Annexes to the Inventory of U.S. GHG Emissions and Sinks

The following nine annexes provide additional information related to the material presented in the main body of this report as directed in the *UNFCCC Guidelines on Reporting and Review* (UNFCCC 2014). Annex I contains an analysis of the key categories of emissions discussed in this report and a review of the methodology used to identify those key categories. Annex 2 describes the methodologies used to estimate CO_2 emissions from fossil fuel combustion, the carbon content of fossil fuels, and the amount of carbon stored in products from non-energy uses of fossil fuels. Annex 3 discusses the methodologies used for a number of individual source categories in greater detail than was presented in the main body of the report and includes explicit activity data and emission factor tables. Annex 4 presents the IPCC reference approach for estimating CO_2 emissions from fossil fuel combustion. Annex 5 addresses the criteria for the inclusion of an emission source or sink category and discusses some of the sources that are excluded from U.S. estimates. Annex 6 provides a range of additional information that is relevant to the contents of this report. Annex 7 provides data on the uncertainty of the emission estimates included in this report. Annex 8 provides information on the QA/QC methods and procedures used in the development of the Inventory, including responses to UNFCCC reviews. Finally, Annex 9 provides an overview of GHGRP data use in the Inventory.

Annexes to the Inventory of U.S. GHG Emissions and Sinks 1
ANNEX 1 Key Category Analysis 3
ANNEX 2 Methodology and Data for Estimating CO_2 Emissions from Fossil Fuel Combustion 62
2.1. Methodology for Estimating Emissions of CO_2 from Fossil Fuel Combustion 62
2.2. Methodology for Estimating the Carbon Content of Fossil Fuels 88
2.3. Methodology for Estimating Carbon Emitted from Non-Energy Uses of Fossil Fuels 129
ANNEX 3 Methodological Descriptions for Additional Source or Sink Categories 159
3.1. Methodology for Estimating Emissions of CH_4, N_2O, and Indirect Greenhouse Gases from Stationary Combustion 159
3.2. Methodology for Estimating Emissions of CH_4, N_2O, and Indirect Greenhouse Gases from Mobile Combustion and Methodology for and Supplemental Information on Transportation-Related Greenhouse Gas Emissions 167
3.3. Methodology for Estimating Emissions from Commercial Aircraft Jet Fuel Consumption – TO BE UPDATED FOR THE FINAL INVENTORY REPORT 218
3.4. Methodology for Estimating CH_4 Emissions from Coal Mining 224
3.5. Methodology for Estimating CH_4, CO_2, and N_2O Emissions from Petroleum Systems - TO BE UPDATED FOR FINAL INVENTORY REPORT 233
3.6. Methodology for Estimating CH_4, CO_2, and N_2O Emissions from Natural Gas Systems - TO BE UPDATED FOR FINAL INVENTORY REPORT 239
3.7. Methodology for Estimating CO_2, CH_4, and N_2O Emissions from the Incineration of Waste 248
3.8. Methodology for Estimating Emissions from International Bunker Fuels used by the U.S. Military 254
3.9. Methodology for Estimating HFC and PFC Emissions from Substitution of Ozone Depleting Substances 261
3.10. Methodology for Estimating CH_4 Emissions from Enteric Fermentation 293
3.11. Methodology for Estimating CH_4 and N_2O Emissions from Manure Management 322
3.12. Methodologies for Estimating Soil Organic C Stock Changes, Soil N_2O Emissions, and CH_4 Emissions and from Agricultural Lands (Cropland and Grassland) 358
3.13. Methodology for Estimating Net Carbon Stock Changes in Forest Ecosystems and Harvested Wood Products for *Forest Land Remaining Forest Land* and *Land Converted to Forest Land* as well as Non-CO_2 Emissions from Forest Fires. ... 411
3.14. Methodology for Estimating CH4 Emissions from Landfills 449
ANNEX 4 IPCC Reference Approach for Estimating CO_2 Emissions from Fossil Fuel Combustion 472
ANNEX 5 Assessment of the Sources and Sinks of Greenhouse Gas Emissions Not Included 483
ANNEX 6 Additional Information 496
6.1. Global Warming Potential Values 496
6.2. Ozone Depleting Substance Emissions 505
6.3. Sulfur Dioxide Emissions 507
6.4. Complete List of Source and Sink Categories 509
6.5. Constants, Units, and Conversions 510
6.6. Abbreviations 513
6.7. Chemical Formulas 520
ANNEX 7 Uncertainty – TO BE UPDATED FOR FINAL REPORT 525
7.1. Overview – TO BE UPDATED FOR FINAL REPORT 525

7.2. Methodology and Results – TO BE UPDATED FOR FINAL REPORT 526
7.3. Reducing Uncertainty – TO BE UPDATED FOR FINAL REPORT 533
7.4. Planned Improvements – TO BE UPDATED FOR FINAL REPORT 534
7.5. Summary Information on Uncertainty Analyses by Source and Sink Category – TO BE UPDATED FOR FINAL REPORT 535
ANNEX 8 QA/QC Procedures 536
8.1. Background 536
8.2. Purpose 536
8.3. Assessment Factors 538
8.4. Responses to Review Processes – TO BE UPDATED FOR FINAL REPORT 540
ANNEX 9 Use of EPA Greenhouse Gas Reporting Program in Inventory 587

ANNEX 1 Key Category Analysis

The United States has identified national key categories based on the estimates presented in this report. The *2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) describes a key category as a "[category] that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals." By definition, key categories are sources or sinks that have the greatest contribution to the absolute overall level of national emissions in any of the years covered by the time series. In addition, when an entire time series of emission estimates is prepared, a determination of key categories must also account for the influence of the trends of individual categories. Therefore, a trend assessment is conducted to identify source and sink categories for which significant uncertainty in the estimate would have considerable effects on overall emission trends. Finally, a qualitative evaluation of key categories should be performed, in order to capture any key categories that were not identified in either of the quantitative analyses, but can be considered key because of the unique country-specific estimation methods. A qualitative review of key categories, along with non-key categories has not identified additional categories to consider as key.

The methodology for conducting a key category analysis, as defined by Volume 1, Chapter 4 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006), includes:

- Approach 1 (including both level and trend assessments);
- Approach 2 (including both level and trend assessments, and incorporating uncertainty analysis); and
- Qualitative approach.

This Annex presents an analysis of key categories, both for sources only and also for sources and sinks (i.e., including Land Use, Land-Use Change and Forestry LULUCF); discusses Approach 1, Approach 2, and qualitative approaches used to identify key categories for the United States; provides level and trend assessment equations; and provides a brief evaluation of IPCC's quantitative methodologies for defining key categories. The United States key category analysis generally follows the IPCC suggested aggregation level of analysis, but in some cases does differ by avoiding disaggregating into many smaller categories (i.e., separating pools and subcategories within LULUCF source categories). The UNFCCC common reporting format reporting software generates Table A-7, which also identifies key categories using an Approach 1 analysis based on the default disaggregation approach provided in Volume 1, Chapter 4 of the *2006 IPCC Guidelines*.

Table A-1 presents the key categories for the United States (including and excluding LULUCF categories) using emissions and uncertainty data in this report, and ranked according to their sector and CO_2 Eq. emissions in 2019. The table also indicates the criteria used in identifying these categories (i.e., level, trend, Approach 1, Approach 2, and/or qualitative assessments).