

ANNEX 8 QA/QC Procedures

8.1. Background

The purpose of this annex is to describe the Quality Assurance/Quality Control (QA/QC) procedures and information quality considerations that are used throughout the process of creating and compiling the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. This includes the evaluation of the quality and relevance of data and models used as inputs into the Inventory; proper management, incorporation, and aggregation of data; and review of the numbers and estimates to ensure that they are as accurate and transparent as possible. Quality control—in the form of both good practices (such as documentation procedures) and checks on whether good practices and procedures are being followed—is applied at every stage of inventory development and document preparation. In addition, quality assurance occurs at two stages—an expert review and a public review. While both phases can significantly contribute to the quality of the Inventory, the public review phase is also essential for promoting the openness of the Inventory development process and the transparency of the inventory data and methods. As described in respective source category text, comments received from these reviews may also result in updates or changes to continue to improve inventory quality.

8.2. Purpose

The *Quality Assurance/Quality Control and Uncertainty Management Plan for the U.S. Greenhouse Gas Inventory* (QA/QC Management Plan) guides the process of ensuring the quality of the Inventory. The QA/QC Management Plan describes data and methodology checks, develops processes governing peer review and public comments, and provides guidance on conducting an analysis of the uncertainty surrounding the emission estimates. The QA/QC Management Plan procedures also stress continual improvement, providing for corrective actions that are designed to improve the inventory estimates over time.

Key attributes of the QA/QC Management Plan are summarized in Figure A-21. These attributes include:

- *Procedures and Forms*: detailed and specific systems that serve to standardize the process of documenting and archiving information, as well as to guide the implementation of QA/QC and the analysis of uncertainty.
- *Implementation of Procedures*: application of QA/QC procedures throughout the whole Inventory development process from initial data collection, through preparation of the emission estimates, to publication of the Inventory.
- *Quality Assurance*: expert and public reviews for both the Inventory estimates and the report (which is the primary vehicle for disseminating the results of the Inventory development process). The expert technical review conducted by the UNFCCC supplements these QA processes, consistent with the QA good practice and the *2006 IPCC Guidelines* (IPCC 2006).
- *Quality Control*: application of *General (Tier 1) and Category-specific (Tier 2)* quality controls and checks, as recommended by *2006 IPCC Guidelines* (IPCC 2006), along with consideration of secondary data and category-specific checks (additional Tier 2 QC) in parallel, and coordination with the uncertainty assessment; the development of protocols and templates, which provide for more structured communication and integration with the suppliers of secondary information.
- *Record Keeping*: provisions to track which procedures have been followed, the results of the QA/QC process, uncertainty analysis, and feedback mechanisms for corrective action based on the results of the investigations, which provide for continual data quality improvement and guided research efforts.
- *Multi-Year Implementation*: a schedule for coordinating the application of QA/QC procedures across multiple years, especially for category-specific QC, focusing on key categories.
- *Interaction and Coordination*: promoting communication within the EPA, across Federal agencies and departments, state government programs, and research institutions and consulting firms involved in supplying data or preparing estimates for the Inventory. The QA/QC Management Plan itself is intended to be revised to reflect new information that becomes available as the program develops, methods are improved, or additional

supporting documents become necessary. Further information on verification will be included in future submissions.

In addition, based on the national QA/QC Management Plan for the Inventory, source and sink-specific QA/QC plans have been developed for a number of sources and sinks. These plans follow the procedures outlined in the national QA/QC plan, tailoring the procedures to the specific text and spreadsheets of the individual sources. For each greenhouse gas emissions source or sink included in this Inventory, minimum general QA/QC analysis consistent with Vol. 1, Chapter 6 of the *2006 IPCC Guidelines* has been undertaken. Where QA/QC activities for a particular source or sink category go beyond the general level, and include category-specific checks, further explanation is provided within the respective category text. Similarly, responses or updates based on comments from the expert, public and the international technical expert reviews (e.g., UNFCCC) are also addressed within the respective source or sink category text. For transparency, responses to public and expert review comments are also posted on the EPA website with the final report.

Figure A-21: U.S. QA/QC Plan Summary

	Data Gathering	Data Documentation	Calculating Emissions	Cross-Cutting Coordination
Inventory Analyst	- Obtain data in electronic format (if possible) - Review spreadsheet construction - Avoid hardwiring - Use data validation - Protect cells - Develop automatic checkers for: - Outliers, negative values, or missing data - Variable types match values - Time series consistency - Maintain tracking tab for status of gathering efforts	- Contact reports for non-electronic communications - Provide cell references for primary data elements - Obtain copies of all data sources - List and location of any working/external spreadsheets - Document assumptions - Complete QA/QC checklists - CRF and summary tab links	- Clearly label parameters, units, and conversion factors - Review spreadsheet integrity - Equations - Units - Inputs and outputs - Develop automated checkers for: - Input ranges - Calculations - Emission aggregation - Trend and IEF checks	- Common starting versions for each inventory year - Utilize unalterable summary and CRF tab for each source spreadsheet for linking to a master summary spreadsheet - Follow strict version control procedures - Document QA/QC procedures
QA/QC Analyst	- Check input data for transcription errors - Inspect automatic checkers - Identify spreadsheet modifications that could provide additional QA/QC checks	- Check citations in spreadsheet and text for accuracy and style - Check reference docket for new citations - Review documentation for any data / methodology changes - Complete QA/QC checklists - CRF and summary tab links	- Reproduce calculations - Review time series consistency - Review changes in data/consistency with IPCC methodology	

8.3. Assessment Factors

The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* development process follows guidance outlined in EPA's *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by the Environmental Protection Agency*¹⁶⁶ and *A Summary of General Assessment Factors for Evaluating the Quality of*

¹⁶⁶ EPA report #260R-02-008, October 2002, Available online at <<http://www.epa.gov/quality/guidelines-ensuring-and-maximizing-quality-objectivity-utility-and-integrity-information>>.

*Scientific and Technical Information.*¹⁶⁷ This includes evaluating the data and models used as inputs into the Inventory against the five general assessment factors: soundness, applicability and utility, clarity and completeness, uncertainty and variability, evaluation and review. Table A-256 defines each factor and explains how it was considered during the process of creating the current Inventory.

Table A-256: Assessment Factors and Definitions

General Assessment Factor	Definition	How the Factor was Considered
Soundness (AF1)	The extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with their intended application.	The underlying data, methodologies, and models used to generate the <i>Inventory of U.S. Greenhouse Gas Emissions and Sinks</i> are reasonable for and consistent with their intended application, to provide information regarding all sources and sinks of greenhouse gases in the United States for the Inventory year, as required per UNFCCC Annex I country reporting requirements. The U.S. emissions calculations follow the <i>2006 IPCC Guidelines</i> developed specifically for UNFCCC inventory reporting. They are based on the best available, peer-reviewed scientific information, and have been used by the international community for over 25 years. When possible, Tier 2 and Tier 3 methodologies from the <i>2006 IPCC Guidelines</i> are applied to calculate U.S. emissions more accurately.
Applicability and Utility (AF2)	The extent to which the information is relevant for the Agency's intended use.	The Inventory's underlying data, methodology, and models are relevant for their intended application because they generate the sector-specific greenhouse gas emissions trends necessary for assessing and understanding all sources and sinks of greenhouse gases in the United States for the Inventory year. They are relevant for communicating U.S. emissions information to domestic audiences, and they are consistent with the <i>2006 IPCC Guidelines</i> developed specifically for UNFCCC reporting purposes of international greenhouse gas inventories.
Clarity and Completeness (AF3)	The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyzes employed to generate the information are documented.	The methodological and calculation approaches applied to generate the <i>Inventory of U.S. Greenhouse Gas Emissions and Sinks</i> are extensively documented in the <i>2006 IPCC Guidelines</i> . The Inventory report describes its adherence to the <i>2006 IPCC Guidelines</i> , and the U.S. Government agencies provide data to implement the <i>2006 IPCC Guidelines</i> approaches. Any changes made to calculations, due to updated data and methods, are explained and documented in the report consistent with UNFCCC reporting guidelines.
Uncertainty and Variability (AF4)	The extent to which the variability and uncertainty	The evaluation of uncertainties for underlying data is documented in the Annex 7 Uncertainty to the <i>Inventory of</i>

¹⁶⁷ EPA report #100/B-03/001, June 2003, Available online at <<http://www.epa.gov/risk/guidance-evaluating-and-documenting-quality-existing-scientific-and-technical-information>>, and Addendum to: A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information, December 2012, Available online at <<http://www.epa.gov/risk/summary-general-assessment-factors-evaluating-quality-scientific-and-technical-information>>.

	(quantitative and qualitative) in the information or in the procedures, measures, methods or models are evaluated and characterized.	<i>U.S. Greenhouse Gas Emissions and Sinks</i> . In accordance with the 2006 IPCC Guidelines, the uncertainty associated with the Inventory's underlying input data was evaluated by running a Monte Carlo uncertainty analysis on most source and/or category emissions data to produce a 95 percent confidence interval for the annual greenhouse gas emissions for that source and/or sink. The error propagation approach is used to quantify uncertainties for some categories that are not significant contributors to emissions across the time series. To develop overall uncertainty estimates, the Monte Carlo simulation output data for each emission source and/or sink category uncertainty analysis were combined by type of gas, and the probability distributions were fitted to the combined simulation output data where such simulated output data were available.
Evaluation and Review (AF5)	The extent of independent verification, validation and peer review of the information or of the procedures, measures, methods or models.	The majority of the underlying methodology, calculations, and models used to generate the <i>Inventory of U.S. Greenhouse Gas Emissions and Sinks</i> have been independently verified and peer reviewed as part of their publication in the 2006 IPCC Guidelines and the 2019 Refinement. In cases where the methodology differs slightly from the 2006 IPCC Guidelines, these were independently verified and validated by technical experts during the annual expert review phase of the Inventory development process. For the data used in calculating greenhouse gas emissions for each source, multiple levels of evaluation and review occur. Data are compared to results from previous years, and calculations and equations are continually evaluated and updated as appropriate. Throughout the process, inventory data and methodological improvements are planned and incorporated. The Inventory undergoes annual cycles of expert and public review before publication. This process ensures that both experts and the general public can review each category of emissions and sinks and have an extended opportunity to provide feedback on the methodologies used, calculations, data sources, and presentation of information.

8.4. Responses to Review Processes

EPA is continually working to improve transparency, accuracy, completeness, comparability, and consistency of emission estimates in the Inventory in response to the feedback received during the Expert, Public, and UNFCCC Review periods, as well as supplemental stakeholder outreach efforts. For instance, as mentioned in the Planned Improvements section of the Petroleum and Natural Gas Systems source categories (Section 3.6 and 3.7), EPA has engaged in stakeholder outreach to increase the transparency in the Inventory methodology and to identify supplemental data sources that can lead to methodological improvements. During the annual preparation of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, in considering and prioritizing improvements, EPA reviews the significance of the

source and sink category (i.e., key categories), along with QC, QA, and uncertainty assessments. Identified planned improvements to methods (including data, emissions factors, and other key parameters), along with QA/QC and uncertainty assessments are documented within each source and sink category to complement the Recalculations and Improvements chapter. Additionally, the Executive Summary also highlights key changes in methodologies from previous Inventory reports.

As noted in the previous section, for transparency, responses to comments received while developing the annual estimates from Public Review and Expert Review are posted on the EPA website with the final Inventory.¹⁶⁸

As noted above in section 8.2, the expert technical review conducted by the UNFCCC supplements these QA processes. This review by an international expert review team (ERT) occurs after submission of the final report to the UNFCCC and assesses consistency with UNFCCC reporting guidelines. More information on the UNFCCC reporting guidelines and the review process can be found here:

- UNFCCC Reporting Guidelines for annual national greenhouse gas inventories¹⁶⁹
- UNFCCC Review Process and Guidelines for annual national greenhouse gas inventories¹⁷⁰
- Inventory Review reports of annual submissions (latest reviews).¹⁷¹

The final annual review report with findings from the UNFCCC expert review of the April 2020 Inventory submission conducted on November 2-7, 2020 was not received at the time of publication of this report. EPA was unable to provide accurate responses on how the latest ERT recommendations have been reflected in this Inventory (i.e., to be submitted to UNFCCC in April 2021) as the draft annual review report was only received for review on April 7, 2021 as this report was being finalized for submission. Following receipt of the final review report from the UNFCCC ERT, this Annex will be updated to include a table indicating status areas of improvement identified through UN review to facilitate future reviews. The updated Annex will be posted on EPA's website.¹⁷²

¹⁶⁸ See <<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>>.

¹⁶⁹ Available online at: <<https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2>>.

¹⁷⁰ Available online at: <<https://unfccc.int/resource/docs/2014/cop20/eng/10a03.pdf#page=3>>.

¹⁷¹ Available online at: <<https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/inventory-review-reports-2019>>.

¹⁷² See <<https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2019>>.