summed to considerably less [approx. 50-60%] than independent compilations by others, for example, 1) the discontinued historic Biocycle Magazine/Columbia Univ. "State of Garbage" reports using state-reported totals and, more recently, 2) Powell, J. et al., 2016, Estimates of solid waste disposal rates and reduction targets for landfill gas emissions. Nature Climate Change, Volume 6, Issue 2, pp. 162-165. Powell et al. summed reported GHGRP data specifically for landfilled waste, reporting on significantly higher totals than EPA's annual reporting.

As valid decisions going forward regarding waste management policy, practices, and regulations cannot be made without credible data, EPA should develop and maintain a comprehensive database on U.S. waste generation, transport, recycling/reuse, and disposal as part of general record-keeping for U.S. waste management practices. Coordinating this compilation with the various state agencies would be a useful first step; however, given the diversity of state practices and procedures, Federal oversight is greatly desirable for achieving a minimum compliance level for record-keeping across all the states. EPA is undoubtedly familiar with Eurostat—the statistics agency within the EU which, for waste, annually tracks a large number of waste streams for the EU countries (municipal, industrial, agricultural, mining, forestry, etc.). I would recommend emulating and, indeed, coordinating with Eurostat to similarly track U.S. waste. Further information can be obtained at:

https://ec.europa.eu/eurostat/web/waste/overview
https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics
https://ec.europa.eu/eurostat/web/environment/waste.

In general, the U.S. is at a disadvantage in this age of metadata because we lack a national statistics agency such as Eurostat.

Response: EPA appreciates commenter's feedback on the current lack of a comprehensive database of composting facilities and general lack of recordkeeping on waste management practices in the U.S. EPA has reviewed the Institute for Local Self-Reliance publication and has found it useful for certain information on state and municipal composting legislation and activities, but not as a comprehensive listing of facilities as would be needed to create a more detailed estimation of emissions from composting nationwide. We agree that a comprehensive database as outlined in the feedback would no doubt facilitate improving and updating these estimates for the Inventory, but note that initiating such an effort would not be justified for the Inventory alone and would involve budgetary decisions that go far beyond the scope of this report. At current activity levels, these emissions are 3% of the waste sector emissions. With existing resources, consistent with IPCC good practice, EPA needs to prioritize time and resources for future improvements on significant emission and removal categories (or key categories). Nevertheless, we will continue to review and incorporate the best available data in future reports given changing trends in this category.

Comment 51: Industrial Food Processing Waste Datasets
"Please comment on datasets that detail the quantities of industrial food processing waste that is disposed of in industrial waste landfills. The GHGRP dataset for industrial waste landfills includes select food processing facilities, however this dataset is not representative of the entire food processing sector. The Inventory methodology applies a disposal factor to the annual amount of foods processed. Currently, we do not have a representative data set for this sector with which to improve the methodology. "

I would recommend surveying major food processing companies and food technology consultants. The information you seek is not likely to be readily available and thus will require some EPA investment in time and resources to dig it out, organize it, and develop a strategy for annual updates. Therefore, it is highly recommended that food waste tracking be initiated for both "industrial" and "domestic" waste landfills. As above, I would highly recommend consulting existing Eurostat databases and emulating the Eurostat system for the U.S. going forward to includes multiple types of industrial, agricultural, forestry, domestic, construction/building and other waste streams. That would insure compatibility across much of the developed world with regard to waste statistics.

Response: EPA appreciates commenter's feedback on lack of available data on industrial food processing waste and agrees that obtaining this data would require significant resources and effort.

Comment 52: Generation and Disposal Data: States and Municipalities Composting
Page 7-34, lines 20-31- this paragraph doesn't mention the rise of states and municipalities composting food waste and the handful of bans that address specifically that. It focuses on yard waste, but it seems like it should at least mention the rise of food waste composting. (CB)

Response: EPA notes commenter's suggestion to add information about food waste composting trends and state and municipal bans on food waste disposal also influencing those trends. EPA will

add text regarding these trends in subsequent Inventory reports as applicable to describe related GHG-emissions trends.

Comment 53: Planned Improvements for Composting
Page 7-36, in the Planned Improvements section (for composting), they discuss wanting to collect more information on composting including quantity of waste composted, households served, etc. I think we could point them to some existing and soon to be released resources that would help. Happy to put that together or just call the appropriate person in OAR to discuss. (CB)

Response: EPA appreciates commenter's offer to provide resources on composting and will contact the commenter to obtain this information.

Comment 54: Generation and Disposal Data: Composted Waste Data Source
On page 7-34, line 9, it says from 1990 to 2017 the amount composted in the US went from 3,810 kt to 21,333 kt. What is the source of this data? (HP)

Response: As stated in the Methodology section of Section 7.3 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017, "estimates of the quantity of waste composted (M) are presented in Table 7-20*Error! Reference source not found.* ***for select years. Estimates of the quantity composted for 1990, 2005, 2010, and 2014 to 2015 were taken from EPA's Advancing Sustainable Materials Management: Facts and Figures 2015 (EPA 2018); the estimate of the quantity composted for 2012 to 2013 was taken from EPA's Advancing Sustainable Materials Management: Facts and Figures 2014 report; the estimate of the quantity composted for 2011 was taken from EPA's Municipal Solid Waste In The United States: 2012 Facts and Figures (EPA 2014); estimates of the quantity composted for 2016 and 2017 were extrapolated using the 2015 quantity composted and a ratio of the U.S. population growth between 2015 and 2016, and 2016 to 2017 (U.S. Census Bureau 2016, 2017, and 2018)."***

Appendix A: List of Reviewers and Commenters

EPA distributed the expert review chapters of the draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017* to a list of 326 expert reviewers across all sectors of the Inventory. The list below includes names of those expert reviewers who submitted comments as part of the Expert Review Period.

- Marci Baranski - United States Department of Agriculture (USDA), Office of the Chief Economist
- Jean Bogner - University of Illinois at Chicago - Dept. of Earth & Environmental Sciences
- Amy Van Kolken Banister - Waste Management, Republic Services, National Waste & Recycling Association, Solid Waste Association of North America, SCS Engineers, and Weaver Consulting Group
- Kerry Kelly - Waste Management, Republic Services, National Waste & Recycling Association Solid Waste Association of North America, SCS Engineers, and Weaver Consulting Group
- Barry Malmberg - National Council for Air and Stream Improvement, Inc.
- Bryan Staley - Environmental Research & Education Foundation
- Debra Kantner - Environmental Research & Education Foundation
- U.S. EPA's Office of Resource Conservation and Recovery
- Kate Zook - USDA Office of Energy and Environmental Policy
- G. Philip Robertson - Michigan State University - Dept. of Plant, Soil and Microbial Sciences & W.K. Kellogg Biological Station
- Richard A. Kohn - University of Maryland
- David W. Cooke, Ph.D.- Senior Vehicles Analyst, Union of Concerned Scientists
- Hendrik van Oss – (Retired) United States Geological Survey, National Minerals Information Center

Note: Names of commenters are listed in no particular order.

Appendix B: Dates of review

- Agriculture, Energy, Industrial Processes and Product Use (IPPU), and Waste: October 16 – November 14, 2018
- Land Use, Land Use Change and Forestry (LULUCF): November 9 – December 3, 2018

Appendix C: EPA Charge Questions to Expert Reviewers

To facilitate expert review and indicate where input would be helpful, the EPA included charge questions for the Expert Review Period of the draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017* report. EPA also noted to expert reviewers that while these charge questions were designed to assist in conducting a more targeted expert review, comments outside of the charge questions were also welcome. Included below is a list of the charge questions by Inventory chapter.

Energy

General Questions:

1. Please provide your overall impressions of the clarity and transparency of the Energy chapter.
2. Please provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the Energy chapter.

Source Specific Questions:

Fossil Fuel Combustion: CO_2 from Fossil Fuel Combustion

1. Please provide your overall impressions of the clarity of the discussion on trends in CO_2 emissions from fossil fuel combustion. Please provide recommendations for any information that could be added to the discussion to provide additional transparency and clarity.
2. Data for energy use in U.S. Territories comes from the International Energy Statistics provided by EIA. This source has data only through 2014, the years 2015 through 2017 are proxies. Are there other sources of U.S. Territory energy use that could be used?
3. Facility-level combustion emissions data from EPA's GHGRP are currently used to help describe the changes in the industrial sector. Are there other ways in which the GHGRP data could be used to help better characterize the industrial sector's energy use? Are there ways the industrial sector's emissions could be better classified by industrial economic activity type?

Fossil Fuel Combustion: CH_4 and N_2O from Stationary Combustion

1. The CH_4 and N_2O emission factors for electric power sector are based on a Tier 2 methodology, whereas all other sectors utilize a Tier 1 methodology. The emission factors are primarily taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Are there other more U.S.-specific CH_4 and N_2O emission factor data sources that could be utilized, especially for natural gas combustion sources?

Carbon Emitted from Non-Energy Uses of Fossil Fuels

1. Please provide your overall impressions of the clarity of the discussion on Carbon Emitted from Non-Energy Uses of Fossil Fuels. Please provide recommendations for any information that could be added to the discussion to provide additional transparency and clarity, especially in regards to links with the IPPU chapter.

Mobile Sources

1. Please provide your overall impressions of the clarity and transparency of the proposed mobile source updates.

2. Please provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the proposed mobile source updates.

Methodology for Estimating Electricity Use by On-Highway Electric Vehicles

Previous versions of the Inventory allocated electricity use, and associated emissions, between economic sectors based on electricity sales data provided by the industry through U.S. Energy Information Administration (EIA) reports. The data for electricity used in the Transportation Sector only includes electricity used for railroads and railways. Electricity used to charge electric vehicles currently fall under the Residential and Commercial Sectors associated with home and public charging stations. Due to the increasing numbers of electric vehicles (EVs) in the United States, EPA has developed a method to estimate the portion of total electricity used to charge electric vehicles, and to re-allocate that portion of electricity and emissions from the Residential and Commercial Sectors of the Inventory to the Transportation Sector. The proposed methodology would not impact total electricity production or emissions; only the allocation of electricity across the Transportation, Residential, and Commercial Sectors is impacted.

1. The proposed update uses monthly vehicle sales data to estimate nation-wide populations of BEV and PHEV vehicles. Fleet data from EIA are used to estimate populations of neighborhood electric vehicles and electric buses. Are there other population data sources EPA should consider for this update?
2. The outlined methodology uses FHWA Highway Statistics' "Average miles traveled per vehicle" to estimate annual vehicle miles traveled (VMT) by BEVs and PHEVs. This average – around 11,300 miles per vehicle in 2015 and 2016 – includes vehicles of all fuel types (e.g., gasoline, diesel, electricity, compressed natural gas, propane). Is it reasonable to apply this annual VMT statistics to electric vehicles? Are there other data sources which could be used to derive annual VMT by BEVs and PHEVs?
3. The proposed update requires reallocating emissions from the Residential and Commercial Sectors of the Inventory into the Transportation Sector. EPA has used an 85% residential/15% commercial split based on a technical report from Idaho National Laboratory to reassign these emissions. Is this a reasonable split of the emissions? Are there other studies on the location of charging EVs?

Industrial Processes and Product Use (IPPU)

***General Questions*:**

1. Please provide your overall impressions of the transparency of the IPPU chapter.
2. Please provide any recommendations of improvements that EPA can consider to improve the completeness and/or accuracy of the IPPU chapter.
3. For the source categories included in the expert review draft, is the state of the industry current and accurately described? Are there technologies, practices, or trends that EPA should consider?

***Source Specific Questions*:**

Minerals Production

1. **Other process uses of carbonates -** Please provide input on:
    - Data on carbonate use in non-metallurgical magnesium production.
    - Data on carbonate use in the production of ceramics.

Chemicals Production

2. **Caprolactam, Glyoxal and Glyoxylic Acid Production** - With the inclusion of this new IPPU source category as of last Inventory, EPA requests feedback on the overall chapter text, assumptions and information on the state of the industry.
3. **Calcium Carbide Production** - Please provide input on data sources and industry information on production to estimate emissions using IPCC methods.

Metals Production

4. The EPA seeks comments on assumptions applied to determine the split between primary and secondary zinc production based on U.S. Geological Survey national totals. Are other options/data sources available to distinguish between process production totals?

Other IPPU Categories

5. **N_2O Product Use** - Please provide input on recent/alternative production statistics for various N_2O product use subcategories listed within the Nitrous Oxide from Product Uses source chapter.
6. **ODS Substitutes -** The EPA seeks comments on possible sources of hydrofluorocarbon (HFC) use that are not reflected, or whose use is modeled lower than actual, as evident from a comparison of the underlying model with data reported under EPA's Greenhouse Gas Reporting Program (GHGRP).
7. **Semiconductor Manufacturing -** In addition to general comments on the semiconductor inventory, EPA is specifically seeking input on the items outlined below, which discuss recent methodological changes in the inventory to account for:

   i. Emissions from the non-reporting population.
   ii. Changes in the Subpart I emission factors and default destruction or removal efficiencies between the 2013 and 2014 reporting years.

More details on the targeted semiconductor manufacturing specific feedback are included below.

Semiconductor Manufacturing Targeted Feedback

7.i) Input on Estimating emissions from the non-reporting population of the semiconductor industry.
In 2017, EPA developed a new approach for estimating emissions for the segment of the semiconductor industry that does not report through EPA's GHGRP, Subpart I (Electronic Manufacturing) for the 1990-2016 Inventory. This same method has also been applied in the 1990-2017 Inventory. This approach is described in the accompanying Semiconductor Inventory Chapter text. In addition to seeking experts' comment on the approach, EPA is requesting feedback on the following:

7.i.1. Method for Development of Emission Factors for Non-GHGRP Reporting U.S. Semiconductor Population.
EPA develops emission factors using emissions data reported from the GHGRP (Subpart I); information on the use of abatement from the GHGRP (Subpart I); and activity data (substrate area and manufactured layers) from the World Fab Forecast, Census Bureau[1], and the *International Technology*

[1] United States Census Bureau (USCB) *Historical Data: Quarterly Survey of Plant Capacity Utilization*. Available online at: <https://www.census.gov/manufacturing/capacity/historical_data/index.html>.

Roadmap for Semiconductors. With this information EPA develops emission factors in the units of emissions per total manufactured layer area (TMLA), for each year, for both 200 mm and 300 mm wafer sizes, for each fluorinated greenhouse gas (F-GHG) and N_2O. EPA is considering one of the following two approaches to develop these emission factors:

- Approach 1 - Weighted averages (by wafer size, year, and gas type), calculated as total emissions divided by total TMLA (currently used for 2015 and 2016); or
- Approach 2 - Regression analyses (by wafer size, year, and gas type), based on a regression through the origin analysis.
    a. Which approach would semiconductor manufacturing experts suggest using to calculate emission factors? Alternatives?
    b. Do you agree that the best approach to developing emission factors is based on wafer size as opposed to other characteristics such as substrate type?

7.i.2. Data Sources for Development of Emission Factors for Non-GHGRP Reporting U.S. Semiconductor Population.

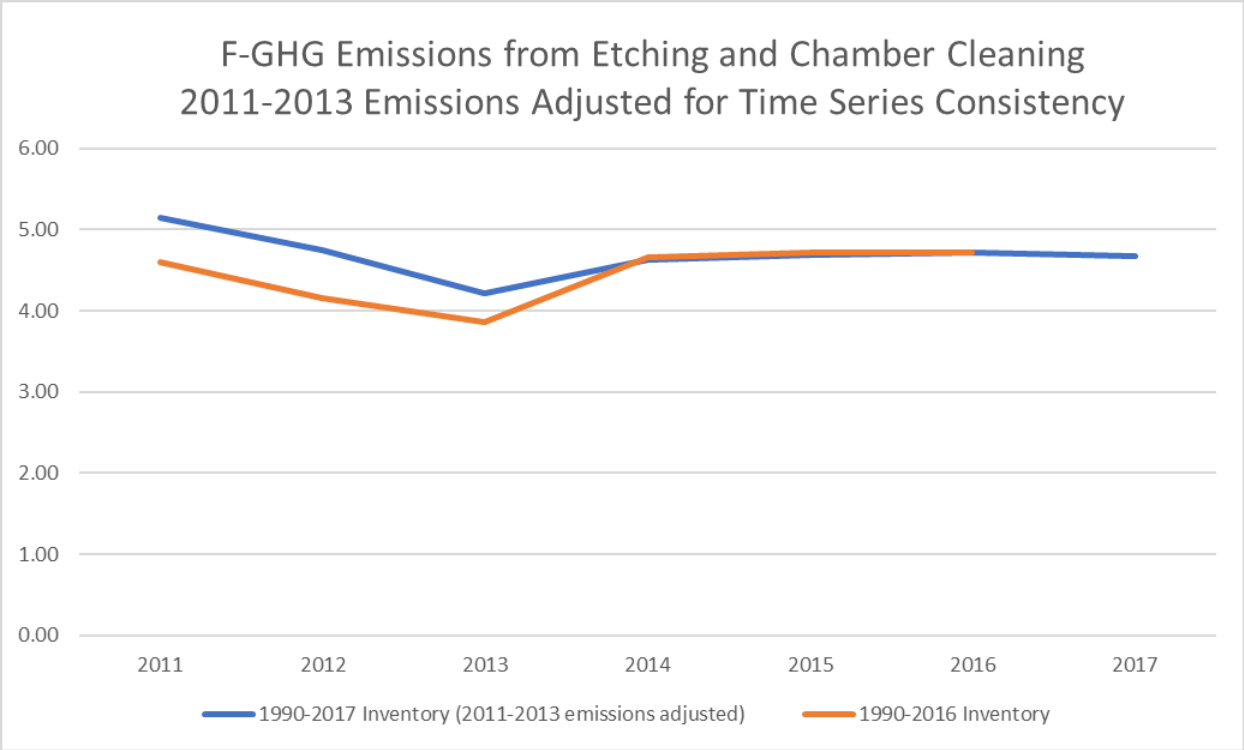
EPA relies on the number of layers by nodes defined in the Technology Roadmap to estimate TMLA. The number of layers currently used in the inventory are from the tables supporting the most recently available roadmap (2015).[2]

a. Please provide feedback on whether these numbers are accurate, or whether they should be adjusted? If they should be adjusted, how would you suggest adjusting them?

7.ii) Addressing time series consistency issues with the Subpart I emission factors and default destruction or removal efficiencies.

Changes to the default emission factors and default destruction or removal efficiencies (DREs) used for GHGRP reporting affected the apparent emissions trend between 2013 and 2014. These changes did not reflect actual emission rate changes but data improvements. Therefore, for the Expert Review Draft of the 1990-2017 Inventory, EPA adjusted the time series of GHGRP-reported data for 2011 through 2013 to ensure time-series consistency using a series of calculations that took into account the characteristics of a facility (e.g., wafer size and abatement use). This approach is described in the accompanying Semiconductor Inventory Chapter text. The graph below compares the adjusted time series from the Expert Review Draft of the 1990-2017 Inventory to the unadjusted time series from the 1990-2016 GHG Inventory.

[2] https://www.dropbox.com/sh/3jfh5fq634b5yqu/AAD7uR0pBadu8-bsMAlN9TQUa/2015%20ITRS%202.0%20FT%20TABLES?dl=0&subfolder_nav_tracking=1



In addition to seeking experts' comment on the approach, EPA has the following specific questions:

a. Would you suggest any adjustments to the assumed site-specific DREs used in the readjustment calculations?

EPA assumed site-specific DREs were as follows:

Gas	Process Type	Assumed Site-Specific DRE
CF4	Etch	90%
All Other Gases	Etch	98%
NF3	Clean	95%
CF4	Clean	80%
All Other Gases	Clean	80%

b. Do expert reviewers have suggestions for alternative approaches for adjusting 2011-2013 emissions for fabs and facilities which abate and report to the GHGRP? Specifically, EPA is seeking feedback on the amounts of gas assumed to be abated in the adjustment analysis as well as the use of the fab-wide DRE from 2014 to aid in the adjustment calculations for 2011-2013. EPA can provide fab or facility-specific data to help aid in reviews if requested. As a reminder:

- To adjust emissions for facilities that abated emissions in 2011 through 2013, EPA first calculated the quantity of gas abated in 2014 using reported F-GHG emissions, the revised default DREs (or the estimated site-specific DRE, if a site-specific DRE was indicated), and the fab-wide DREs reported in 2014.
- EPA then estimated the quantity of NF_3 abated for remote plasma clean in 2014 using the

ratio of emissions reported for CF_4 (which is not abated) and NF_3. This abated quantity was then subtracted from the total abated quantity calculated above.
    - To account for the resulting remaining abated quantity, EPA assumed that the percentage of gas passing through abatement systems was the same across all remaining gas and process type combinations where abatement was reported for 2014.
    - The percentage of gas abated was then assumed to be the same in 2011-2013 (if the facility claimed abatement that year) as in 2014 for each gas abated in 2014.

c. For facilities that have more than one fab, do expert reviewers have suggestions on how to calculate facility-wide DREs from the fab-wide DREs reported for 2014? (Emissions and other parameters were only reported at the facility level before 2014). We currently use the straight average of the fab-wide DREs.
d. For fabs that have multiple wafer sizes in the same fab, do expert reviewers have suggestions on how we should allocate emissions to each wafer size? We assumed that emissions were split 50/50 if there was no other information to go on. Note that in general, the time series adjustment *decreases* 2011-2013 estimated emissions for 300-mm fabs while it *increases* 2011-2013 estimated emissions for 200-mm fabs.
e. If possible, EPA would appreciate it if experts could share data to support their comments on how the changes in emission factors and DREs between the 2013 and 2014 GHGRP reporting years impacted GHG emissions, and/or any data to help support comments and feedback on EPA's proposed method for adjusting GHGRP emissions from 2011-2013.

Agriculture

***General Questions*:**

1. Provide your overall impressions of the clarity and transparency of the Agriculture chapter.
2. Provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the Agriculture chapter.
3. Provide feedback on the methodologies, assumptions and activity data used to estimate emissions for categories within the Agriculture chapter.

Source Specific Questions:

1. For the Manure Management source category, is the state of the industry current accurately described? Are there other technologies, practices, trends that we should consider?
2. Are the parameters and discussion of uncertainty within the Manure Management source category estimates adequately reflecting all uncertainties from this industry and the data EPA is currently using?
3. The Manure Management source category relies on national/regional livestock production and management data for calculating emissions estimates from USDA APHIS and NASS. Are there other/newer data sources that EPA should be aware of and consider in the calculating these emissions? Especially for:
    - Waste management system data, particularly seasonal changes in emissions from different WMS
    - Maximum methane producing capacity
    - Volatile solids and nitrogen excretion rates
    - Measured emission estimates (by waste management system) to help refine estimates of methane conversion factors
4. For the Enteric Fermentation source category, is the state of the industry current and accurately

described? Are there other technologies, practices, trends that we should consider?

5. The Enteric Fermentation source category relies on national/regional livestock production, diet and management data for calculating emissions estimates. Are there other/newer data sources or methods that EPA should be aware of and consider in the calculating these emissions? Especially for:
    - Dry matter/gross energy intake
    - Annual data for the DE, Y_m, and crude protein values of specific diet and feed components for foraging and feedlot animals
    - Monthly beef births and beef cow lactation rates
    - Weights and weight gains for beef and dairy cattle

6. For the Enteric Fermentation source category and the Cattle Enteric Fermentation Model (CEFM), are the various regional designations of U.S. states (as presented in Annex 3.10) used for characterizing the diets of foraging cattle appropriate? The CEFM is used to estimate cattle CH_4 emissions from enteric fermentation, and incorporates information on livestock population, feeding practices, and production characteristics.

Land Use, Land-Use Change, and Forestry (LULUCF)

General Questions:

1. Provide your overall impressions of the clarity and transparency of the categories provided in the LULUCF chapter.
2. Provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the LULUCF chapter.
3. Provide feedback on the methodologies and activity data used to estimate emissions for categories within the LULUCF chapter.

Category Specific Questions:

1. For Forest Land Remaining Forest Land category, are the methods used to estimate carbon stock changes on forest lands in interior Alaska as well as the new state-level methodology used to estimate carbon stock changes on forest lands in western states appropriate and clearly described?
2. For Settlement Trees (formerly Urban Trees), is the new approach using the settlement area from the land representation in the GHG Inventory and percent tree cover applied to developed land from NLCD an appropriate methodology and clearly described?
3. For the Yard Trimmings and Food Scraps category, is the state of the industry current and accurately described? Are there other technologies, practices, trends that we should consider?
4. For the Yard Trimmings and Food Scraps category, are there other data sources that EPA should be aware of and consider in the calculating these emissions? Especially for:
    - C storage, decay rates, etc. for yard trimmings and food scraps
    - Decay rates of food scraps, leaves, grass, and branches
    - National yard waste compositions
    - Precipitation range percentages for populations for the decay rate sensitivity analysis

Waste

General Questions:

1. Please provide your overall impressions of the clarity and transparency of the Waste chapter.
2. Please provide any recommendations that EPA can consider to improve the completeness and/or accuracy of the Waste chapter.

Source Specific Questions:

<u>Wastewater</u>

1. The wastewater source category relies on national production data from a variety of sources for calculating emissions estimates. Are there other data sources that EPA should be aware of and consider in the emissions calculations of this source?
2. Please provide input on any additional sources of wastewater outflow or BOD production that we may not consider in our industrial methane emissions calculations. Do our estimates of the percent of wastewater treated anaerobically seem reasonable?
3. For domestic wastewater emissions, please provide input on:
    a. Any additional sources for the N content of sludge, amount of sludge produced, and sludge disposal practices.
    b. National Level data on the type of wastewater treatment systems in operation,
    c. National level data on the biogas generations and recovery operations,
    d. The estimates of the percent of BOD removed by aerobic, anaerobic, and other treatment systems for our methane estimates,
    e. The protein estimates and overall calculations for nitrous oxide. For example, do you have suggestions for developing a country-specific factor, rather than the IPCC default factor, to estimate the amount of nitrogen from industrial and commercial sources co-treated with domestic wastewater? and
    f. Sources of data for development of a country-specific methodology for N_2O emissions associated with on-site industrial wastewater treatment operations, including the appropriateness of using IPCC's default factor for domestic wastewater (0.005 kg N_2O-N/kg N).
4. Are there additional industries that are sources of methane or nitrous oxide emissions that should be included in the wastewater inventory? Are there available sources of national-level data for these industries?
5. Do you have suggestions for improving the discussion of our methodology? Is there any additional information that should be included to provide additional transparency?
6. Is the state of domestic and industrial wastewater treatment current and accurately described?

<u>Landfill Specific</u>

1. Please comment on datasets available on industrial composting facilities located in the U.S. territories of Puerto Rico, Guam, U.S. Virgin Islands, Northern Mariana Islands, and American Samoa. We are aware of composting facilities in Puerto Rico. In order to accurately estimate GHG emissions from these facilities data is needed on the first year of operation, approximate annual quantities processed or number of households serviced, and whether the amount of waste composted is consistent from year to year.
2. Please comment on datasets that detail the quantities of industrial food processing waste that is disposed of in industrial waste landfills. The GHGRP dataset for industrial waste landfills includes select food processing facilities, however this dataset is not representative of the entire food processing sector. The Inventory methodology applies a disposal factor to the annual amount of foods processed. Currently, we do not have a representative data set for this sector with which to improve the methodology.
3. A comprehensive Internet search by state was conducted to identify waste characterization studies published as of July 2018. We plan to conduct analyses to generate DOC values specific to the time frame of 1990 to 2004. This time frame is specified because the Inventory uses directly reported

GHGRP net emissions, which incorporate the DOC values allowed under the rule, in years beyond 2004. Please comment and provide information on any additional studies that have not been published on the Internet from 1990 to date that may further these efforts.

4. An analysis is being conducted on decay rate values reported by developed countries (e.g. UNFCCC Annex 1 countries) in their annual National Inventory Reports, as well as decay rate values used as defaults in first order decay models, as compared to the U.S. Greenhouse Gas Inventory defaults used in the U.S. Waste model. This analysis is specific to the 1990 to 2004 time frame, because the Inventory uses directly reported GHGRP net emissions, which incorporate the decay rate values allowed under the rule, for years beyond 2004. Please comment and provide information on any additional studies and models that have not been published on the Internet from 1990 to date if any stakeholders have this information available to share.