APPENDIX E

EMISSIONS MODELING

2021 REGIONAL HAZE STATE IMPLEMENTATION PLAN
REVISION

PROJECT NUMBER 2019-112-SIP-NR

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CHAPTER 1: GENERAL MODELING EMISSIONS DEVELOPMENT

The Federal Clean Air Act (FCAA) and the United States Environmental Protection Agency (EPA) regulations require states to submit state implementation plans (SIP) to make "reasonable progress" in reducing visibility impairment at Federal Class I areas resulting from anthropogenic pollution. FCAA, 169A(a)(1), "declares as a national goal the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Federal Class I areas which impairment results from man-made air pollution." The Texas Commission on Environmental Quality (TCEQ) conducted photochemical modeling using Comprehensive Air Quality Model with Extensions[1] (CAMx) to assess visibility at Class I areas in and near Texas for the second implementation period covering 2019 through 2028. This appendix details the TCEQ's development of modeling emissions inputs for the 2021 Regional Haze SIP Revision, hereafter referred to as the Regional Haze SIP Revision.

Emissions modeling refers to the development of inputs suitable for use with a photochemical model and includes preparing emissions inventories (EI) for several anthropogenic and natural emissions source categories. Emissions inputs for the Regional Haze SIP Revision were developed for the CAMx modeling domain shown in Figure 1-1: *Map of Regional Haze SIP Revision CAMx Modeling Domains*.

[1] http://www.camx.com

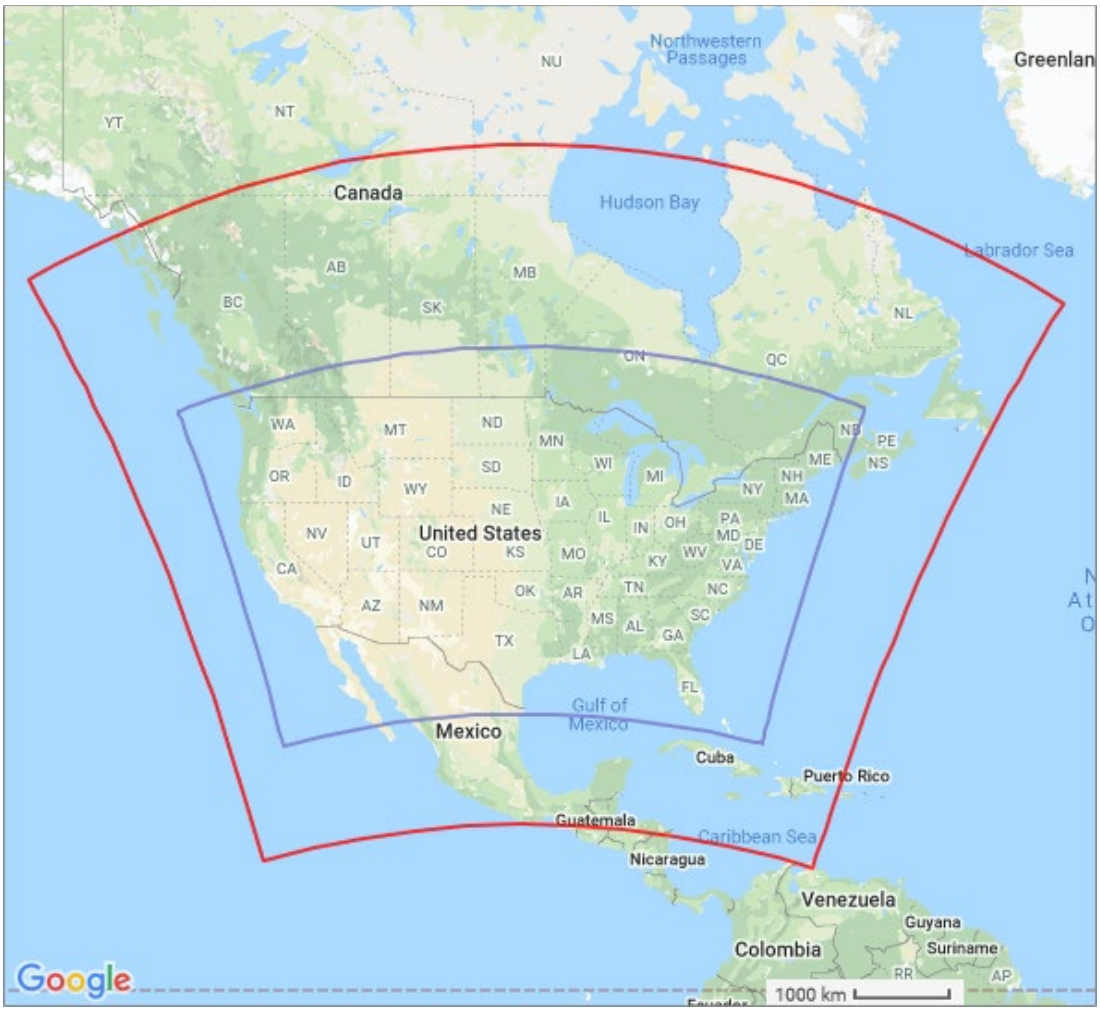

Figure 1-1: Map of Regional Haze SIP Revision CAMx Modeling Domains

Figure 1-1 depicts the two CAMx domains of different grid resolution specified in kilometers (km). A 12 km grid resolution domain covers the continental United States (U.S.) plus southern Canada and northern Mexico. A 36 km grid resolution domain extends into northern Canada, southern Alaska, southern Mexico, parts of Central America, Cuba, and Puerto Rico.

The TCEQ's modeling is based on the EPA's *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze* (EPA, 2018), which recommends using the model results in an relative sense. This relative approach is based on how the model responds to the change in emissions between a base and a future year. Therefore, three modeling emissions data sets were developed for this Regional Haze SIP Revision:

- 2016 base case emissions;
- 2028 future year emissions; and
- 2028 future year sensitivity analyses.

This appendix presents details on the development of modeling emissions for annual episode base and future years for point sources, on-road, non-road, and off-road mobile sources, area sources, and biogenic sources. The EI files described in this appendix are available on the TCEQ modeling file transfer protocol (FTP) site, ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/.

1.1 BASE CASE MODELING EMISSIONS

Base case modeling for regional haze is performed to simulate observed pollution concentrations during historical pollution episodes and to develop confidence that the model can reliably predict how future pollution levels will change in response to changes in emissions (EPA, 2018). For this SIP revision, the historical episode is the entire year (366 days) of 2016. To maximize model performance, base case emission inputs were estimated as accurately as possible. In the development of the base case modeling emissions, several quality assurance techniques were used to evaluate the reasonableness of the emission magnitudes, spatial distributions and temporal profiles.

Emissions were developed for the criteria pollutants: nitrogen oxides (NO_X), volatile organic compounds (VOC), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), ammonia (NH_3) and carbon monoxide (CO). $PM_{2.5}$ emissions were speciated into the components of primary organic aerosol (POA), primary elemental carbon (PEC), particulate sulfate (PSO_4), particulate nitrate (PNO_3), particulate ammonium (PNH_4), fine other primary (FPRM), particulate chloride (PCL), particulate sodium (PNA), particulate water (PH_2O), and/or fine crustal particulate (FCRS).

The EIs were prepared for photochemical modeling inputs using Version 3 of the Emissions Processing System (EPS3).

Summaries of the primary data sources for the development of the base case modeling emissions are provided in Table 1-1: *Summary of Base Case Point Source Emission Data Sources*, Table 1-2: *Summary of Base Case On-Road Mobile Source Emission Data Sources*, and Table 1-3: *Summary of Base Case Non-Road Mobile, Off-Road, Area, Oil-and-Gas, and Biogenic Source Emission Data Sources.*

Table 1-1: Summary of Base Case Point Source Emission Data Sources

Region	Data Source
Texas	2016 State of Texas Air Reporting System (STARS) for non-Electric Generating Units (non-EGUs)
Other States	2016 National Emissions Inventory Collaborative (NEIC) platform Beta version (2016 NEIC platform vβ) for non-EGUs
All States	2016 EPA's Air Markets Program Data (AMPD) hourly data for EGUs
Offshore	2014 Bureau of Ocean Energy Management (BOEM) Gulfwide Emission Inventory (GWEI) platforms of western Gulf of Mexico
Mexico and Canada	2016 NEIC platform vβ
Other Countries	2010 Emissions Database for Global Atmospheric Research (EDGAR) v4.2
U.S. Fires	2016 Fire Inventory from the National Center for Atmospheric Research (FINN)

Table 1-2: Summary of Base Case On-Road Mobile Source Emission Data Sources

Region	Data Source
HGB and DFW	2016 based on Motor Vehicle Emission Simulator (MOVES2014a) emission rates and Highway Performance Monitoring System (HPMS) for vehicle miles traveled (VMT) activity estimates
Other Texas	2016 based on MOVES2014a emission rates and HPMS for VMT activity estimates
Outside Texas	2016 NEIC platform vβ

Note: Houston-Galveston-Brazoria (HGB) and Dallas-Ft. Worth (DFW) nonattainment areas

Table 1-3: Summary of Base Case Non-Road Mobile, Off-Road, Area, Oil-and-Gas, and Biogenic Source Emission Data Sources

Region	Non-Road Mobile Sources	Area Sources	Off-Road Sources	Oil-and-Gas Sources	Biogenic Sources
Texas	2016 run of Texas NONROAD model, version 2 (TexN2)	2016 NEIC platform vβ and 2016 NEIC platform Version One (2016 NEIC v1)	2016 NEIC platform vβ and v1	Railroad Commission of Texas data and equipment-specific emission rates	Biogenic Emission Inventory System (BEIS) 3.61
Other U.S. States	2016 NEIC platform vβ	2016 NEIC platform vβ and v1	2016 NEIC platform vβ and v1	2016 NEIC platform vβ	BEIS 3.61
Canada	2016 NEIC platform vβ	2016 NEIC platform vβ and v1	2016 NEIC platform vβ	2016 NEIC platform vβ	BEIS 3.61
Mexico	2016 NEIC platform vβ	2016 NEIC platform vβ and v1	2016 NEIC platform vβ	2016 NEIC platform vβ	BEIS 3.61

1.2 FUTURE YEAR MODELING EMISSIONS

The Regional Haze Rule requires states to evaluate reasonable progress toward visibility goals in Class I areas at specific intervals. The second implementation period ends in the year 2028, therefore it is the future year for modeling. In general, 2028 future year emissions were estimated by applying growth projections and accounting for known existing federal, state, and local controls.

The development of 2028 modeling emissions for the Regional Haze SIP Revision includes some methods used in previous SIP modeling for ozone[2], such as the Federal Tier 3 Vehicle Emission and Fuel Standards Program, the Mass Emissions Cap-and-

[2] https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2018_2015OzoneInfTransport/2015Ozone_Inf-Transport_2018_Archive.pdf

Trade (MECT) Program in the HGB area, the Highly Reactive VOC Emission Cap-and-Trade (HECT) Program in Harris County, the Midlothian Cement Kiln caps and related agreed orders in the DFW area, and the EPA's final Cross-State Air Pollution Rule (CSAPR) update.

Summaries of the primary data sources for the development of the future case modeling emissions are provided in Table 1-4: *Summary of Future Case Point Source Emission Data Sources*, Table 1-5: *Summary of Future Case On-Road Mobile Source Emission Data Sources*, and Table 1-6: *Summary of Future Case Non-Road Mobile, Off-Road, Area, Oil-and-Gas, and Biogenic Source Emission Data Sources.*

Table 1-4: Summary of Future Case Point Source Emission Data Sources

Region	Data Source
Texas	2016 STARS for non-EGUs; 2018 AMPD hourly data for EGUs
Other States	2028 from 2016 NEIC platform vβ for non-EGUs; Eastern Regional Technical Advisory Committee (ERTAC) 2028 Projection for EGUs
Offshore	2014 BOEM GWEI platforms of western Gulf of Mexico
Mexico and Canada	2028 from 2016 NEIC platform vβ
Other Countries	2010 EDGAR v4.2
U.S. Fires	2016 Fire Inventory from the National Center for Atmospheric Research (FINN)

Table 1-5: Summary of Future Case On-Road Mobile Source Emission Data Sources

Region	Data Source
HGB and DFW	2028 based on MOVES2014a emission rates and HPMS for VMT activity estimates
Other Texas	2028 based on MOVES2014a emission rates and HPMS for VMT activity estimates
Outside Texas	2028 from 2016 NEIC platform

Table 1-6: Summary of Future Case Non-Road Mobile, Off-Road, Area, Oil-and-Gas, and Biogenic Source Emission Data Sources

Region	Non-Road Mobile Sources	Area Sources	Off-Road Sources	Oil-and-Gas Sources	Biogenic Sources
Texas	2028 run of Texas NONROAD model, version 2 (TexN2)	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ and v1	Railroad Commission of Texas data and equipment-specific emission rates	BEIS 3.61
Other U.S. States	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ and v1	2028 from 2016 NEIC platform vβ	BEIS 3.61
Canada	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ and v1	2028 from 2016 NEIC platform vβ	BEIS 3.61
Mexico	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ	2028 from 2016 NEIC platform vβ and v1	2028 from 2016 NEIC platform vβ	BEIS 3.61

1.3 FUTURE YEAR CONTROL STRATEGY AND/OR SENSITIVITY ANALYSES

For this Regional Haze SIP Revision, sensitivity modeling runs for three scenarios were performed to determine the impact of NO_X and SO_2 reductions at specific sources on the future visibility at Class I areas. Details of these sensitivity modeling runs are provided in Section 2.3: *2028 Point Source Sensitivity Analyses*.

1.4 2016 NATIONAL EMISSION INVENTORY COLLABORATIVE

Texas was part of the NEIC group of state, local area, and the EPA staff that developed a national emissions modeling platform for 2016, and projections of 2023 and 2028 (NEIC, 2019). Workgroups were formed to create the emission inventories by category. This Regional Haze SIP uses a mix of 2016 NEIC platform vβ and v1 inventories due to SIP and NEIC data release timing.

The TCEQ converted the pre-merged Community Multi-scale Air Quality (CMAQ) model-ready emissions to CAMx format using the CMAQ2CAMX interface program (Ramboll, 2016). The 2016 NEIC platform files were used for all categories except Texas point, Texas on-road, Texas non-road, Texas oil-and-gas sources, and countries outside of the United States, including Mexico and Canada.

1.5 EMISSION PROCESSING SYSTEM VERSION 3 (EPS3)

For the Texas point, Texas on-road, Texas non-road, and Texas oil-and-gas sources, EPS3 was used to process the text-based emission and activity data to binary gridded photochemical model input. In general, the EPS3 modules used are detailed in Table 1-7: *EPS3 Modules for Processing Emissions*.

Table 1-7: EPS3 Modules for Processing Emissions

EPS3 Module	Description
LBASE	Spatially allocate on-road link-based emissions among grid cells
PREAM	Prepares area source and non-link roadway emissions for further processing
PREFIR	Prepares fire emissions for further processing and identifies the fire class
PREPNT	Prepares point source or stationary extended idling emissions for further processing
PRESHP	Prepares shipping emissions for further processing and grids emissions
CNTLEM	Apply controls to model strategies, apply adjustments, etc.
TMPRL	Apply temporal profiles to extended idling emissions
SPCEMS	Chemically speciate VOC emissions into olefins, paraffins, etc.
PSTFIR	Splits fires to low-level and lofted emissions, determines plume depth
PSTPNT	Generates a list of elevated sources and emission inventory files to be processed by the PiGEMS module
PSTSHP	Vertically allocates shipping emissions, determines plume depth, and identifies sources to be processed by the PiGEMS module
PIGEMS	Determines the sources for Plume-in-Grid (PiG) treatment, merges elevated point source files, and creates a CAMx ready elevated emissions file
GRDEM	Sum emissions by grid cell for photochemical model input
MRGUAM	Merge and adjust multiple gridded files for photochemical model input

1.6 MODELING FILE AVAILABILITY

The gridded photochemical modeling input files for the 2016 and 2028 emissions are provided along with the full emission processing message log files at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/. For questions regarding these files, please email amda@tceq.texas.gov.

CHAPTER 2: POINT SOURCE MODELING EMISSIONS DEVELOPMENT

The point source category includes large stationary sources of emissions, such as electric generating units (EGUs), smelters, industrial boilers, petroleum refineries, and manufacturing facilities. Point source emissions were developed for the January 1 through December 31, 2016 annual episode with a 2028 future year projection. The data sources for development of the point source modeling emissions are summarized in Table 2-1: *Sources of Point Source Emissions Data*.

Table 2-1: Sources of Point Source Emissions Data

Sources of Data	Calendar Year(s) Used
Texas Commission on Environmental Quality (TCEQ) State of Texas Air Reporting System (STARS)	2016
TCEQ Mass Emissions Cap and Trade (MECT) Allocations for sources in HGB	2028
TCEQ Highly Reactive VOC Emission Cap-and-Trade (HECT) Allocations for sources in Harris County	2028
EPA Air Markets Program Data (AMPD) hourly EGU emissions from Continuous Emissions Monitors (CEMs) for all states	2016, 2018
Eastern Regional Technical Advisory Committee (ERTAC) EGU projections for other states	2028
EPA Cross State Air Pollution Rule (CSAPR) Update allocations for applicable states	2028
Electric Reliability Council of Texas (ERCOT) Capacity, Demand, and Reserve report	2028
TCEQ Air Permits for proposed EGUs	2028
U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM) Gulfwide Emission Inventory (GWEI) platforms of western Gulf of Mexico	2014
2016 National Emission Inventory Collaborative Beta Version (2016 NEIC platform vβ)	2016, 2028
2010 Emissions Database for Global Atmospheric Research (EDGAR) v4.2	2010
Fire Inventory from the National Center for Atmospheric Research (FINN)	2016

2.1 2016 BASE CASE POINT SOURCE MODELING EMISSIONS DEVELOPMENT

The following sections describe the development of point source emissions inputs for Comprehensive Air Quality Model with Extensions (CAMx) base case modeling.

2.1.1 Preparation of CAMx Model-Ready Files with EPS3

EPS3 is used to process the emissions in the Aerometric Information Retrieval System (AIRS) Facility Subsystem (AFS) file into a format ready for CAMx input. The AFS file format used by the TCEQ, including expanded field descriptions and options, can be found on the TCEQ modeling FTP site[3].

All point source U.S. emissions were prepared in the AFS format for CAMx.

CAMx model inputs require that the emissions be chemically speciated, temporally allocated, and spatially allocated to grid cells or assigned to fixed three-dimensional locations. The EPS3 User's Guide provides additional details for processing the point source emissions for photochemical model input (Ramboll Environ, 2015). The remainder of this section discusses some of the specific point source emissions processing procedures.

[3] ftp://amdaftp.tceq.texas.gov/EI/2012_episodes/dfw_hgb_fy20_sip/base_2012/point/ancilliary/

2.1.1.1 Chemical Speciation with EPS3

The volatile organic compound (VOC) values that are included in the AFS file are speciated into carbon bond groups for the specific chemical mechanism used in CAMx. The TCEQ used the Carbon Bond Version 6 (Yarwood et al., 2010), release 4 with condensed halogen chemistry and sea salt emissions (CB6r4h).

2.1.1.2 Particulate Matter Speciation

Small particles can be directly emitted into and react in the atmosphere causing visibility impairment. To take advantage of CAMx modules for treatment of coarse and fine particulate matter, the $PM_{2.5}$ point source emissions were converted into CAMx species. To perform the speciation, EPS3 SPCEMS (SPeCiate EMiSsions) module was run using EPA $PM_{2.5}$ SPECIATE 5.0 speciation profiles and cross-references. CAMx was run using particulate matter chemistry algorithms including the static two-mode coarse/fine (CF) scheme, inorganic gas-aerosol partitioning (ISORROPIA), and secondary organic gas-aerosol partitioning (SOAP) and oxidation.

2.1.1.3 Temporal Allocation with EPS3

EPS3 can temporally distribute emissions by month, day of the week, and hour of a specific episode when enough detail is available. CAMx requires emissions inputs for each simulation hour of the base case for both the base and future years. The 2010 HGB SIP Revision for the 1997 Eight-Hour Ozone standard (available in Appendix B of the 2010 HGB SIP Submittal at https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/hgb_sip_2009/09017SIP_ado_Appendix_B.pdf) provides detail about temporal allocation, along with examples of the cross reference and profile records.

2.1.1.4 Spatial Allocation with EPS3

CAMx uses a three-dimensional Eulerian system in which emissions are allocated to individual grid cells. Emissions occur at or near the surface for most source categories such as area, biogenic, on-road mobile, and non-road mobile. These near-surface emissions are classified as low-level emissions, are allocated to grid cells, and are released at the same time in the time step and mixed throughout the grid cell. Numerous point sources also fall into the low-level source category, but tall stacks such as large combustion sources (e.g., power plants and refineries) are categorized as elevated sources because their hot exhaust gases can rise several hundred meters into the atmosphere.

Low-level point sources are allocated to grid cells and merged with the other low-level source categories prior to CAMx input, whereas elevated point sources are kept at their reported locations and assumed to emit from the calculated effective plume height (above the reported stack height) to better simulate physical mixing in the elevated layers of the photochemical model. EPS3 processing of point source emissions is divided into low-level and elevated streams. This division allows for merging of low-level files, and for a better vertical distribution of elevated emissions prior to mixing and reacting with surface emissions within CAMx. A plume cutoff height of 30 meters was chosen to divide the point sources into low-level and elevated categories to correspond to the 34-meter height of the first CAMx model layer.

2.1.1.5 Plume-in-Grid (PiG) Source Selection

CAMx provides the option to model selected point sources with a PiG algorithm. NO_X reaction chemistry is enhanced by treating these selected point source plumes as Lagrangian puffs. The Greatly Reduced Execution and Simplified Dynamics (GREASD) PiG option in CAMx was used, which is most applicable to large NO_X plumes. This option was selected for emissions from point sources processed with EPS3 that emitted over 15 tons per day (tpd) NO_X and located within the portion of the continental U.S. (CONUS) within the 36-km CAMx domain shown in Figure 1-1.

The NO_X threshold is established such that any individual stack or co-located group of stacks with NO_X emissions over the threshold on an episode day is tracked as a PiG source. Stacks are considered collocated when multiple stacks are close enough together for their plumes to merge (within 200 meters) and the aggregate NO_X emission rate for the cluster exceeds the threshold value. A new source representing the collocated sources is created with the combined emission rate of the cluster, and this source is flagged for PiG treatment. The stack parameters of the new source become an average of the stack parameters of all the sources in the cluster. The TCEQ modeled both individual PiGs and combined PiGs. The EPS3 documentation for the PiGEMS module provides a summary of the PiG treatment (Ramboll, 2015).

2.1.2 EGU Point Sources

To develop base case modeling emissions for EGUs in the U.S., hourly records from the EPA's Air Markets Program Data (AMPD) were used. Under several federal cap-and-trade programs, EGUs are required to report their emissions of SO_2, NO_X, and CO_2, along with other parameters such as heat input collected using continuous emissions monitoring systems (CEMS). The EPA quality controls the reported raw hourly data and provides datasets and a query wizard on the AMPD website (https://ampd.epa.gov/ampd/) for downloading the data. Missing or invalid hourly data that arise from CEMS equipment problems are handled by the EPA using specific substitution criteria. Hourly data were downloaded from the EPA's AMPD website for the contiguous lower 48 states for January through December 2016. Non-emissions parameters, such as stack parameters, were obtained from STARS for Texas units, and from the 2011 National Emission Inventory[4] (NEI) for non-Texas units. The TCEQ maintains STARS-to-AMPD and NEI-to-AMPD cross reference files to assist with matching units in the 2016 NEIC platform. Sources that match are removed from the respective databases to avoid double counting of emissions.

Hourly ammonia (NH_3), particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometer ($PM_{2.5}$) and diameter less than or equal to a nominal 10 micrometer (PM_{10}), VOC, and CO emissions for each unit were estimated by multiplying the NEI and STARS annual NH_3, $PM_{2.5}$, PM_{10}, VOC, and CO emissions by the ratio of AMPD hourly heat input to annual heat input. The hourly EGU emissions records were compiled into an AFS file format that can be processed with the modules of EPS3.

Figure 2-1: *Tile Plot of non-Texas CONUS EGU NO_X Emissions for June 14, 2016* and Figure 2-2: *Tile Plot of non-Texas CONUS EGU SO_2 Emissions for June 14, 2016* are maps

[4] https://www.epa.gov/air-emissions-inventories/2011-national-emissions-inventory-nei-data

of non-Texas CONUS NO_X and SO_2 emissions for a sample day in June 2016, respectively.

Figure 2-3: *Tile Plot of Texas EGU NO_X Emissions for June 14, 2016* and Figure 2-4: *Tile Plot of Texas EGU SO_2 Emissions for June 14, 2016* are maps of Texas NO_X and SO_2 emissions for a sample day in June 2016, respectively. Reported on all tile plots in this appendix are the total emissions in the lower left corner and the corresponding diurnal profile of the sources in the lower right corner. A colored/shaded tile represents the total quantity of emissions in tpd.

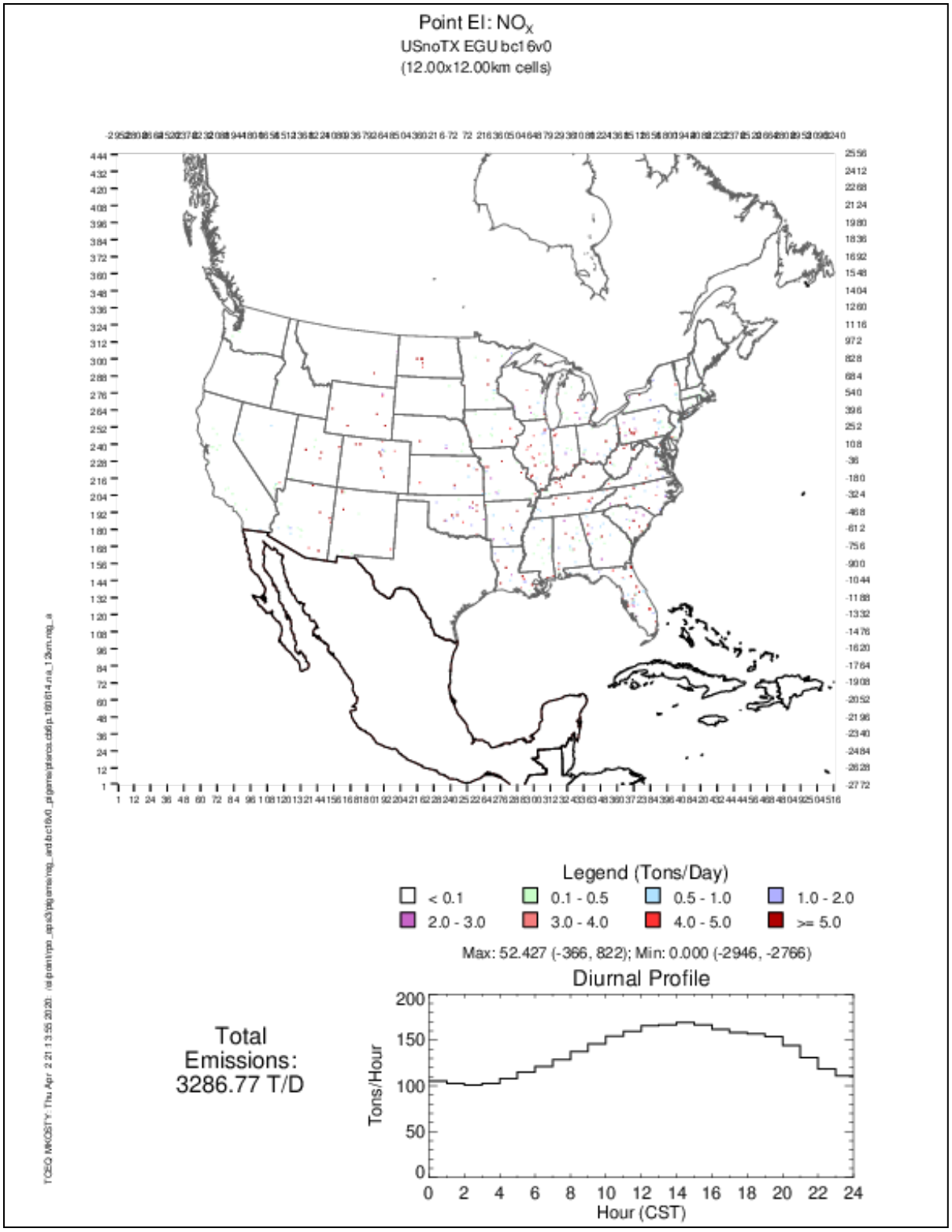

Figure 2-1: Tile Plot of non-Texas CONUS EGU NO_X Emissions for June 14, 2016

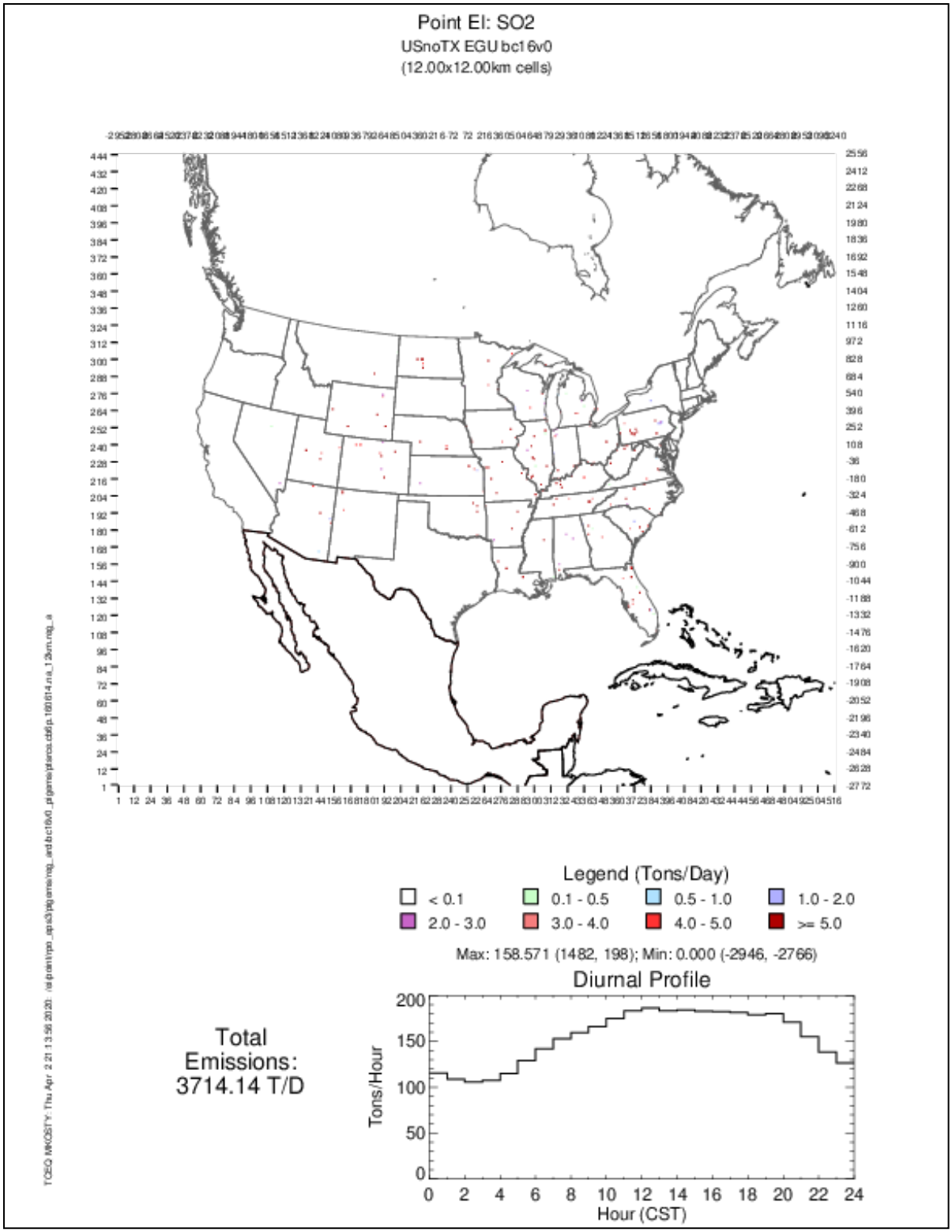

Figure 2-2: Tile Plot of non-Texas CONUS EGU SO_2 Emissions for June 14, 2016

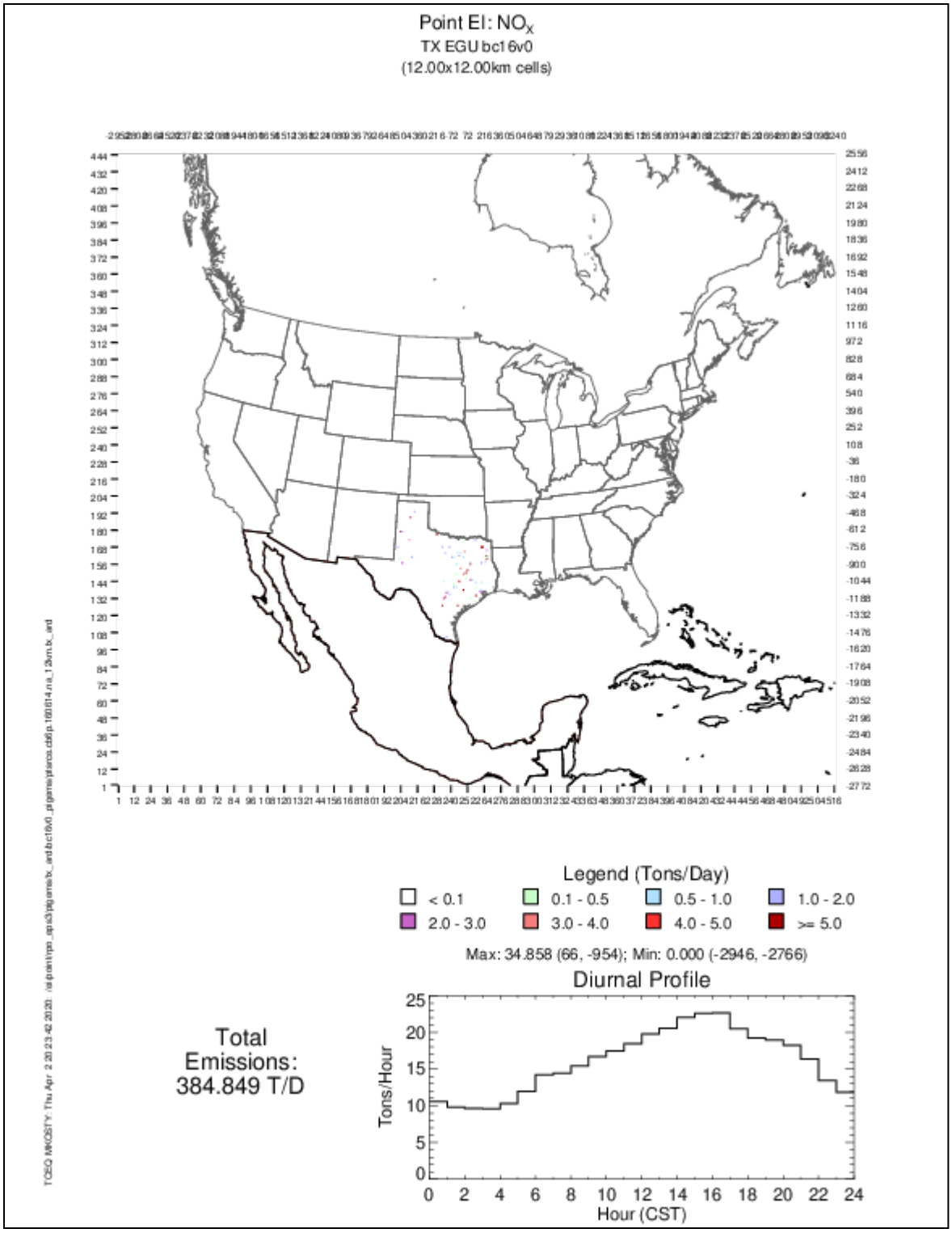

Figure 2-3: Tile Plot of Texas EGU NO_X Emissions for June 14, 2016

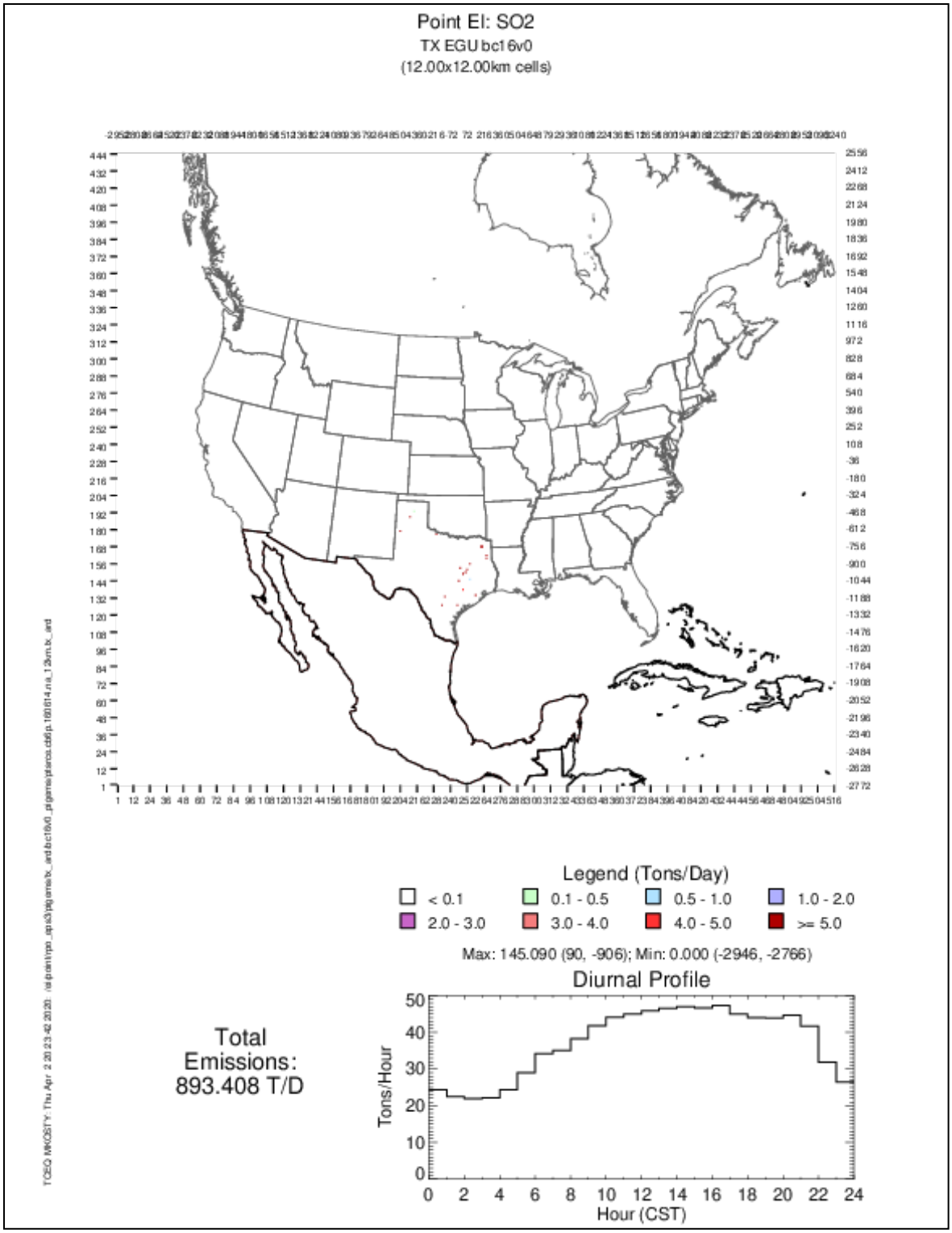

Figure 2-4: Tile Plot of Texas EGU SO_2 Emissions for June 14, 2016

2.1.3 Texas Non-EGU Point Sources

Emissions modeling data for the 2016 base case Texas non-EGUs were extracted from the TCEQ's STARS database.

2.1.3.1 STARS

The STARS database is a repository of emissions data for criteria pollutants from point sources in Texas. It includes approximately 2,000 industrial sites whose emissions rates meet the reporting threshold specified in 30 Texas Administrative Code (TAC) §101.10 and are required to update their emissions annually. Development of the Texas point source emission modeling files began with queries of the quality-assured data of the STARS database. The STARS modeling extract report is a snapshot of Texas emissions, since regulated entities can update their information, when warranted, at any time. Updated modeling query reports are typically run when significant STARS updates are completed. The reporting requirements, guidance documents, trends, and summaries of the most recently quality assured year of reported data can be found on the TCEQ Point Source Emissions Inventory website at https://www.tceq.texas.gov/airquality/point-source-ei/psei.html.

Perl and SAS computer programming code were used to parse and format the STARS extract into an AFS file. Each record of the AFS file contains references for the TCEQ Regulated Entity Number (RN), equipment or Facility Identification Number (FIN), and exhaust point or Emission Point Number (EPN), making up a unique emissions path. The code performs various logical checks and comparisons, assigns defaults for missing data, applies rule effectiveness to VOC emissions paths with control devices, removes EGUs that have AMPD data, and formats the data into an AFS file for input to EPS3.

The STARS extract contains four types of emission rates: annual, ozone season day (OSD), annual emission events (EE), and annual scheduled maintenance startup and shutdown (SMSS). For each source, annual emission rates plus any reported annual EE/SMSS emissions were modeled. Where provided, seasonal and daily use percentages were used to create source specific temporal distributions of emissions. EGUs that have AMPD data are not included in the STARS annual emission file. An example of STARS extract data is available in Section 2.1.1 of Appendix B of the 2010 HGB SIP Revision for the 1997 Eight-Hour Ozone Standard at https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/hgb_sip_2009/09017SIP_ado_Appendix_B.pdf.

2.1.3.2 Rule Effectiveness (RE)

The TCEQ applies RE to the STARS VOC emissions where relevant. The purpose is to account for the possibility that not all facilities covered by a rule comply 100% of the time and that control equipment does not always operate at its assumed control efficiency. Additional details about rule effectiveness and how it is applied are described on Page B-17 of Appendix B from the 2010 HGB SIP Revision for the 1997 Eight-Hour Ozone Standard.

2.1.3.3 AFS File for EPS3 Input

The resultant STARS annual AFS file is in a format suitable for input to EPS3. The STARS-derived AFS file for modeled pollutants typically has more than 200,000

records. For Regional Haze modeling purposes, values for emission of NO_X, VOC, SO_2, NH_3, $PM_{2.5}$, PM_{10}, and CO are retained in the AFS file for EPS3 input.

2.1.3.4 Speciation of Texas Non-EGU Point Sources

VOC emissions in STARS can be reported as individual compounds, mixtures, classes of compounds, total VOC, and unclassified VOC. When the composition of the VOC reported for a specific source is fully speciated, point specific speciation profiles are developed. If the composition is unknown or not fully-speciated, the default speciation profile from EPA's SPECIATE database software program (EPA, 2014b) is applied based on the source classification code (SCC). Ethane and acetone are also extracted from STARS and used to develop point source-specific speciation. Because ethane and acetone are additive to the VOC total, the modeled and tabulated VOCs from EPS3 will almost always be greater than reported (STARS) VOC totals.

For Texas non-EGU emissions, the TCEQ chose a day in June to represent a typical episode day. Figure 2-5: *Tile Plot of Texas Non-EGU NO_X Emissions for June 14, 2016* and Figure 2-6: *Tile Plot of Texas Non-EGU SO_2 Emissions for June 14, 2016* are maps of Texas NO_X and SO_2 emissions for a sample day in June 2016, respectively.

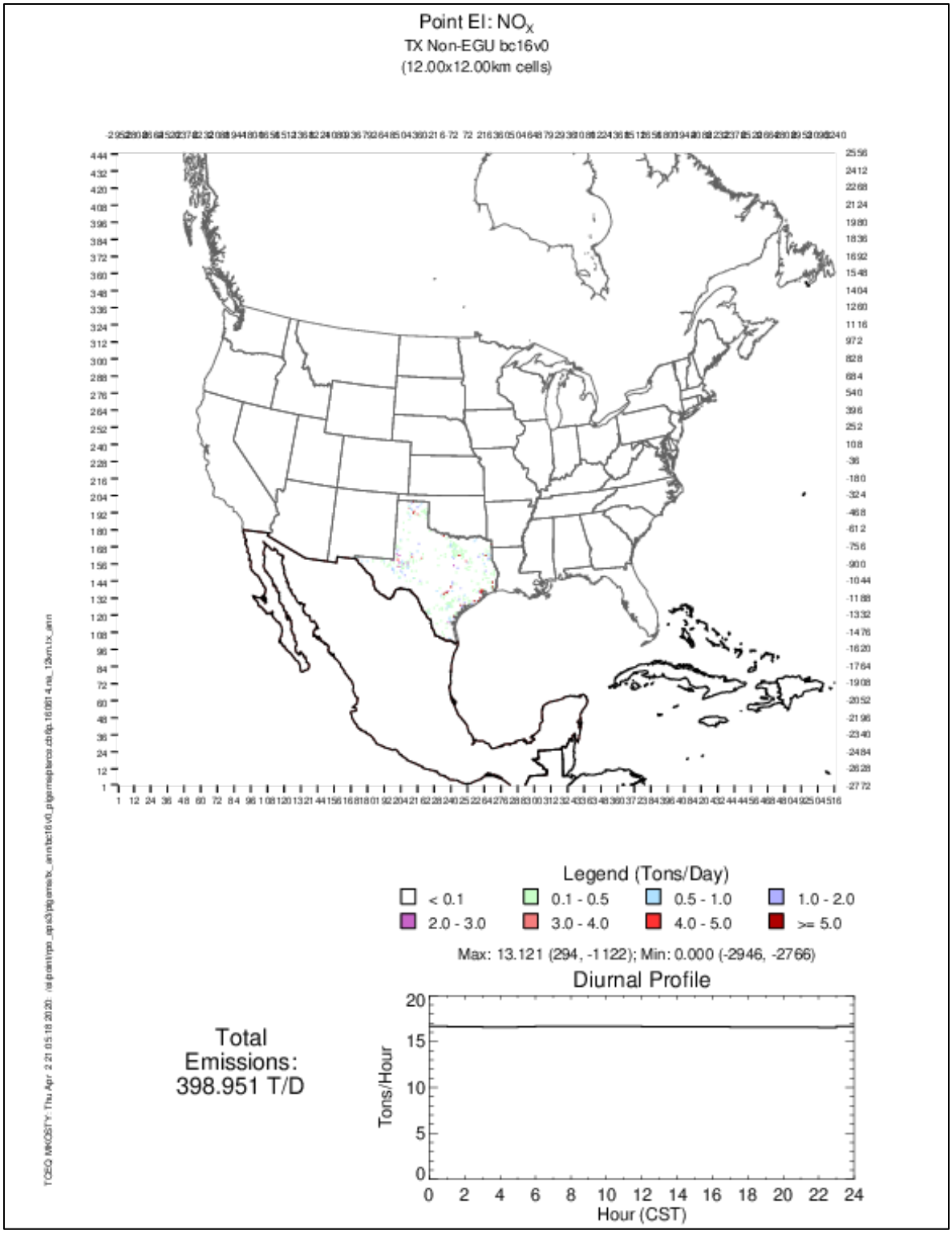

Figure 2-5: Tile Plot of Texas Non-EGU NO_X Emissions for June 14, 2016

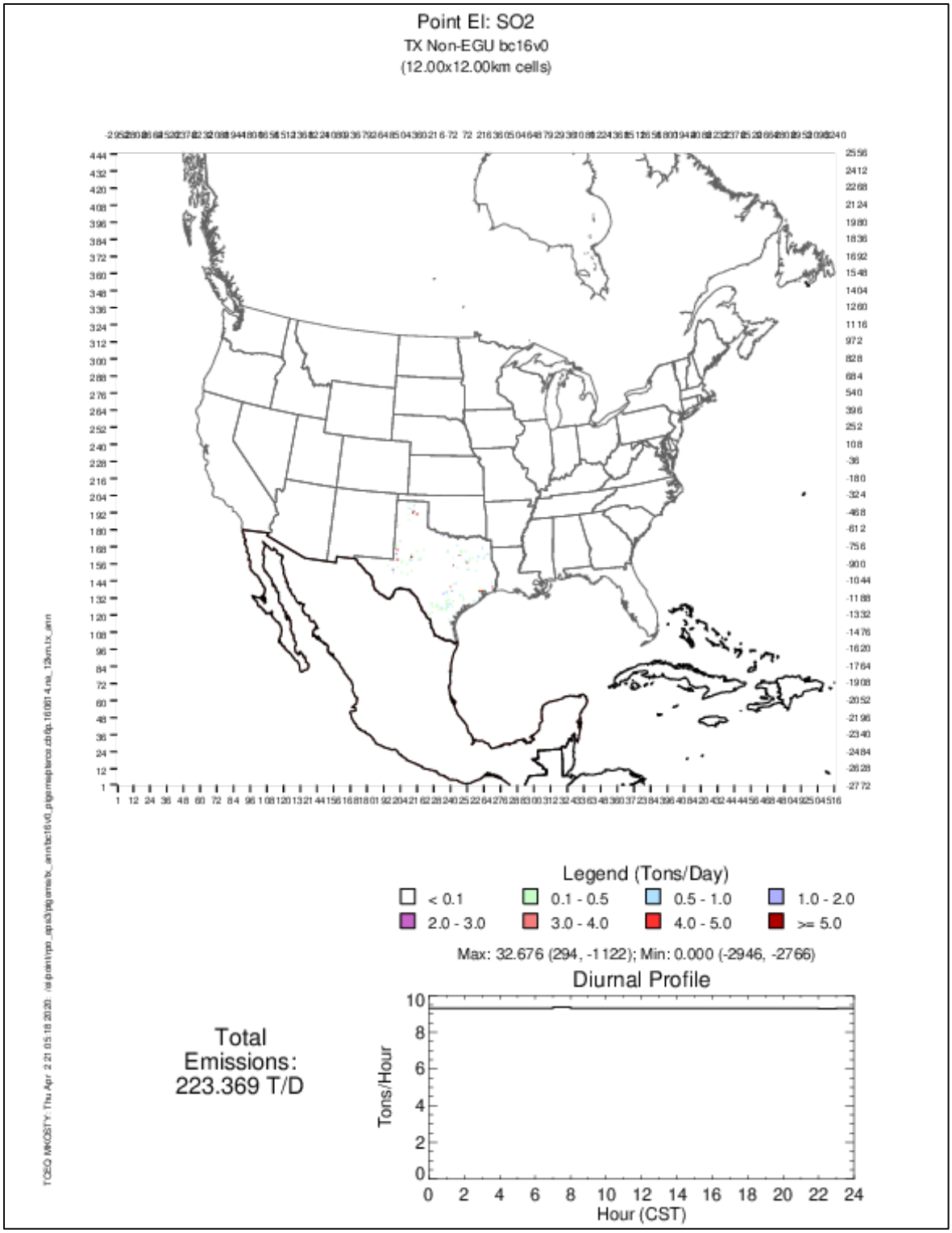

Figure 2-6: Tile Plot of Texas Non-EGU SO_2 Emissions for June 14, 2016

2.1.4 Point Sources Outside of Texas

This section discusses the point source modeling emissions development for areas outside of Texas but within the modeled CAMx domain. The non-Texas CONUS EGUs are discussed in Section 2.1.2 above. This section describes the following areas:

- CONUS non-EGUs;
- Offshore (Gulf of Mexico);
- Mexico and Canada; and
- Other countries.

2.1.4.1 CONUS Non-EGUs

The 2016 NEIC platform vβ was used for non-EGU point sources for states outside of Texas (NEIC, 2019). The non-EGU point source files consist of all non-EGU point sources not associated with oil-and-gas activity. Point source emissions from airport and railyards emissions are separated and treated as low-level sources. The oil-and-gas point source file contains oil-and-gas sources in CONUS and oil-and-gas sources operating in the federal waters of the Gulf of Mexico. The Gulf of Mexico sources were removed and prepared separately as described below in Section 2.1.4.2: *Offshore (Gulf of Mexico)*. The temporal allocation file for Sparse Matrix Operation Kernel Emissions (SMOKE) was converted to EPS3 format and used to create the daily-varying temporal distribution of emissions, based on SCC and county, for each day.

EGUs that do not report hourly varying emissions to AMPD are also included in this category. Temporal profiles from the 2016 NEIC platform vβ are used to create monthly files for the non-AMPD units, with daily emissions for a given month being the same.

For non-Texas CONUS non-EGU point sources, the TCEQ chose a day in June to represent a typical episode day because June has an average number of anthropogenically-impaired days at monitors of interest in and near Texas. Figure 2-7: *Tile Plot of non-Texas CONUS Non-EGU NO_X Emissions for June 14, 2016* is a map of non-Texas CONUS combined low-level and elevated NO_X emissions for a day in 2016. Figure 2-8: *Tile Plot of non-Texas CONUS Non-EGU SO_2 Emissions for June 14, 2016* is a map of non-Texas CONUS combined low-level and elevated SO_2 emissions for a day in 2016.

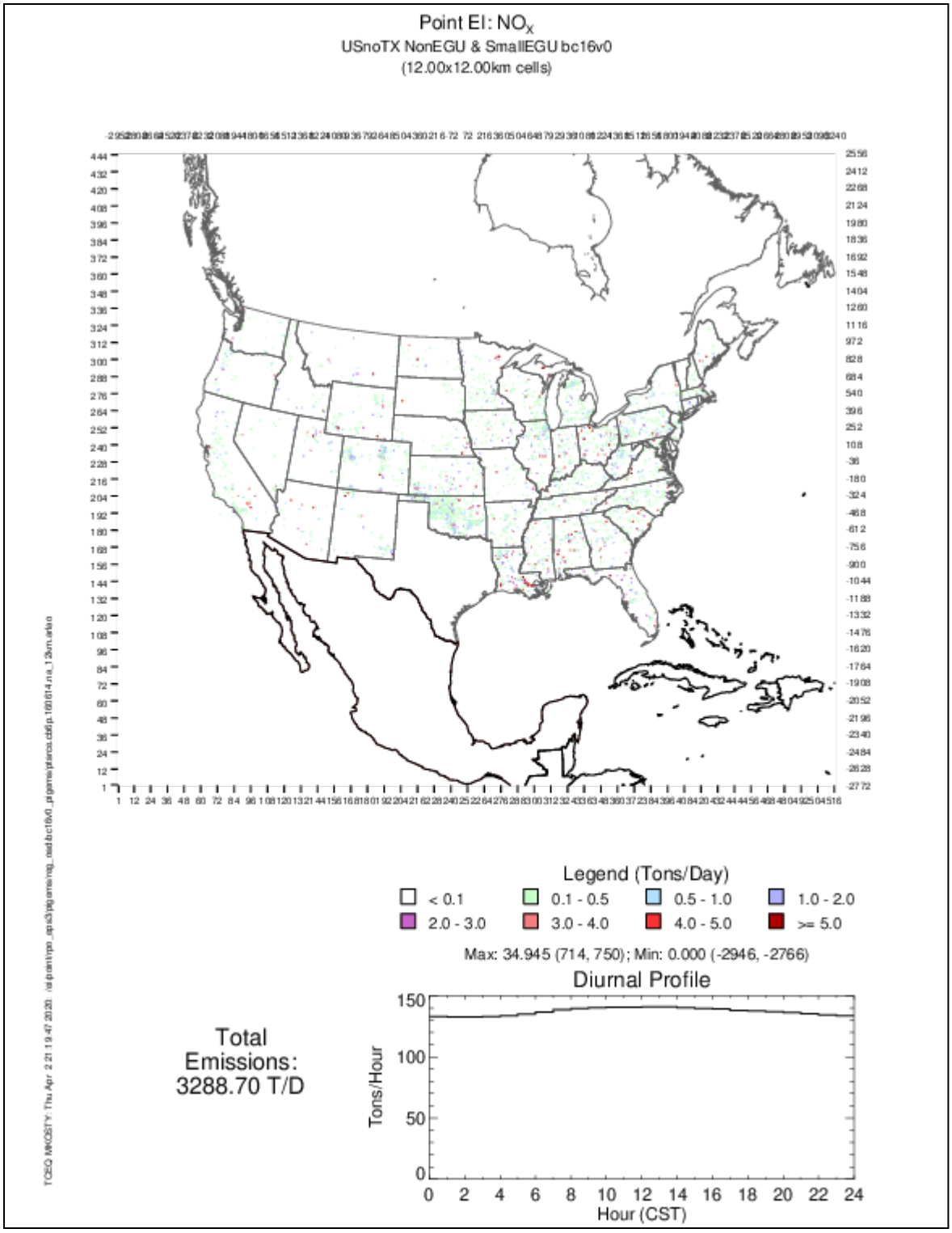

Figure 2-7: Tile Plot of non-Texas CONUS Non-EGU NO_x Emissions for June 14, 2016

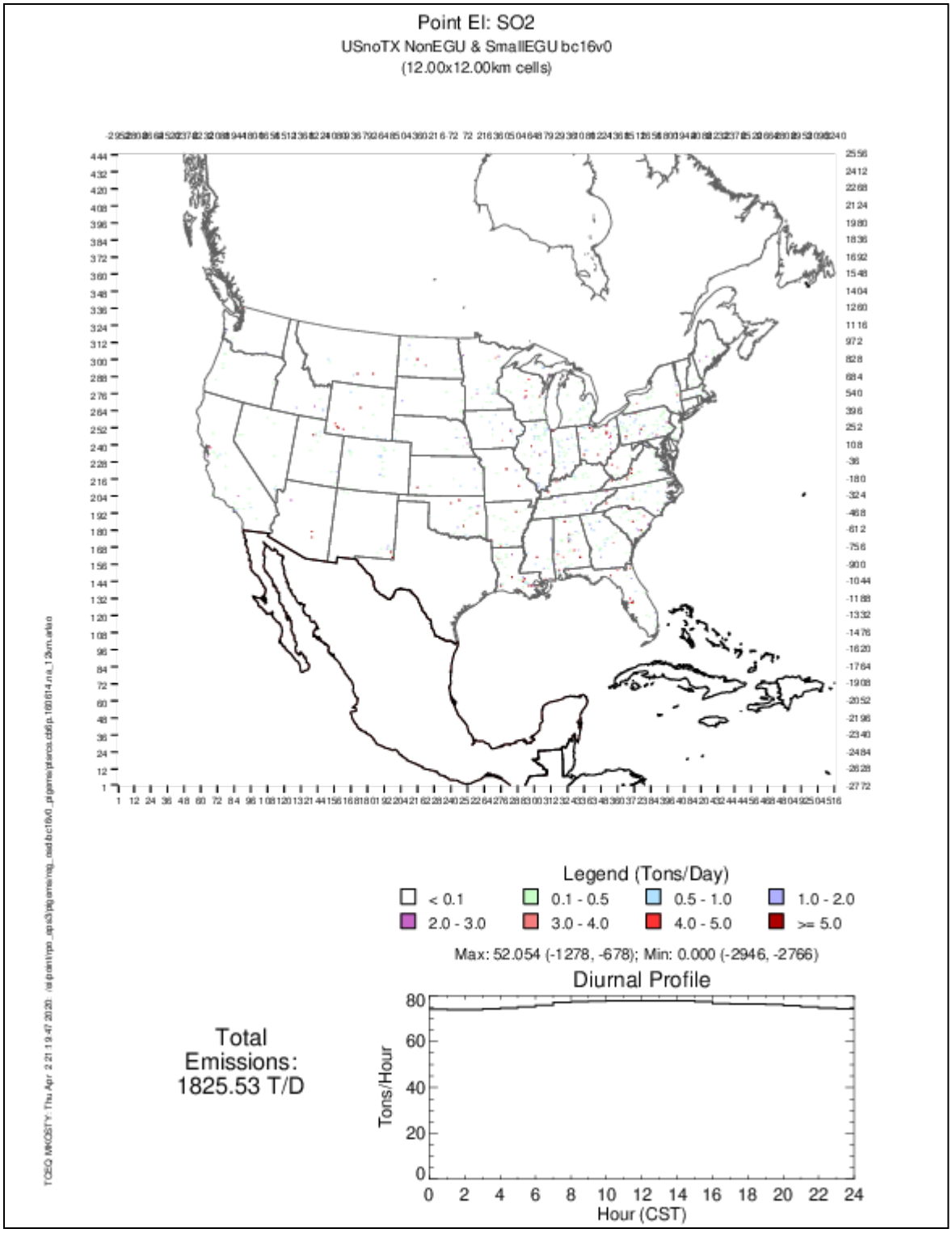

Figure 2-8: Tile Plot of non-Texas CONUS Non-EGU SO_2 Emissions for June 14, 2016

2.1.4.2 Offshore (Gulf of Mexico)

The Gulfwide Emission Inventory (GWEI), developed by Eastern Research Group (ERG) under contract to the Bureau of Ocean Energy Management (BOEM), is typically updated every three years. The 2014 GWEI was used because it was the closest available inventory year to the base case; ERG did not provide a mechanism to forecast to 2016. The report and data are divided into two parts: oil-and-gas exploration and production platform (point) sources, and non-platform (area) low-level sources.

Emissions are provided on a monthly basis for each of the twelve months. Diurnal curves to temporalize the emissions to hourly are not available for the 2014 GWEI, so curves developed for 2008 GWEI were used, as advised in ERG's documentation for the 2014 inventory (ERG, 2017). Table 2-2: *GWEI Platform Emissions Summary* summarizes the annual emissions in tons per year (tpy) from offshore point sources.

Table 2-2: GWEI Platform Emissions Summary

Year	CO (tpy)	NO_X (tpy)	VOC (tpy)	SO_2 (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)
2014	50,070	48,706	48,195	501.82	667.83	666.73

2.1.4.3 Mexico and Canada

The TCEQ used the 2016 NEIC platform vβ for Mexican and Canadian point source emissions. Mexican emissions were based on the 2008 Mexican NEI and originally projected to years 2014 and 2018. The emissions values from those two years were interpolated to 2016. Canadian emissions were based on the 2015 Canadian NEI and used directly for year 2016. More information, including details on speciation and temporalization can be found in the 2016 NEIC platform documentation for Canada and Mexico[5].

2.1.4.4 Other Countries

Anthropogenic point source emissions from other countries within the 36-km domain were processed by Ramboll under a TCEQ contract (Ramboll, 2019). Emissions were from the 2010 Emissions Database for Global Atmospheric Research (EDGAR) version 4.2 were processed using SMOKE and made into CAMx ready format.

2.1.5 Fires

Agricultural and forest fire emissions for 2016 were created from version 1.5 of the Fire Inventory from the National Center for Atmospheric Research, or FINN model. The fire emissions were downloaded in the Model for Ozone and Related chemical Tracers, version 4 (MOZART4) speciation format and were projected to the model's Lambert Conformal Conic modeling projection and grouped if fires were within 5 km. The fires were processed through EPS3 following the methodology of Environ (Environ, 2008). The fire emissions were temporally allocated according to the temperate North American cycle of fires from (Mu et al., 2011.)

[5] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_canada-mexico-point_15Sep2019.pdf

2.1.6 Summary of 2016 Base Case Point Sources

The base case point source emission files processed with EPS3 are presented in Table 2-3: *Base Case EPS3 AFS Files Used for the Annual January to December 2016 Episode*. EGU AFS files have hourly emissions, and the regional AFS files for the non-AMPD EGUs and the GWEI contain monthly emissions for the year. The Texas and regional non-EGU AFS files contain annual emissions. The Base Case point source AFS files are available at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/. Emissions for Mexico, Canada, and other countries within the 36-km domain were prepared outside of EPS3 and converted to CAMx ready format.

Table 2-3: Base Case EPS3 AFS Files Used for the Annual January to December 2016 Episode

Area	AFS Point Source Emissions File	Record Type
Texas	afs.re_annual_NEGU_for_2016_amp_based_on_2016v5a_stars_v2	Annual
Texas	afs.amp_01Jan_to_31Dec16_episode_all_pols_RPOlcp.v3	Hourly
Non-Texas	afs.2016_USA_noTX_nonEGU_CollabBeta16_v1and afs.2016_USA_noTX_ptOilGAS_CollabBeta16_v1	Annual
Non-Texas	afs.2016_USA_noTX_smallEGUs_CollabBeta16_v1	Monthly
Non-Texas	afs.amp_usa_episode_minus_TX_01jan_to_31dec16_lcpRPO_v2	Hourly
Non-Texas	afs.gwei.2014.lcpRPO	Monthly

The TCEQ chose a day in June as a representative day for reporting base case emissions totals. Table 2-4: *Base Case Texas Emissions Summary for June 14, 2016* summarizes the modeled Texas emissions of NO_X, VOC, CO, SO_2, NH_3, $PM_{2.5}$ and PM_{10} for that day. Table 2-5: Base Case Texas CAMx $PM_{2.5}$ Species Emissions for June 14, 2016 summarizes the modeled CAMx $PM_{2.5}$ species emissions for Texas. Note, emissions in summary tables represent EPS3 input, while emissions in tile plots above represent emissions after EPS3 processing.

Table 2-4: Base Case Texas Emissions Summary for June 14, 2016

Emission Source	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Non-EGUs	399.11	426.01	326.90	223.38	5.50	52.64	75.70
EGUs (AMPD)	384.85	9.34	542.24	893.41	3.80	44.83	57.62

Table 2-5: Base Case Texas CAMx $PM_{2.5}$ Species Emissions for June 14, 2016

Emission Source	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)
Non-EGUs	10.60	8.34	8.46	0.63	0.00	24.61
EGUs (AMPD)	13.65	6.24	4.57	0.42	0.00	19.95

Table 2-6: *Base Case Non-Texas CONUS Emissions Summary for June 14, 2016* summarizes the modeled non-Texas CONUS emissions of NO_X, VOC, CO, SO_2, NH_3, $PM_{2.5}$ and PM_{10} for that day. Table 2-7: *Base Case Non-Texas CAMx $PM_{2.5}$ Species Emissions for*

June 14, 2016 summarizes the modeled CAMx $PM_{2.5}$ species emissions for non-Texas CONUS.

Table 2-6: Base Case Non-Texas CONUS Emissions Summary for June 14, 2016

Emission Source	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Non-EGUs	3,258	2,206	4,207	1,8134	185.13	679.41	1,055
EGUs (AMPD)	3,287	69.10	1,289	3,714	51.20	362.90	450.90

Table 2-7: Base Case Non-Texas CAMx $PM_{2.5}$ Species Emissions for June 14, 2016

Emission Source	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)
Non-EGUs	128.90	58.94	82.17	6.35	2.59	298.47
EGUs (AMPD)	45.15	40.87	38.81	1.67	0.94	235.40

2.2 2028 FUTURE YEAR POINT SOURCE MODELING EMISSIONS DEVELOPMENT

To develop Future Case 2028 emissions, the most recent STARS data, year 2016, were used as the Projection Base for non-EGU projections in Texas, and 2028 emissions data from the 2016 NEIC platform vβ was used for non-EGUs for states outside of Texas. AMPD data from 2018 was used as a Projection Base for Texas EGUs and the Eastern Regional Technical Advisory Committee (ERTAC) projection model, based on year 2016 AMPD, was used for EGU emissions for states outside Texas. In general, Projection Base year emissions are grown to the attainment year and existing controls (in place prior to the future year) are applied.

The following sections describe development of the future year point source modeling emissions within the modeling domain for the annual January through December 2016 episode.

2.2.1 EGU Point Sources

Texas EGU emissions for 2028 were developed using 2018 AMPD, downloaded February 1, 2019, as the Projection Base. It was the latest complete year of AMPD data available at the time of modeling and was used instead of a projection tool. Other CONUS states' EGU emissions were developed using the ERTAC projection model[6]. For each month of the annual January through December 2028 future year episode, hourly NO_X emissions were averaged for each hour of the day for each unit, to create a monthly average day. For all units, the TCEQ generated hourly emissions for NH_3, CO, $PM_{2.5}$, and VOC for an average day using the pollutant to heat input ratios computed from reported emissions and heat input values. For Texas units, the pollutant to heat input ratio was computed from the 2016 STARS inventory year annual emissions, and annual heat input from 2018 AMPD. For units outside of Texas, the pollutant to heat input ratio was computed from the 2011 NEI year annual emissions, and annual heat input from 2028 ERTAC output. The ratios were applied to the hourly heat input from AMPD for Texas, and ERTAC output for the non-Texas CONUS, to calculate the hourly

[6] https://marama.org/technical-center/ertac-egu-projection-tool/

pollutant emissions. Growth in Texas EGUs is described below in Section 2.2.1.2 *Texas EGU Point Sources*, and non-Texas CONUS EGU projections are described below in Section 2.2.1.3 *EGU Point Sources Outside of Texas.* For all applicable sources, the TCEQ ensured the modeled emissions complied with the overall CSAPR state budget, described in Section 2.2.1.1 *CSAPR Update*.

2.2.1.1 CSAPR Update

On September 7, 2016, the EPA finalized the CSAPR Update Rule[7] to address interstate transport obligations related to the 2008 eight-hour ozone NAAQS. The CSAPR Update Rule finalized more stringent ozone season NO_X emissions state budgets for 22 states (including Texas). For this SIP revision, the future emissions of sources subject to the CSAPR ozone season (May through September) NO_X program in Texas and other states were computed while taking into consideration the CSAPR Update Rule provisions and budgets. CSAPR specified the ozone season NO_X and annual NO_X and SO_2 emissions caps for most AMPD EGUs in CSAPR states. The CSAPR Update state allocations files can be obtained at https://www.epa.gov/csapr/cross-state-air-pollution-rule-csapr-state-budgets-variability-limits-and-assurance-provisions.

2.2.1.2 Texas EGU Point Sources

The 2018 AMPD Projection Base data was modified to match the temporal pattern of 2016. The 2018 annual emission values were preserved and the TCEQ assumed growth for non-renewable EGUs would be accomplished with the addition of newly permitted EGUs since the projection base year of 2018. Retiring EGUs are also accounted for and in combination with the new units, net growth is established. The TCEQ prepared EGU emissions to meet the requirements of the Regional Haze and Interstate Visibility Transport Federal Implementation Plan[8] (FIP) finalized October 17, 2017. In it, the EPA issued final Best Available Retrofit Technology (BART) for EGUs (BART FIP), which included an alternative trading program for SO_2. The EPA administers the trading program, which includes only specific EGUs in Texas and no out-of-state trading. Additionally, all AMPD EGUs in Texas must meet the requirements of the ozone season (May-September) CSAPR Update described in Section 2.2.1.1. The projection base 2018 AMPD ozone season NO_X emissions for Texas EGUs was equivalent to the CSAPR ozone season state budget for Texas with just enough room to incorporate emissions from new EGUs as described below in *Newly Permitted and Retirement of Texas EGUs*. Therefore, the TCEQ modeled the hourly 2018 AMPD emissions for Texas plus newly permitted EGUs and planned shutdown units as future case 2028 emissions, accounting for the CSAPR Update and the SO_2 BART FIP.

Newly Permitted and Retirement of Texas EGUs

New EGUs were identified by researching and compiling data from various sources, which include the Electric Reliability Council of Texas (ERCOT), TCEQ air permitting projects with combustion turbines, TCEQ New Source Review Permits, and the U.S. Energy Information Administration (EIA). The criteria for adding new units are: (1) the units are expected to be operational before year 2028, (2) the owners applied for and were granted a TCEQ air permit, and (3) the owners obtained an Interconnection

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[7] https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
[8] 82 FR 48324

Agreement (IA) from ERCOT (for those units planned within the ERCOT grid). The TCEQ assumed that units with planned retirement dates prior to January 1, 2028 on EIA Form 860 (2017) or ERCOT's Capacity, Demand, and Reserves[9] (CDR) report (May 2019) would be retired.

ERCOT covers approximately 85% of the power grid in the state. For the six years between 2018 and the end of the ERCOT CDR planning period (2024), the TCEQ verified that all new units planned by ERCOT are accounted for. Between 2018 and 2024, the ERCOT CDR projected approximately 2,000 megawatts of new resources providing service to the grid and a reserve margin of approximately 8%. For the years between 2024 and 2028, the TCEQ expects continued growth in electric generation from renewables and natural gas units. Except for cogeneration units and solid waste incinerators, new fossil fueled units having greater than 25-megawatt nameplate capacity will be subject to the CSAPR Update caps limiting their NO_X emissions.

Newly permitted EGU emission rates were calculated based on the permit Maximum Allowable Emission Rates Table (MAERT), which is almost always greater than actual operating emissions. Pollutants acquired from the permits were NO_X, VOC, CO, $PM_{2.5}$ and SO_2. If available, maintenance, startup and shutdown (MSS) emission limits were included in the rates, which are especially important for peaking units that have many MSS events during the summer. Stack parameters and coordinate location information were obtained from the permits, and the newly permitted EGUs in Texas were modeled at the locations specified in the permit applications. The temporal distributions of the newly permitted EGU emissions are based on those of existing units of similar equipment type or SCCs. For each SCC included in the newly permitted EGU list, an average temporal distribution was calculated, based on diurnal profiles of existing units with the same SCC within the state.

All data sources were reconciled to ensure all units were accounted for, and that their status as of August 2019 was modeled. The list of newly permitted EGUs added to the projection base for Texas, sorted by county, is provided in Table 2-8: *Newly Permitted EGUs (post 2018) in Texas as of August 2019*.

[9] http://www.ercot.com/gridinfo/resource/index.html

Table 2-8: Newly Permitted EGUs (post 2018) in Texas as of August 2019

Site Name	County	EPN	Modeled NO_X (tpd)	Modeled SO_2 (tpd)	Modeled $PM_{2.5}$ (tpd)
Halyard Wharton Energy Center	Wharton	CTG1	0.76	0.01	0.10
Halyard Wharton Energy Center	Wharton	CTG2	0.76	0.01	0.10
Halyard Henderson Energy Center	Henderson	CTG1	0.76	0.01	0.10
Halyard Henderson Energy Center	Henderson	CTG2	0.76	0.01	0.10
FGE Texas	Mitchell	GT1	0.31	0.10	0.20
FGE Texas	Mitchell	GT2	0.31	0.10	0.20
Ineos Chocolate Bayou	Brazoria	Turbine1	0.11	0.00	0.08
Ineos Chocolate Bayou	Brazoria	Turbine2	0.11	0.00	0.08
Victoria City Peaking Facility	Victoria	1	0.10	0.07	0.04
Victoria City Peaking Facility	Victoria	2	0.10	0.07	0.04
Victoria Port Peaking Facility	Victoria	1	0.10	0.07	0.04
Victoria Port Peaking Facility	Victoria	2	0.10	0.07	0.04

The NO_X, SO_2, and $PM_{2.5}$ emission rates in Table 2-8 reflect the calculated NO_X, SO_2, and $PM_{2.5}$ emissions from permit applications and MAERTs, and the inclusion of existing rules that may apply to the EGUs. The TCEQ assumed NO_X controls, offsets, or credit purchases will be used if necessary, to meet these NO_X emissions rates. VOC and CO rates are modeled at their permitted levels.

EGUs scheduled to be shutdown prior to January 1, 2028 were removed from the future case if such status was determined by ERCOT or other grid operators. EGUs scheduled to be mothballed or placed on Reliability Must Run (RMR) status were not removed as their status is subject to change. The list of EGUs that operated in 2018 but have shut down or are scheduled to shutdown prior to January 1, 2028 are listed in Table 2-9: *EGUs Scheduled to Shutdown Prior to January 1, 2028*. Note, the Monticello coal-fired plant retired in 2017, thus does not have 2018 AMPD data.

Table 2-9: EGUs Scheduled to Shutdown Prior to January 1, 2028

Site Name	County	Plant ID	Boiler ID	Fuel Type	ERCOT Operation Notice
Big Brown	Freestone	3497	1	Coal	M-C101317-02
Big Brown	Freestone	3497	2	Coal	M-C101317-02
Sandow	Milam	6648	4	Coal	M-A101317-02
Sandow Station	Milam	52071	5A	Coal	M-B101317-02
Sandow Station	Milam	52071	5B	Coal	M-B101317-02
Gibbons Creek	Grimes	6136	1	Coal	W-B062819-01

After modeling was completed, on April 30, 2020 ERCOT approved an interconnection agreement for Gibbons Creek. On May 13, 2020, the plant appeared on ERCOT's preliminary planned resource adequacy table, and on that same date appeared on their CDR report, showing the unit's availability for the summer of 2021 and onward. Gibbons Creek averaged 333 tpy of SO_2 during its most recent 5 years of operation, 2014 to 2018. In its last year of operation (2018), it ran approximately 2,700 hours, all during May through September, and emitted 271 tons of SO_2.

Gibbons Creek was included in the area of influence analysis areas for Caney Creek and Wichita Mountains based on its ERTAC-forecasted 2028 SO_2 emissions, 109 tpy, placing in the lowest 2% of ranked SO_2 sources for Caney Creek and the lowest 4% of such sources for Wichita Mountains. See Section 7.2.1 *Area of Influence and Q/d Analysis for Source Selection* of the Regional Haze SIP documentation for a description of this analysis. Therefore, not including it in the modeling is not anticipated to affect the results.

Figure 2-9: *Tile Plot of Texas EGU NO_X Emissions for a Sample June Day in 2028* and Figure 2-10: *Tile Plot of Texas EGU SO_2 Emissions for a Sample June Day in 2028* are maps of Texas EGU NO_X and SO_2 emissions for a sample June day in 2028, respectively.

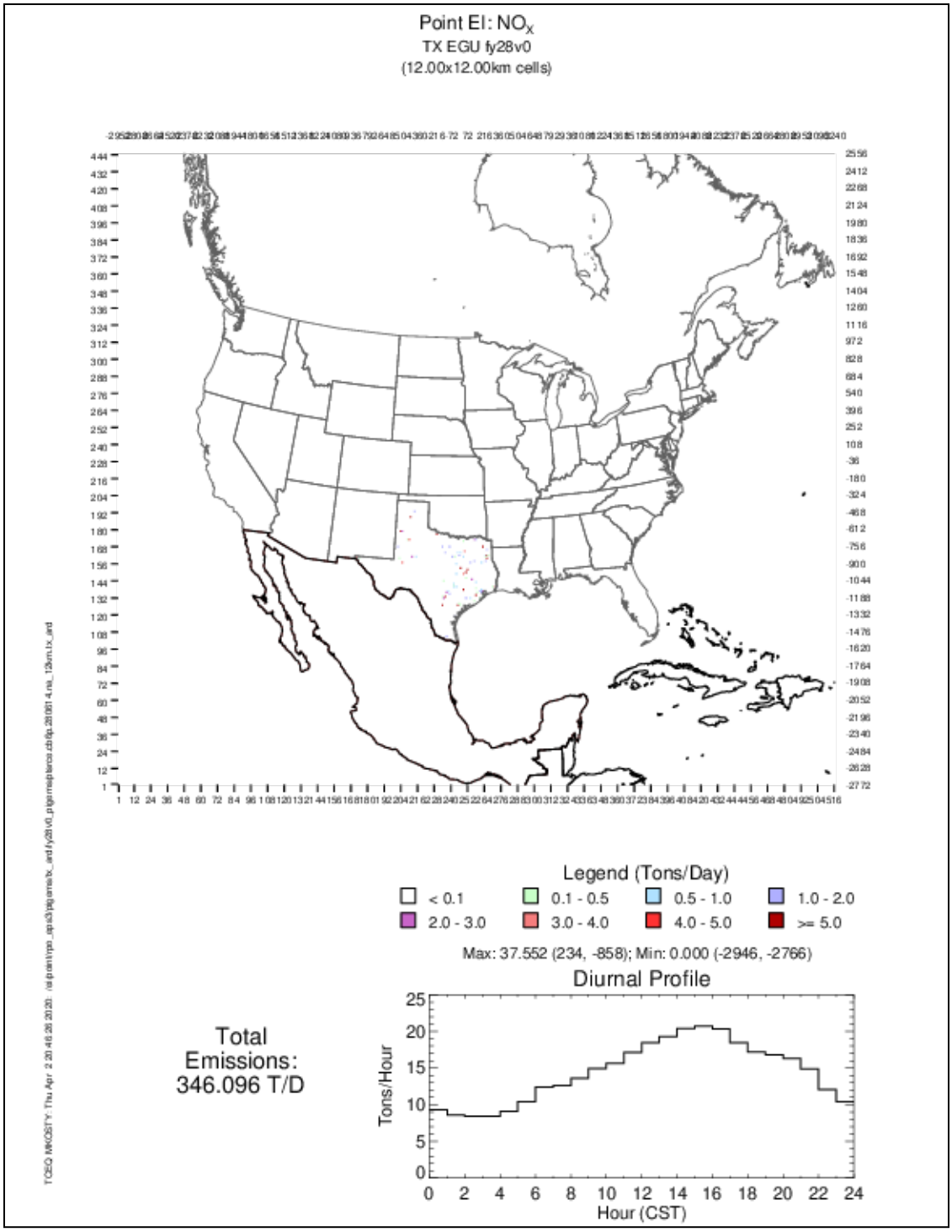

Figure 2-9: Tile Plot of Texas EGU NO_X Emissions for a Sample June Day in 2028

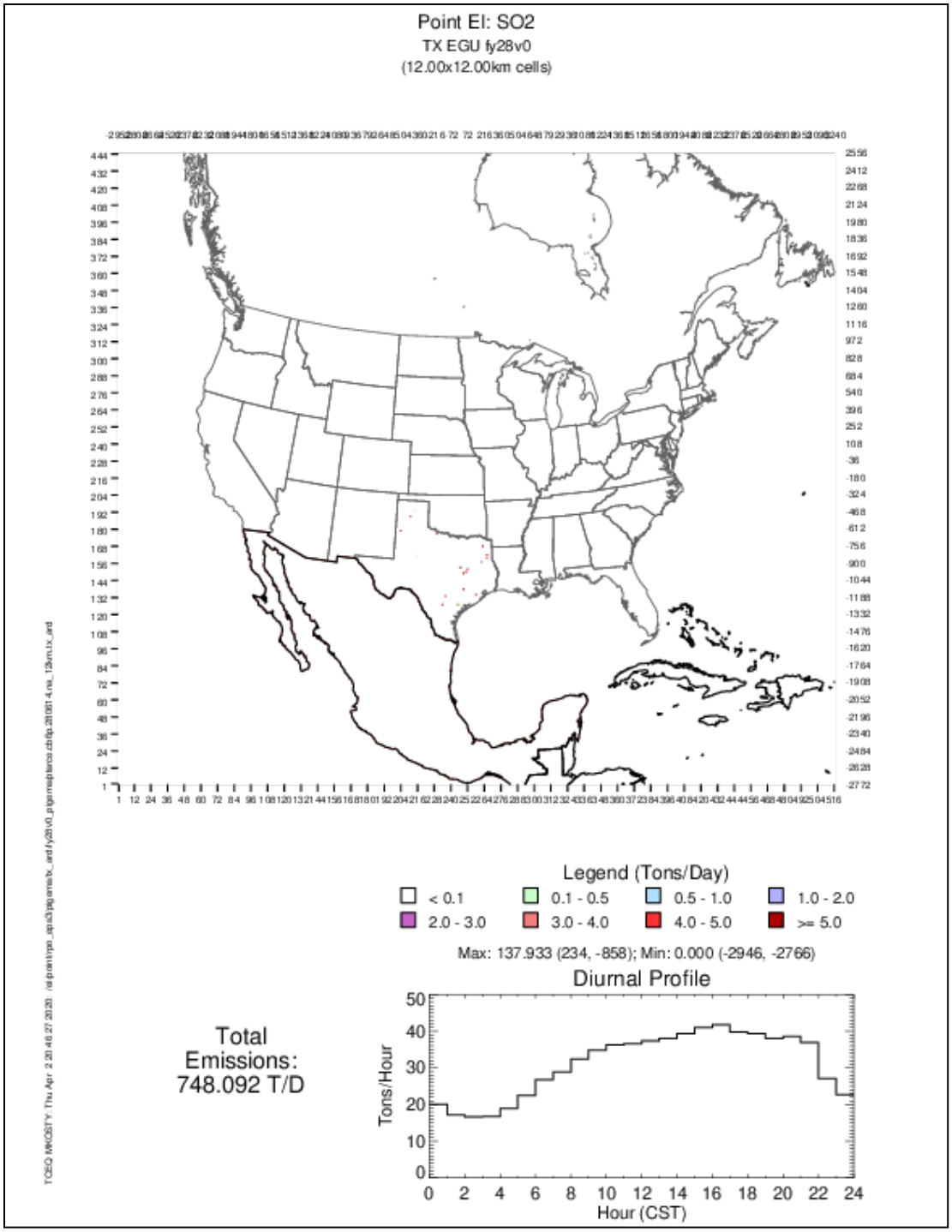

Figure 2-10: Tile Plot of Texas EGU SO_2 Emissions for a Sample June Day in 2028

2.2.1.3 EGU Point Sources Outside of Texas

To develop the 2028 future year EGU emissions for states outside of Texas, the TCEQ used Version 16.0 of the ERTAC[10] EGU projection model, released in May 2019. This version used year 2016 AMPD hourly data as a base year to project EGU growth. The model used annual growth factors from the EIA Annual Energy Outlook (AEO) 2018, and peak growth factors from North American Electric Reliability Corporation (NERC) 2017. The model creates hour-specific growth rates based on several factors, such as the hourly base year generation profile for the region, and fuel/unit type. In addition to the 2016 base year data and growth factors, the model uses information compiled from 2018 AMPD, National Electric Energy Data System (NEEDS) database, the EIA Form 860, and the latest (2018-2019) state supplied information. If existing and planned future year EGUs fail to meet demand, the model creates generation deficit units (GDUs) of specific fuel/unit types in specific regions. Model output is unit level hourly heat input and emissions of NO_X and SO_2 for the future year. The TCEQ ensured that the ERTAC model output met the requirements of the CSAPR Update Rule described in Section 2.2.1.1.

Figure 2-11: *Tile Plot of non-Texas CONUS EGU NO_X Emissions for a Sample June Day in 2028* and Figure 2-12: *Tile Plot of non-Texas CONUS EGU SO_2 Emissions for a Sample June Day in 2028* are maps of non-Texas CONUS EGU NO_X and SO_2 emissions for a sample June day in 2028, respectively.

[10] https://marama.org/technical-center/ertac-egu-projection-tool/

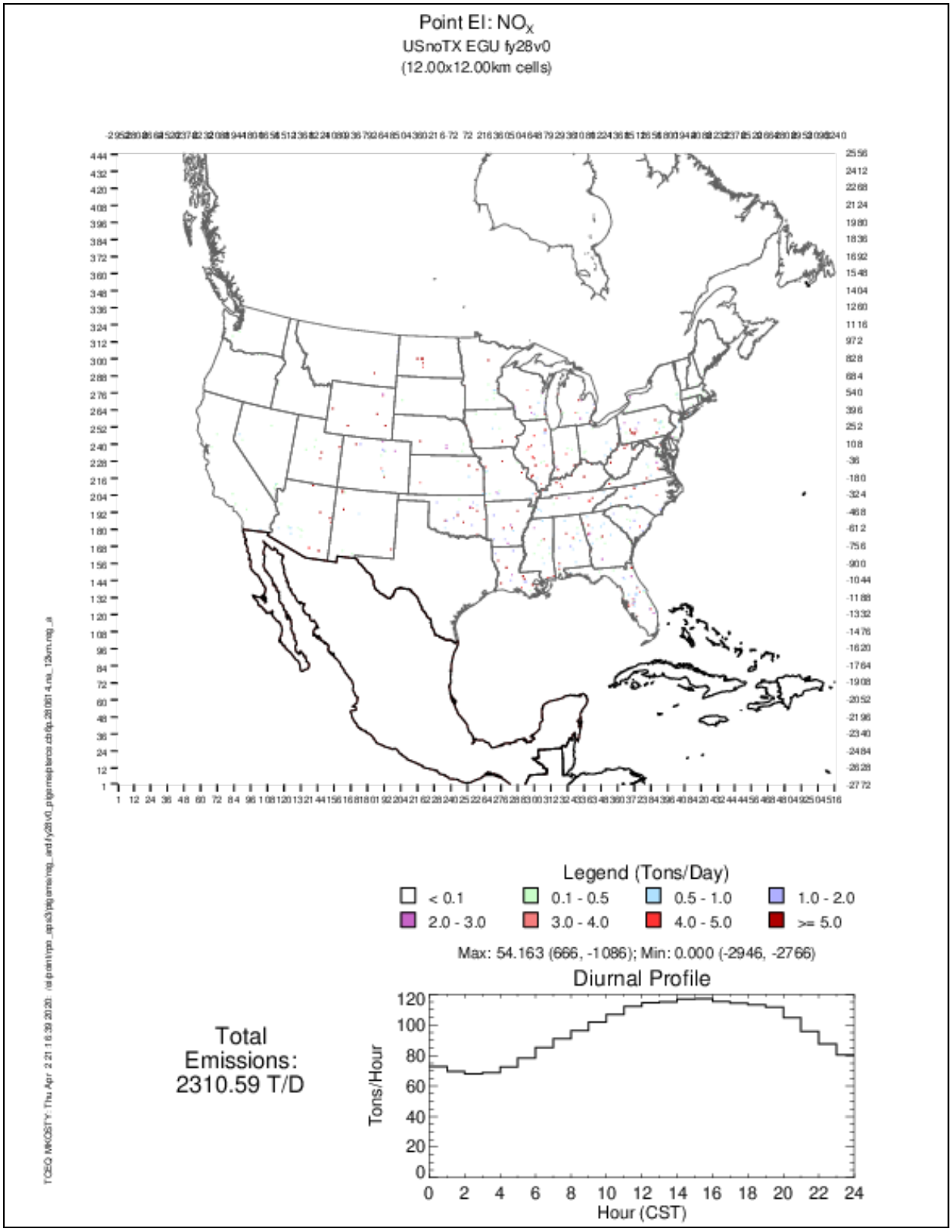

Figure 2-11: Tile Plot of non-Texas CONUS EGU NO_x Emissions for a Sample June Day in 2028

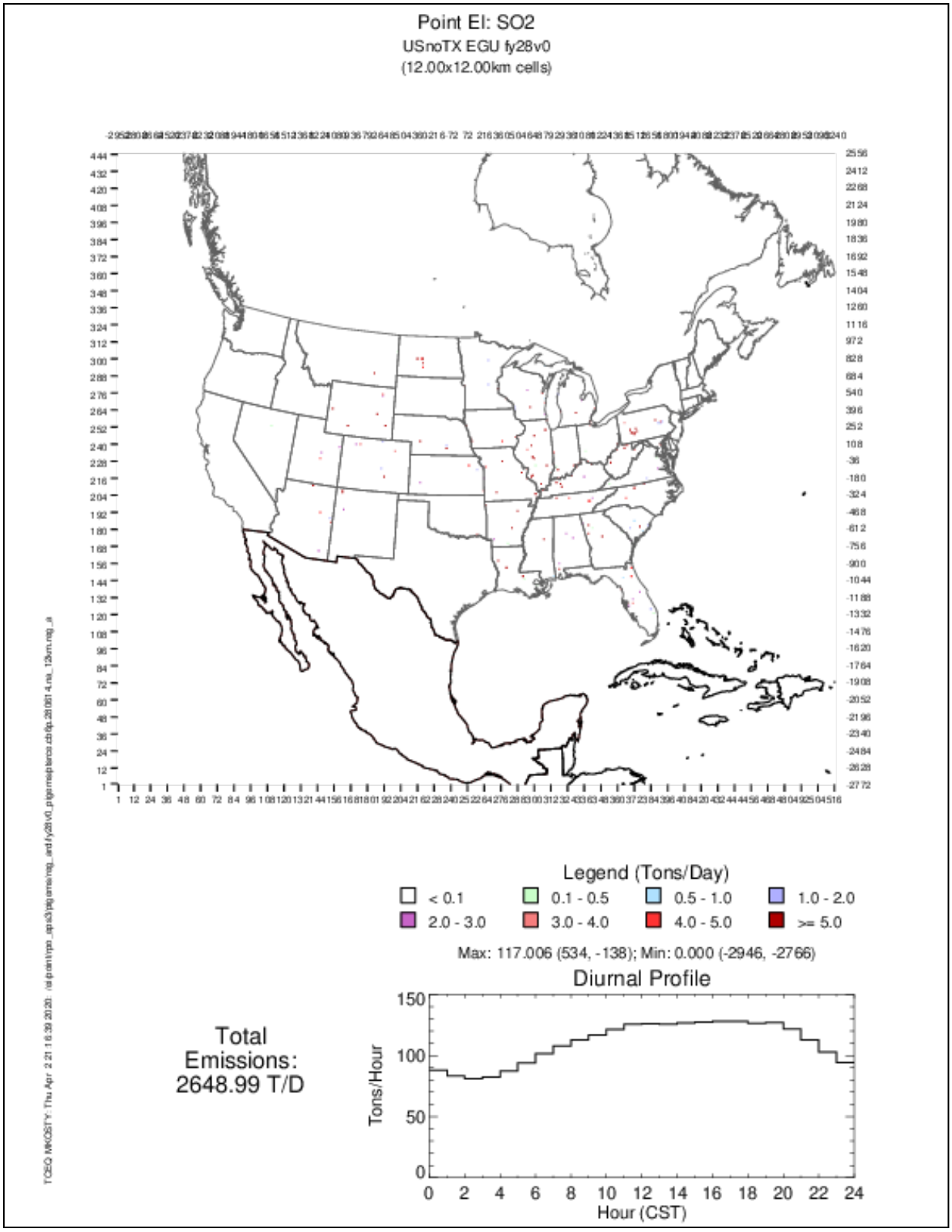

Figure 2-12: Tile Plot of non-Texas CONUS EGU SO_2 Emissions for a Sample June Day in 2028

2.2.2 Texas Non-EGU Point Sources

This section details how future year emissions for Texas non-EGUs were estimated. Texas non-EGU sources were separated into non-EGU sources in attainment counties, non-EGU sources subject to cap-and-trade-programs, and non-EGU in the HGB and DFW nonattainment areas.

2.2.2.1 Non-EGU Sources in Attainment Counties

For the Texas Non-EGU point sources located in attainment counties, the TCEQ estimated the 2028 future year emissions by starting with the 2016 Projection Base STARS extract and projecting it to 2028 using growth factors developed by ERG in 2016 under contract to the TCEQ (ERG, 2016). The ERG growth factors are based on county or Federal Information Processing Standard (FIPS) codes and Standard Industrial Classification (SIC) codes. The TCEQ applied growth factors to all 2016 STARS emissions paths. The ERG data provided growth factors for most of the STARS paths (uniquely identified by FIPS, plant, stack and point). In situations where there was not a FIPS/SIC growth factor, the emissions path was assigned a growth factor equal to the SIC average for the state. If there was no SIC match, the next default applied was the county (FIPS) average growth, and then the statewide average. All pollutants for a path were assigned the same growth factor, since the growth factors are percentages by which the Projection Base emissions are grown (or reduced), on a county/SIC basis.

2.2.2.2 Non-EGU Sources Subject to Cap-and-Trade Programs

The TCEQ administers three cap-and-trade programs in Texas: (1) the Emissions Banking and Trading (EBT) of Allowances program (also known as the SB7 program for EGUs) for SO_2 and NO_X emissions, (2) the MECT program for NO_X emissions in the HGB nonattainment area, and (3) the HECT program for highly reactive VOC (HRVOC) emissions in Harris County. The TCEQ estimates future year emissions for Texas non-EGU sources subject to these cap-and-trade programs by taking into consideration the appropriate program's total future year cap, the trading history of subject sources, and other provisions of the program. If multiple programs cover a set of sources, the program with the most stringent emissions restrictions is modeled. The SB7 program, which affects Texas EGUs, is not modeled as it is less stringent than the federal CSAPR (see Section 2.2.1.2 *Texas EGU Point Sources*). Therefore, the two Texas cap-and-trade programs applied to the 2028 future year are MECT for the HGB area NO_X emissions, and HECT for Harris County HRVOC emissions. Additionally, separate NO_X caps apply to certain kilns in the DFW area.

MECT

The MECT program is a market-based cap-and-trade program administered by the TCEQ that implements the annual NO_X emission caps for applicable sources in HGB, as specified in 30 TAC §101.351. Sites with MECT-applicable point sources comply with the source category NO_X emissions limits in 30 TAC Chapter 117. The TCEQ allocates a specific amount of NO_X allowances to each applicable point source (i.e., piece of equipment) at a site (account) for each compliance year. To comply with the MECT program, each site in the MECT program must have enough MECT allowances to cover the total annual NO_X emissions from all its MECT sources. The MECT program allows the banking and trading of MECT allowances between subject sources and unused

MECT allowances can be banked for one additional compliance year. Details about the MECT program can be found 30 TAC Chapter 101, Subchapter H, Division 3.

The MECT cap of 40,248.7 tpy, or 110.3 tpd, from allocations was used in this SIP revision. In addition to the allocation portion of the MECT cap, the MECT program allows the use of certain Emission Reduction Credits (ERCs), specifically Discrete ERCs (DERCs) and Mobile DERCs (MDERCs) for MECT compliance. To account for the possible use of DERCs and MDERCs to cover emissions from MECT subject sources, an additional 1,230.4 tpy, or 3.4 tpd, of emissions was added to the MECT cap for a total of 41,479.1 tpy. The method used to determine this quantity is described below in Section 2.2.2.3 *Non-EGU Sources in Nonattainment Areas*. Because some MECT sites sell all or a portion of their allowances each year permanently via "stream trades," MECT source emissions were modeled using a more spatially realistic future year distribution. More detail about how the MECT cap is applied to future year model emissions can be found in the Bexar County 179B SIP Revision documentation (TCEQ, 2020).

HECT

The HECT program limits HRVOC (ethylene, propylene, butadiene, and all isomers of butene) emissions discharged from applicable point sources in Harris County as specified in 30 TAC §101.391. The HECT cap applies to HRVOC emissions from sources such as flares, non-tank stacks, and cooling tower emissions.

The HECT applicable source emissions were first grown to 2028 using the point source growth factors. The grown emissions were then compared to the HECT caps to determine whether the emissions exceed or are below the cap. The grown HRVOC emissions for all applicable sources exceeded the cap, therefore the HECT sources were cap limited in this SIP revision. More details about the HECT program can be found 30 TAC Chapter 101, Subchapter H, Division 6.

DFW Cement Kilns

Holcim's cement kilns were modeled at the account-specific NO_X cap specified in 30 TAC §117.3123. Modeled emissions for TXI and Ash Grove's kilns were based on NO_X per ton clinker limits specified in agreed orders and permitted production limits. The future year emissions for all other pollutants from the kilns were determined using growth factors, as described in Section 2.2.2.3 *Non-EGU Sources in Nonattainment Areas*.

2.2.2.3 Non-EGU Sources in Nonattainment Areas

Nonattainment New Source Review (NNSR) permitting requires major sources of emissions in nonattainment areas to offset any growth in their emissions of ozone precursors, NO_X and VOC. Sources subject to cap-and-trade programs are allowed to use allowances to offset their emissions growth for the subject pollutant. Sources that are not subject to cap-and-trade programs are required to offset their emissions growth either by purchasing certified credits (ERCs, DERCS, and MDERCs) available in the TCEQ's Emission Credit and Discrete Emission Credit Registries (EBT Credit Registry) or by making contemporaneous period (internal) reductions. Hence, the total certified credits available in the TCEQ's EBT Credit Registry could limit the projected emissions growth estimated using the ERG growth factors.

To estimate the future year emissions of non-EGUs in nonattainment areas that are not subject to cap-and-trade programs or site-level caps, the TCEQ used the more restrictive of the projected growth or the certified credits available in the TCEQ's EBT Credit Registry. If enough certified credits were available in the TCEQ's EBT Credit Registry, the 2028 emissions of non-EGU point sources not subject to cap-and-trade programs or site caps were limited to growth projected using ERG growth factors. Otherwise the 2028 emissions were limited to the total certified credits available in the TCEQ's EBT Credit Registry. This section details the analysis done by the TCEQ to determine if 2028 emissions from non-EGUs in nonattainment areas that are not subject to cap-and-trade programs or site-level caps will be limited by the available certified credits in the TCEQ's EBT Credit Registry.

To begin, the certified credits for HGB and DFW were extracted from the EBT Credit Registry (available at the webpage http://www2.tceq.texas.gov/airperm/index.cfm?fuseaction=ebt_dpa.reg) on 7/18/2019. The next step was to incorporate applicable rules for NNSR permit offsetting and compliance. In the HGB nonattainment area, NO_X DERCs/MDERCs can, with certain restrictions, be used for compliance with the MECT program. Since NO_X DERCs/MDERCs used for MECT compliance will not be available for offsetting, the appropriate amount of NO_X DERCs/MDERCs were deducted from the total NO_X DERCs/MDERCs that could represent growth in HGB. The HGB NO_X DERCs/MDERCs deducted for compliance with the MECT program was 3.4 tpd, as described in Section 2.2.2.2 *Non-EGU Sources Subject to Cap-and-Trade Programs* and is in line with the requirements for DERC/MDERC use for MECT compliance specified in 30 TAC §101.356. In the DFW nonattainment area, the use of NO_X DERCS is limited to 17.0 tpd by the DERC Flow Control Rule in 30 TAC §101.376. Since the certified NO_X DERCs in the EBT Registry at the time of this analysis (17.3 tpd) were more than the 17.0 tpd regulatory limit, the DERC Flow Control Rule limited the potential certified credits available for offsetting growth in 2028.

Lastly, the certified credits were discounted by the applicable Nonattainment NSR offset ratio. The remaining balance of certified credits was considered the Modelable Bank and represents the maximum amount of emissions that could potentially be added as growth to each area in 2028 from certified credits. Table 2-10: *Modelable Bank Analysis for Future year 2028* depicts the process followed to determine the potential certified credits available in the EBT Credit Registry in 2028.

Table 2-10: Modelable Bank Analysis for Future year 2028

NAA	NO_X ERCs (tpy)	VOC ERCs (tpy)	NO_X DERCs (tons)	VOC DERCs (tons)	Modelable NO_X Bank (tpd)	Modelable VOC Bank (tpd)
HGB Registry as of July 18, 2019	121.00	746.70	30,868	1,753		
DFW Registry as of February 26, 2019	43.00	23.20	5,725	8.50		
HGB DERCs/MDERCs used for MECT Compliance			1,240		3.40	
HGB Discounted Registry	100.80	622.30	17,390	1,460	0.30 ERCs 47.60 DERCs	1.70 ERCs 4.00 DERCs
DFW Discounted Registry	35.80	19.30	4,771	7.10	0.10 ERCs 17.00 DERCs	0.10 ERCs 0.03 DERCs

To determine the 2028 emissions for non-EGUs in nonattainment areas that are not subject to cap-and-trade programs, the Modelable Bank values in Table 2-10 were compared to the projected growth. If there were enough credits in the Modelable Bank to cover all the projected growth, then future year emissions were based on Projection Base year emissions (2016 STARS extract) being grown using the ERG growth factors. If there were not enough credits in the Modelable Bank to cover the projected growth, then the future year emissions were limited by the Modelable Banked credits. Historically, ERCs have been preferred for use as offsets in NNSR permitting. Therefore, it is assumed that ERCs will be used to cover as much of the projected growth as possible, with DERCs being used to cover the remaining projected growth. The resulting Modelable Bank emissions for 2028 and the predicted growth values for 2028 are depicted in Table 2-11: *Comparison of the 2028 Modelable Bank and Predicted Growth*.

Table 2-11: Comparison of the 2028 Modelable Bank and Predicted Growth

Area	Pollutant	2028 Modelable Bank (tpd)	2028 Predicted Growth (tpd)	2028 Limiting Attribute
HGB	NO_X	0.30 ERCs and 47.60 DERCs	4.63	Growth
HGB	VOC	1.70 ERCs and 4.00 DERCs	33.53	Bank
DFW	NO_X	0.10 ERCs and 17.00 DERCs	-4.43	Growth
DFW	VOC	0.10 ERCs and 0.03 DERCs	1.69	Bank

2.2.2.4 Summary of Texas Non-EGU Point Sources

Projected growth, cap-and-trade programs, cement kiln account caps and related agreed orders, and nonattainment NSR offsetting requirements were used to develop non-EGU future year emissions for Texas. The projected growth factors were only applied to the sources that were not otherwise limited by existing TCEQ rules or constrained by emissions caps. The HGB and DFW modelable banked emissions and projected growth were compared on a path-by-path basis, automated with programming. Future year emissions were limited to the smaller amount. A path's

share of the bank, based on its fractional emissions of the total, was added to that path's emissions to account for growth.

Figure 2-13: *Tile Plot of Texas Non-EGU NO_X Emissions for a June Day in 2028* and Figure 2-14: *Tile Plot of Texas Non-EGU SO_2 Emissions for a June Day in 2028* are maps of the future year 2028 gridded low-level Texas non-EGU NO_X and SO_2 emissions, respectively.

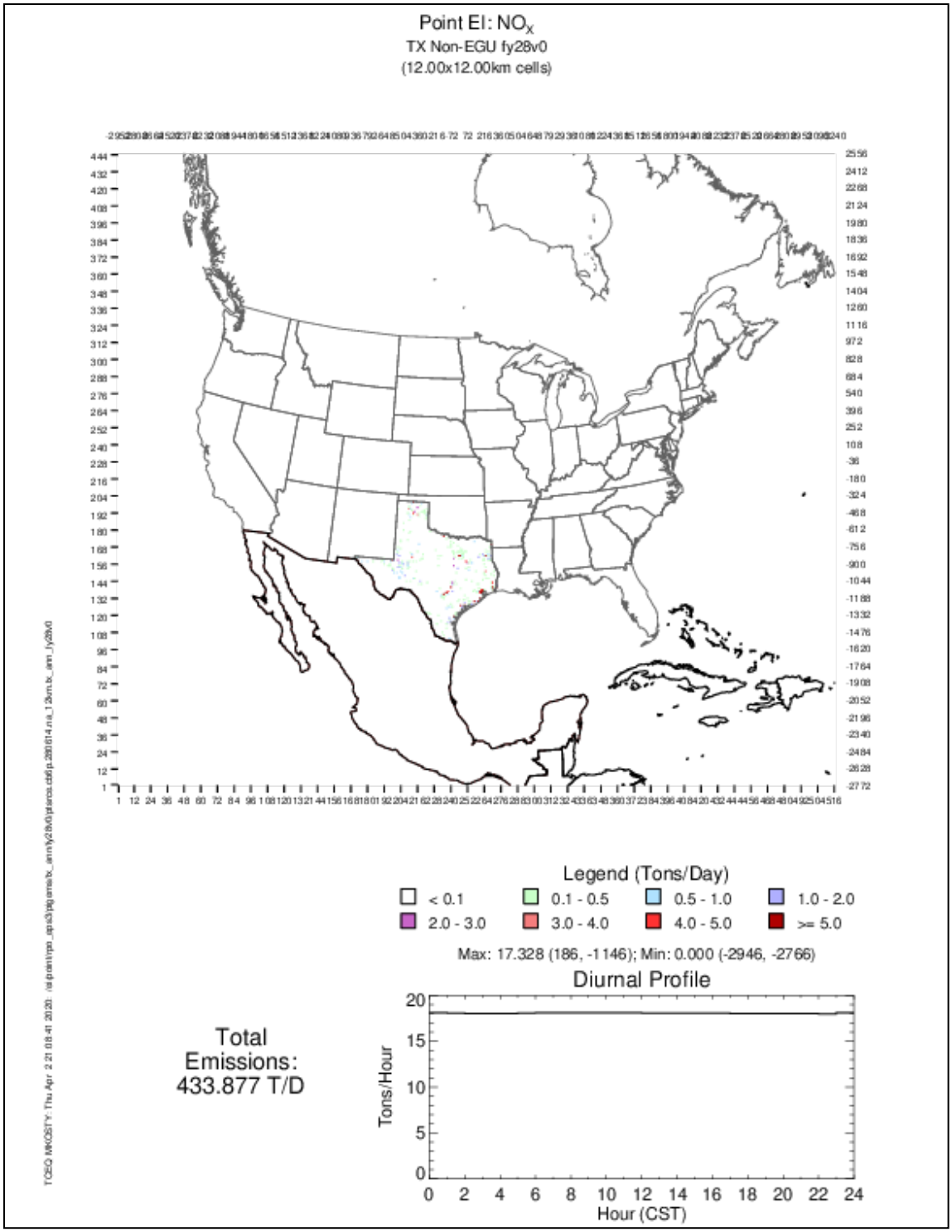

Figure 2-13: Tile Plot of Texas Non-EGU NO_x Emissions for a June Day in 2028

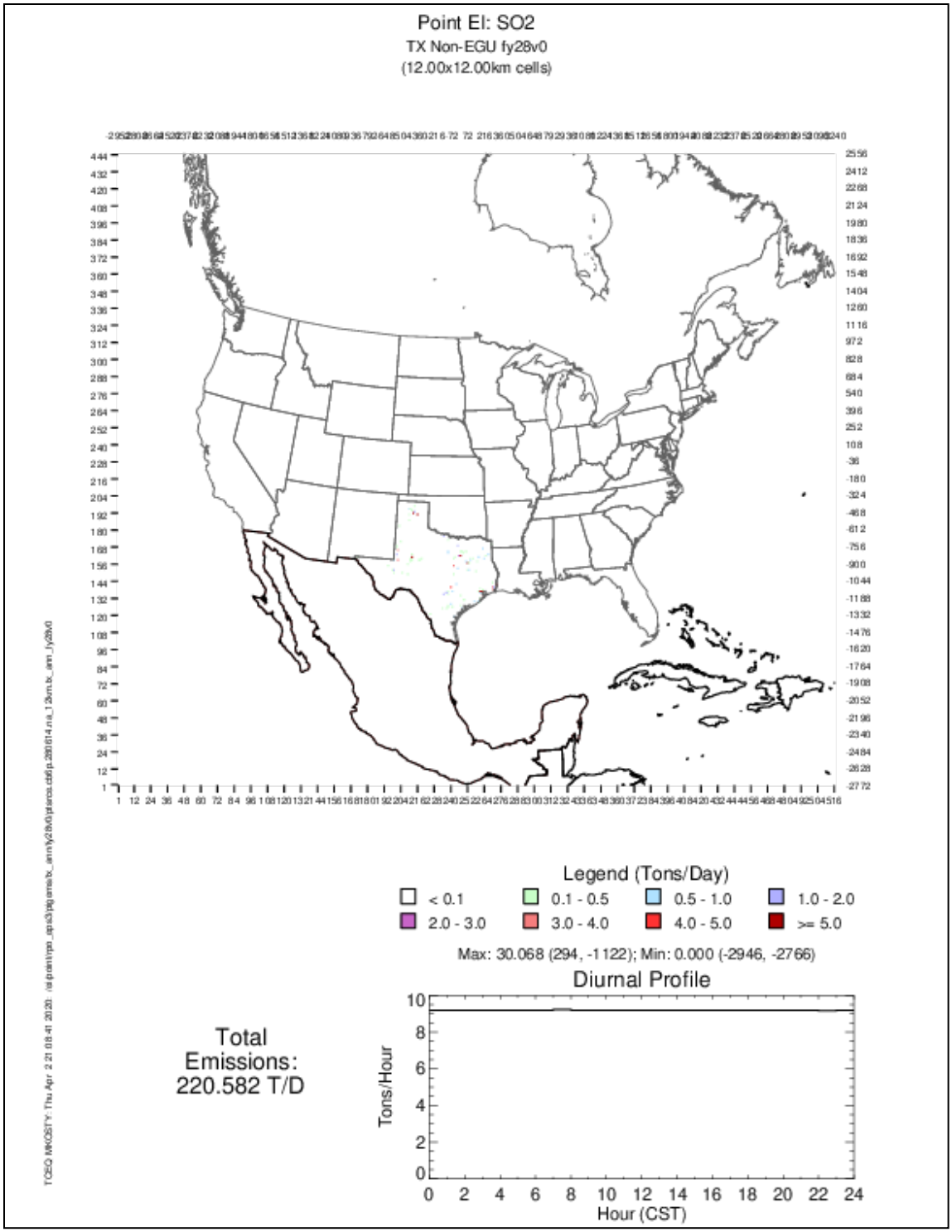

Figure 2-14: Tile Plot of Texas Non-EGU SO_2 Emissions for a June Day in 2028

2.2.3 Other Point Sources Outside of Texas

This section discusses the point source modeling emissions development for areas outside of Texas but within the modeled CAMx domain. Note, the non-Texas CONUS

EGUs are discussed in Section 2.2.1.3 *EGU Point Sources Outside of Texas* above. This section describes the following areas:

- CONUS Non-EGUs;
- Offshore (Gulf of Mexico);
- Mexico and Canada; and
- Other Countries.

2.2.3.1 CONUS Non-EGUs

The 2016 NEIC platform vβ was used for 2028 future case emissions, for non-EGU point sources in states outside of Texas. The non-EGU point source files consist of all non-EGU point sources not associated with oil-and-gas activity. Point source emissions from airports and railyards are separated and treated as low-level sources. The oil-and-gas point source file contains oil-and-gas sources in CONUS, and oil-and-gas sources operating in the federal waters of the Gulf of Mexico. The Gulf of Mexico sources were removed and prepared separately as described in Section 2.1.4.2. The temporal allocation file for SMOKE was converted to EPS3 format and used to create the daily-varying temporal distribution of emissions, based on SCC and county, for each day of the episode.

EGUs that do not report hourly varying emissions to AMPD are also included in this category. Temporal profiles from the 2016 NEIC platform vβ are used to create monthly files for the non-AMPD units, with daily emissions for a given month being the same.

For non-Texas CONUS non-EGU point sources, the TCEQ chose a day in June to represent a typical episode day. Figure 2-15: *Tile Plot of Non-Texas CONUS NO_X Emissions for a June Day in 2028* and Figure 2-16: *Tile Plot of Non-Texas CONUS SO_2 Emissions for a June Day in 2028* are maps of non-Texas CONUS combined low-level and elevated NO_X and SO_2 emissions for a June day in 2028, respectively.

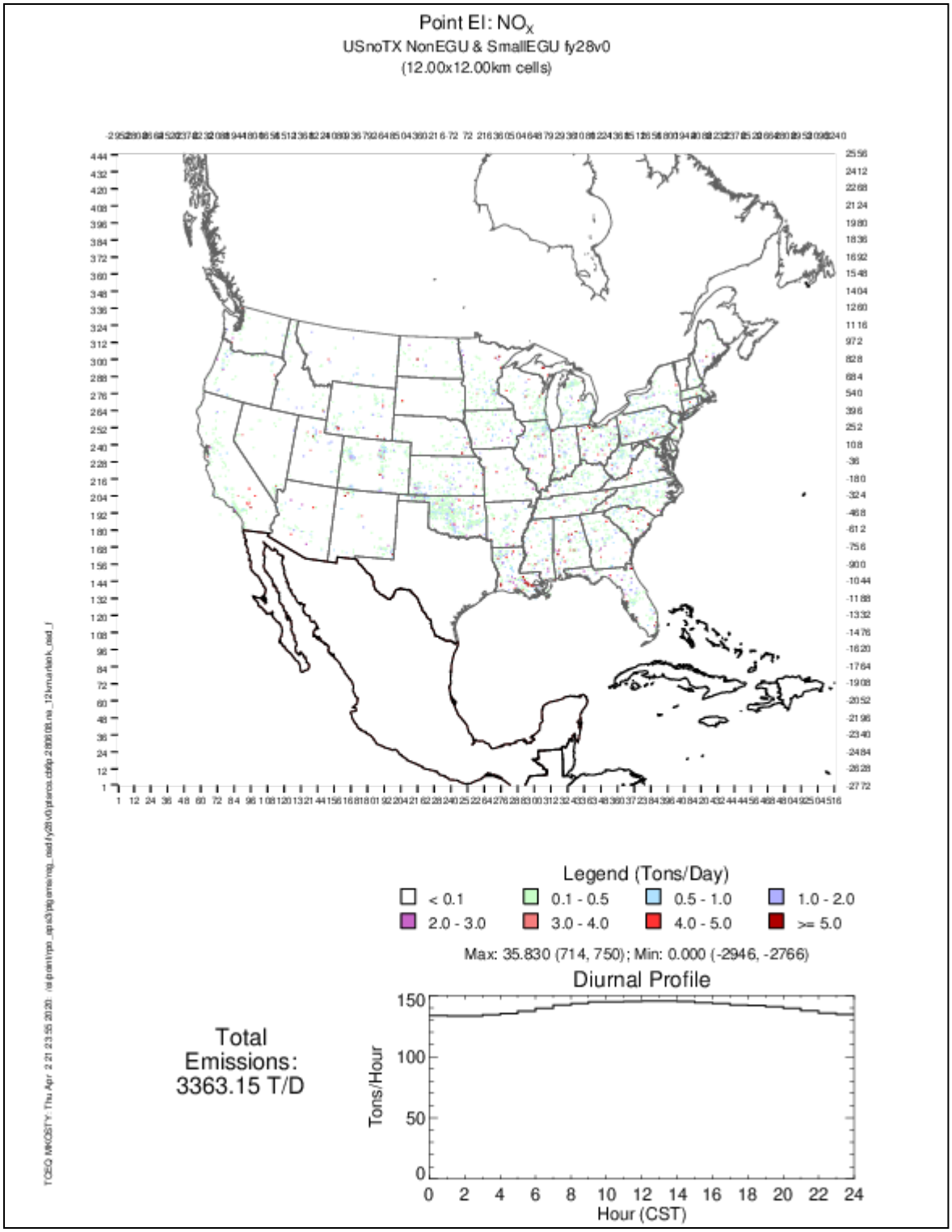

Figure 2-15: Tile Plot of Non-Texas CONUS NO_x Emissions for a June Day in 2028

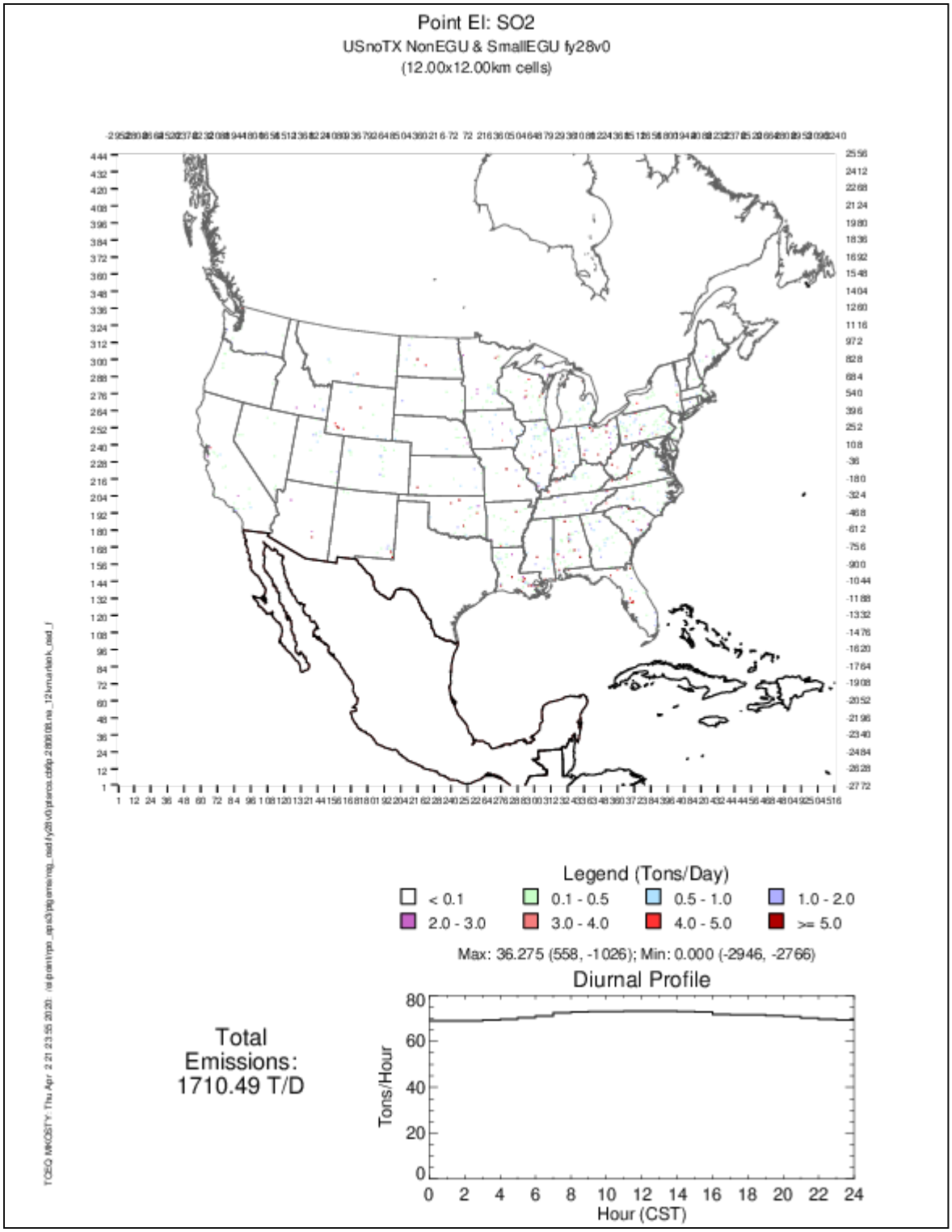

Figure 2-16: Tile Plot of Non-Texas CONUS SO_2 Emissions for a June Day in 2028

2.2.3.2 Offshore (Gulf of Mexico)

The TCEQ used the 2014 GWEI for the 2028 Gulf of Mexico offshore emissions inventory, the same as was used in the base case. At the time the modeling for this SIP was performed, the 2017 GWEI was not finalized. More information on the 2014 GWEI can be found in Section 2.1.4.2.

2.2.3.3 Mexico and Canada

The TCEQ used the 2016 NEIC beta-prime version (vβ-prime) (2028fg) for future year 2028 Mexican and Canadian emissions. The 2028fg inventory includes a reduction in Canadian dust emissions as well as an improvement to the spatial allocation of Canadian agricultural emissions compared to the 2016 NEIC vβ (2028ff) inventory (EPA, 2019).

Mexican emissions were based on the 2008 Mexican NEI and were originally projected to years 2025 and 2030. The 2028 emissions were derived by interpolating between 2025 and 2030. Canadian emissions were based on the 2015 Canadian NEI, and projection data was provided by Environment and Climate Change Canada (ECCC) for 2028. Mexican and Canadian point source emissions files were in the Community Multi-scale Air Quality (CMAQ) format and converted to CAMx ready format with the CMAQ2CAMX utility program (Ramboll, 2016).

2.2.3.4 Other Countries

Anthropogenic point source emissions from other countries within the 36-km domain were processed by Ramboll under a TCEQ contract (Ramboll, 2019). Emissions were from the 2010 Emissions Database for Global Atmospheric Research (EDGAR) version 4.2 were processed using SMOKE and made into CAMx ready format.

2.2.4 Summary of Future Case Point Source Data Files

The future year point source emission files processed with EPS3 are presented in Table 2-12: *Future Case EPS3 AFS Files Used for the Annual January to December 2028 Episode*. EGU AFS files have hourly emissions, the regional AFS files for the non-AMPD EGUs and the GWEI contain monthly emissions for the year, and the Texas and regional non-EGU AFS files contain annual emissions. The 2028 Future Case point source AFS files are available at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/. Emissions for Mexico, Canada, and other countries within the 36-km domain were prepared outside of EPS3 and converted to CAMx ready format.

Table 2-12: Future Case EPS3 AFS Files Used for the Annual January to December 2028 Episode

Area	AFS Point Source Emissions Dataset	Record Type
Texas	afs.{jan...dec}2028_b16_TX_EGUs.RPOlcp	Hourly
Texas	afs.osd_uncontrolled_2028_growth_recs_final	Annual
Texas	afs.2028_HECT_cap_n_trade_HarrisCo_2016_basis_all_pts_v2	Annual
Texas	afs.DFW_HGB_growth_with_bank_credits_final	Annual
Texas	afs.negu_mect_FY2028_HARD_CAP_final	Annual
Texas	afs.midlothian_kiln_2028_agreed_orders_final	Annual
Regional	afs.{jan...dec}2028_b16_USA_EGUs.RPOlcp	Hourly
Regional	afs.2028_USA_noTX_nonEGU_collab_ff_beta_v1 and afs.2028_USA_noTX_ptOilGas_collab_ff_beta_v1	Annual
Regional	afs.2028_USA_noTX_smallEGUs_collab_ff_beta_v1	Monthly
Regional	afs.gwei.2014.lcpRPO	Monthly

The TCEQ chose a day in June as a representative day for reporting future case emissions totals. Table 2-13: *Future Case Texas Emissions Summary for June 14, 2028* summarizes the modeled Texas emissions of NO_X, VOC, CO, SO_2, NH_3, $PM_{2.5}$ and PM_{10} for that day. Table 2-14: *Future Case Texas CAMx $PM_{2.5}$ Species Emissions for June 14, 2028* summarizes the modeled CAMx $PM_{2.5}$ species emissions for Texas for that day. Emissions in the summary tables of this section represent EPS3 input, while emissions in tile plots above represent emissions after EPS3 processing.

Table 2-13: Future Case Texas Emissions Summary for June 14, 2028

Emission Source	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Non-EGUs	434.09	435.64	347.42	220.60	6.69	57.45	84.20
EGUs (AMPD)	346.10	9.32	425.08	748.09	3.52	36.79	45.63

Table 2-14: Future Case Texas CAMx $PM_{2.5}$ Species Emissions for June 14, 2028

Emission Source	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)
Non-EGUs	11.25	8.75	8.76	0.68	0.00	28.01
EGUs (AMPD)	9.80	6.41	3.78	0.39	0.00	16.40

Table 2-15: *Future Case Non-Texas CONUS Emissions Summary for June 14, 2028* summarizes the modeled non-Texas CONUS emissions of NO_X, VOC, CO, SO_2, NH_3, $PM_{2.5}$ and PM_{10} for that day. Table 2-16*: Future Case Non-Texas CONUS CAMx $PM_{2.5}$ Species Emissions for June 14, 2028* summarizes the modeled CAMx $PM_{2.5}$ species emissions for non-Texas CONUS for that day.

Table 2-15: Future Case Non-Texas CONUS Emissions Summary for June 14, 2028

Emission Source	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Non-EGUs	3,329	2,234	4764	1,699	232.70	679.61	1057
EGUs (AMPD)	2,311	59.00	949.90	2,649	49.70	295.50	366.10

Table 2-16: Future Case Non-Texas CONUS CAMx $PM_{2.5}$ Species Emissions for June 14, 2028

Emission Source	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)
Non-EGUs	129.82	58.17	81.38	6.29	2.48	299.70
EGUs (AMPD)	41.03	38.29	31.11	1.69	0.73	182.53

2.3 2028 POINT SOURCE SENSITIVITY ANALYSES

As part of this SIP revision, three sensitivity analysis scenarios were conducted to estimate the impact of potential NO_X and SO_2 reductions in Texas on the future year visibility at Class I areas. The sensitivities were conducted by reducing NO_X and/or SO_2 emissions at specific cement manufacturing, electric generating, flat glass manufacturing, natural gas compression station, paper mill, and packaging materials sites. The details of the three scenarios include:

Scenario 1: Removal of the Oklaunion Power Station as it has announced its retirement in 2020 (ERCOT, 2020). This scenario will be labeled ZeroOKU.

Scenario 2: In addition to Scenario 1, SO_2 reductions at specific sources in several of the sites described above. This scenario will be labeled ZeroOKU&SO2.

Scenario 3: In addition to Scenario 2, NO_X reductions at specific sources several of the sites described above. This scenario will be labeled ZeroOKU&SO2&NOx.

Table 2-17: *Modeled Texas Emissions of NO_X and SO_2 for June 14, 2028 for Sensitivity Analysis Scenarios* summarizes the modeled emissions of NO_X and SO_2 for a sample June day for the 2028 future year, labeled 2028NoControls, and each of the three sensitivity scenarios.

Table 2-17: Modeled Texas Emissions of NO_X and SO_2 for June 14, 2028 for Sensitivity Analysis Scenarios

Scenario	Non-EGU NO_X (tpd)	Non-EGU SO_2 (tpd)	EGU NO_X (tpd)	EGU SO_2 (tpd)	Total NO_X (tpd)	Total SO_2 (tpd)
2028NoControls	434.09	220.60	346.10	748.10	780.19	968.70
ZeroOKU	434.09	220.60	323.00	740.20	757.09	960.80
Reduction from 2028NoControls	0	0	23.10	7.90	23.10	7.90
ZeroOKU&SO2	434.09	217.10	323.00	502.80	757.09	719.90
Reduction from 2028NoControls	0	3.50	23.10	245.30	23.10	248.80
Reduction from ZeroOKU	0	3.50	0	237.40	0	240.90
ZeroOKU&SO2&NOx	423.00	217.10	323.00	502.80	746.00	719.90
Reduction from 2028NoControls	11.09	3.50	23.10	245.30	34.19	248.80
Reduction from ZeroOKU&SO2	11.09	0	0	0	11.09	0

CHAPTER 3: ON-ROAD MOBILE SOURCE MODELING EMISSIONS DEVELOPMENT

On-road mobile sources include cars, trucks, buses, motorcycles, and other vehicles that regularly operate on highways and local roadways.

3.1 WITHIN TEXAS

Texas on-road mobile source emissions for 2016 and 2028 were developed under contract by the Texas A&M Transportation Institute (TTI) for all 254 Texas counties using the 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model. Vehicle miles traveled (VMT) activity data sets used for the on-road inventory development were based on the Highway Performance Monitoring System (HPMS) that is managed by the Texas Department of Transportation (TxDOT). Vehicle population estimates were based on queries of the registration database managed by the Texas Department of Motor Vehicles (TxDMV).

The MOVES2014a model categorizes vehicles by fuel and source use type. Summaries of the estimated vehicle population and VMT by fuel and source use type for all 254 Texas counties are provided in Table 3-1: *2016 Statewide Summary of Vehicle Population and Miles Traveled* and Table 3-2: *2028 Statewide Summary of Vehicle Population and Miles Traveled*. Summaries of VMT are provided for both a Summer weekday scenario and on an annual basis.

Table 3-1: 2016 Statewide Summary of Vehicle Population and Miles Traveled

Fuel and Source Use Type Combination	Vehicle Population	Summer Weekday VMT	Annual VMT
Gasoline - Motorcycle	464,042	493,384	168,928,932
Gasoline - Passenger Car	14,057,372	489,344,658	177,180,408,599
Gasoline - Passenger Truck	4,563,332	139,669,699	50,720,172,984
Gasoline - Light Commercial Truck	1,119,907	34,276,815	12,447,166,644
Gasoline - School Bus	254	12,280	4,200,357
Gasoline - Refuse Truck	6,576	310,260	106,698,345
Gasoline - Single Unit Short-Haul Truck	130,990	6,159,035	2,002,898,892
Gasoline - Single Unit Long-Haul Truck	14,353	670,238	213,921,763
Gasoline - Motor Home	5,193	243,699	83,840,611
Gasoline - Combination Short-Haul Truck	11,917	2,213,024	736,568,672
Diesel - Passenger Car	98,331	3,424,897	1,239,891,306
Diesel - Passenger Truck	77,737	2,380,438	864,167,323
Diesel - Light Commercial Truck	62,221	1,904,247	691,639,384
Diesel - Intercity Bus	4,379	215,445	73,579,305
Diesel - Transit Bus	8,780	430,512	147,101,451
Diesel - School Bus	24,094	1,182,041	403,915,160
Diesel - Refuse Truck	15,901	765,338	266,379,182
Diesel - Single Unit Short-Haul Truck	319,834	15,434,573	5,057,631,222
Diesel - Single Unit Long-Haul Truck	29,943	1,427,683	457,317,257
Diesel - Motor Home	12,486	601,251	209,284,271
Diesel - Combination Short-Haul Truck	100,848	17,073,485	5,661,981,203
Diesel - Combination Long-Haul Truck	167,725	34,032,760	11,544,088,556
Total	21,296,217	752,265,762	270,281,781,419

Note: Totals do not add up due to rounding of individual cells.

Table 3-2: 2028 Statewide Summary of Vehicle Population and Miles Traveled

Fuel and Source Use Type Combination	Vehicle Population	Summer Weekday VMT	Annual VMT
Gasoline - Motorcycle	540,880	572,983	196,073,136
Gasoline - Passenger Car	16,279,446	565,732,887	204,733,527,743
Gasoline - Passenger Truck	5,270,522	161,679,258	58,659,254,891
Gasoline - Light Commercial Truck	1,296,788	39,781,709	14,433,157,565
Gasoline - School Bus	290	14,175	4,819,413
Gasoline - Refuse Truck	7,513	353,874	121,608,179
Gasoline - Single Unit Short-Haul Truck	153,780	7,230,367	2,349,181,991
Gasoline - Single Unit Long-Haul Truck	16,940	791,531	252,498,379
Gasoline - Motor Home	5,303	250,146	85,963,187
Gasoline - Combination Short-Haul Truck	13,693	2,548,891	847,297,797
Diesel - Passenger Car	188,408	6,536,913	2,363,918,202
Diesel - Passenger Truck	105,931	3,249,081	1,178,391,071
Diesel - Light Commercial Truck	72,574	2,226,190	807,716,263
Diesel - Intercity Bus	5,078	249,172	85,045,247
Diesel - Transit Bus	10,446	510,791	174,400,762
Diesel - School Bus	27,659	1,354,676	462,577,989
Diesel - Refuse Truck	18,015	868,848	301,835,563
Diesel - Single Unit Short-Haul Truck	373,414	18,010,886	5,895,295,344
Diesel - Single Unit Long-Haul Truck	35,291	1,684,648	539,238,030
Diesel - Motor Home	12,722	613,909	213,381,228
Diesel - Combination Short-Haul Truck	116,393	19,796,862	6,557,347,063
Diesel - Combination Long-Haul Truck	192,466	39,036,265	13,229,460,362
Total	24,743,552	873,094,061	313,491,989,405

For each Texas county, on-road emissions were estimated for the four activity day types of weekday (Monday-Thursday average), Friday, Saturday, and Sunday within each of the four seasons of Spring (March, April, and May), Summer (June, July, and August), Fall (September, October, and November), and Winter (December, January, and February). On-road emissions were estimated for the criteria pollutants: nitrogen oxides (NO_X), volatile organic compounds (VOC), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), ammonia (NH_3) and carbon monoxide (CO). $PM_{2.5}$ emissions were speciated into the components of primary organic aerosol (POA), primary elemental carbon (PEC), particulate sulfate (PSO_4), particulate nitrate (PNO_3), particulate ammonium (PNH_4), fine other primary (FPRM), particulate chloride (PCL), particulate sodium (PNA), particulate water (PH_2O), and/or fine crustal particulate (FCRS).

These are summarized in units of tons per day (tpd) in Table 3-3: *2016 Statewide On-Road Criteria Pollutant Emissions by Season and Day Type* and Table 3-4: *2028 Statewide On-Road Criteria Pollutant Emissions by Season and Day Type*. The reduction in on-road emissions from 2016 to 2028 is due primarily to fleet turnover where older higher-emitting vehicles are removed through attrition and replaced by newer lower-emitting ones. 2016 was the last year when gasoline sulfur levels were required under federal rules to average 30 parts per million (ppm). Starting in 2017, a phase-in began that requires an average gasoline sulfur content of 10 ppm. The reduction in on-road

SO_2 emissions from 2016 to 2028 is primarily the result of this change in gasoline sulfur concentration from 30 ppm to 10 ppm.

Table 3-3: 2016 Statewide On-Road Criteria Pollutant Emissions by Season and Day Type

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Spring Weekday	838.71	293.06	3,103	5.43	20.69	25.41	54.34
Spring Friday	910.52	303.79	3,354	6.06	23.08	28.11	60.60
Spring Saturday	671.14	258.43	2,757	4.98	19.10	19.36	43.69
Spring Sunday	569.04	245.30	2,502	4.29	16.32	15.71	35.79
Summer Weekday	768.97	318.03	3,780	5.76	20.60	24.89	53.66
Summer Friday	838.73	329.59	4,140	6.45	23.05	27.69	60.12
Summer Saturday	622.79	285.50	3,452	5.31	19.09	19.06	43.37
Summer Sunday	527.98	271.62	3,096	4.54	16.22	15.36	35.29
Fall Weekday	830.65	298.92	3,451	5.86	20.79	25.25	54.31
Fall Friday	906.94	310.36	3,754	6.56	23.30	28.12	60.94
Fall Saturday	671.25	266.68	3,107	5.41	19.32	19.36	43.98
Fall Sunday	568.78	253.23	2,819	4.63	16.48	15.65	35.92
Winter Weekday	912.23	297.62	3,285	5.72	20.76	26.99	56.25
Winter Friday	995.76	308.11	3,513	6.35	23.16	29.91	62.81
Winter Saturday	735.61	259.64	2,892	5.25	19.25	20.85	45.57
Winter Sunday	620.18	246.90	2,654	4.54	16.60	17.04	37.62

Table 3-4: 2028 Statewide On-Road Criteria Pollutant Emissions by Season and Day Type

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Spring Weekday	275.75	146.23	1,797	2.30	19.61	11.32	44.25
Spring Friday	294.67	150.03	1,939	2.55	21.83	12.57	49.70
Spring Saturday	215.87	131.34	1,576	1.95	17.95	9.30	36.93
Spring Sunday	184.44	126.28	1,433	1.64	15.28	7.77	30.50
Summer Weekday	249.85	154.59	2,202	2.44	19.52	11.14	43.94
Summer Friday	268.15	158.58	2,408	2.71	21.81	12.43	49.56
Summer Saturday	197.75	141.48	1,993	2.08	17.95	9.22	36.88
Summer Sunday	168.77	136.24	1,790	1.73	15.19	7.64	30.24
Fall Weekday	266.77	143.99	1,941	2.34	19.70	11.03	44.11
Fall Friday	286.68	147.86	2,103	2.61	22.04	12.33	49.87
Fall Saturday	210.13	130.82	1,720	2.00	18.15	9.11	37.09
Fall Sunday	179.03	125.81	1,565	1.68	15.43	7.56	30.53
Winter Weekday	300.40	148.43	1,861	2.28	19.68	11.64	44.76
Winter Friday	324.12	152.06	1,981	2.53	21.91	12.92	50.34
Winter Saturday	237.41	131.77	1,611	1.95	18.09	9.60	37.53
Winter Sunday	199.69	126.87	1,485	1.64	15.54	8.08	31.24

In addition to the criteria pollutant emissions presented in Table 3-3 and Table 3-4, the MOVES2014a model was used to estimate the $PM_{2.5}$ on-road components POA, PEC, PSO_4, PNO_3, PNH_4, and FPRM. These are summarized in Table 3-5: *2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Day Type* and Table 3-6: *2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Day Type*.

Table 3-5: 2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Day Type

Season and Day Type	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)	$PM_{2.5}$ (tpd)
Spring Weekday	7.55	11.77	0.87	0.07	0.20	4.96	25.41
Spring Friday	8.32	12.99	0.96	0.08	0.22	5.56	28.11
Spring Saturday	5.83	8.55	0.63	0.05	0.16	4.15	19.36
Spring Sunday	4.80	6.82	0.50	0.04	0.13	3.42	15.71
Summer Weekday	7.30	11.56	0.86	0.07	0.19	4.92	24.89
Summer Friday	8.09	12.82	0.95	0.07	0.21	5.53	27.69
Summer Saturday	5.67	8.43	0.62	0.05	0.15	4.13	19.06
Summer Sunday	4.63	6.68	0.49	0.04	0.13	3.38	15.36
Fall Weekday	7.42	11.73	0.87	0.07	0.19	4.97	25.25
Fall Friday	8.23	13.03	0.97	0.08	0.21	5.60	28.12
Fall Saturday	5.76	8.58	0.64	0.05	0.16	4.18	19.36
Fall Sunday	4.72	6.82	0.50	0.04	0.13	3.44	15.65
Winter Weekday	8.46	12.28	0.90	0.07	0.22	5.06	26.99
Winter Friday	9.33	13.57	1.00	0.08	0.24	5.68	29.91
Winter Saturday	6.66	9.03	0.66	0.06	0.18	4.26	20.85
Winter Sunday	5.53	7.25	0.53	0.05	0.15	3.54	17.04

Table 3-6: 2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Day Type

Season and Day Type	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	FPRM (tpd)	$PM_{2.5}$ (tpd)
Spring Weekday	2.93	1.73	1.33	0.02	0.09	5.23	11.32
Spring Friday	3.22	1.88	1.47	0.02	0.09	5.89	12.57
Spring Saturday	2.51	1.36	0.94	0.01	0.08	4.41	9.30
Spring Sunday	2.16	1.15	0.74	0.01	0.07	3.64	7.77
Summer Weekday	2.85	1.66	1.32	0.02	0.08	5.21	11.14
Summer Friday	3.14	1.82	1.46	0.02	0.09	5.89	12.43
Summer Saturday	2.46	1.32	0.94	0.01	0.08	4.41	9.22
Summer Sunday	2.10	1.11	0.73	0.01	0.06	3.62	7.64
Fall Weekday	2.73	1.63	1.33	0.02	0.08	5.24	11.03
Fall Friday	3.01	1.79	1.48	0.02	0.09	5.94	12.33
Fall Saturday	2.34	1.28	0.95	0.01	0.07	4.45	9.11
Fall Sunday	2.00	1.08	0.75	0.01	0.06	3.67	7.56
Winter Weekday	3.06	1.89	1.34	0.02	0.08	5.25	11.64
Winter Friday	3.34	2.05	1.48	0.02	0.09	5.93	12.92
Winter Saturday	2.61	1.49	0.96	0.01	0.08	4.45	9.60
Winter Sunday	2.27	1.28	0.75	0.01	0.07	3.70	8.08

Within each season, weekly on-road emissions totals were developed by multiplying the weekday estimates by a factor of four, and then summing this result with the Friday, Saturday, and Sunday estimates to get emission tons in that week. The results of these efforts are summarized in Table 3-7: *2016 Statewide On-Road Criteria Pollutant Emissions by Season and Week*, Table 3-8: *2028 Statewide On-Road Criteria Pollutant Emissions by Season and Week*, Table 3-9: *2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Week*, and Table 3-10: *2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Week*, respectively.

Table 3-7: 2016 Statewide On-Road Criteria Pollutant Emissions by Season and Week

Season and Week	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Week	5,506	1,980	21,026	37.07	141.25	164.82	357.42
Summer Week	5,065	2,159	25,809	39.34	140.75	161.66	353.41
Fall Weekday	5,470	2,026	23,485	40.04	142.25	164.13	358.09
Winter Week	6,000	2,005	22,198	39.02	142.05	175.77	370.98

Table 3-8: 2028 Statewide On-Road Criteria Pollutant Emissions by Season and Week

Season and Week	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Week	1,798	992.56	12,136	15.35	133.49	74.92	294.13
Summer Week	1,634	1,055	14,998	16.28	133.04	73.84	292.45
Fall Weekday	1,743	980.43	13,150	15.66	134.43	73.12	293.95
Winter Week	1,963	1,004	12,522	15.26	134.24	77.17	298.16

Table 3-9: 2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Week

Season and Week	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring Week	49.14	75.44	5.56	0.45	1.30	32.94	164.82
Summer Week	47.59	74.18	5.48	0.44	1.25	32.71	161.66
Fall Weekday	48.37	75.36	5.59	0.45	1.27	33.09	164.13
Winter Week	55.37	78.96	5.79	0.48	1.45	33.72	175.77

Table 3-10: 2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season and Week

Season and Week	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring Week	19.60	11.31	8.47	0.11	0.58	34.86	74.92
Summer Week	19.09	10.91	8.40	0.11	0.57	34.76	73.84
Fall Weekday	18.27	10.66	8.52	0.10	0.54	35.02	73.12
Winter Week	20.47	12.37	8.54	0.12	0.57	35.10	77.17

Once weekly emissions totals are available by season, seasonal and annual totals can readily be obtained by using the numbers provided in Table 3-11: *Weekly-to-Season Emissions Adjustment Factors*. For example, since there are 13.14 weeks in the Spring and Summer, total seasonal emissions can readily be obtained by multiplying weekly totals by 13.14. Since both 2016 and 2028 are leap years, the Winter leap year adjustment factor of 13.00 was used instead of the 12.86 factor that would apply to non-leap years.

Table 3-11: Weekly-to-Season Emissions Adjustment Factors

Season	Months	Non-Leap Year Days	Leap Year Days	Non-Leap Year Weeks	Leap Year Weeks
Spring	March, April, May	92	92	13.14	13.14
Summer	June, July, August	92	92	13.14	13.14
Fall	September, October, November	91	91	13.00	13.00
Winter	January, February, December	90	91	12.86	13.00
Annual	All	365	366	52.14	52.29

Application of the appropriate factors from Table 3-11 to the weekly totals resulted in the seasonal on-road emissions totals provided in Table 3-12: *2016 Statewide On-Road Criteria Pollutant Emissions by Season*, Table 3-13: *2028 Statewide On-Road Criteria Pollutant Emissions by Season*, Table 3-14: *2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season*, and Table 3-15: *2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season*.

Table 3-12: 2016 Statewide On-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	72,359	26,020	276,341	487.16	1,856	2,166	4,698
Summer	66,574	28,373	339,198	517.10	1,850	2,125	4,645
Fall	71,105	26,338	305,302	520.54	1,849	2,134	4,655
Winter	78,006	26,066	288,577	507.32	1,847	2,285	4,823
Annual	288,043	106,797	1,209,419	2,032	7,402	8,710	18,820

Table 3-13: 2028 Statewide On-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	23,631	13,045	159,503	201.80	1,754	984.67	3,866
Summer	21,477	13,861	197,116	214.01	1,749	970.41	3,844
Fall	22,658	12,746	170,943	203.52	1,748	950.51	3,821
Winter	25,516	13,057	162,790	198.32	1,745	1,003	3,876
Annual	93,282	52,709	690,353	817.65	6,996	3,909	15,407

Table 3-14: 2016 Statewide On-Road $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring	645.80	991.53	73.03	5.88	17.03	432.98	2,166
Summer	625.47	974.94	72.08	5.78	16.49	429.92	2,125
Fall	628.76	979.72	72.63	5.80	16.56	430.22	2,134
Winter	719.84	1,027	75.22	6.23	18.88	438.35	2,285
Annual	2,620	3,973	292.96	23.69	68.96	1,731	8,710

Table 3-15: 2028 Statewide On-Road $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring	257.63	148.59	111.29	1.45	7.60	458.11	984.67
Summer	250.90	143.33	110.40	1.42	7.50	456.87	970.41
Fall	237.56	138.62	110.70	1.36	7.07	455.20	950.51
Winter	266.06	160.85	110.96	1.50	7.42	456.36	1,003
Annual	1,012	591.39	443.35	5.73	29.59	1,827	3,909

The 2016 gridded input files for Texas on-road emissions are provided along with the full EPS3 message streams at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/base

_2016/onroad/. The 2028 gridded input files for Texas on-road emissions are provided along with the full EPS3 message streams at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/future_2028/onroad/.

Plots of the spatial and temporal distribution of 2016 and 2028 on-road Summer weekday emissions for all of Texas at a resolution of 12 kilometers (km) are shown in Figure 3-1: *2016 Summer Weekday Texas On-Road NO_X Emissions Distribution* and Figure 3-2: *2028 Summer Weekday Texas On-Road NO_X Emissions Distribution*. Plots for the other on-road pollutants are not provided because they have an emissions spatial distribution like NO_X.

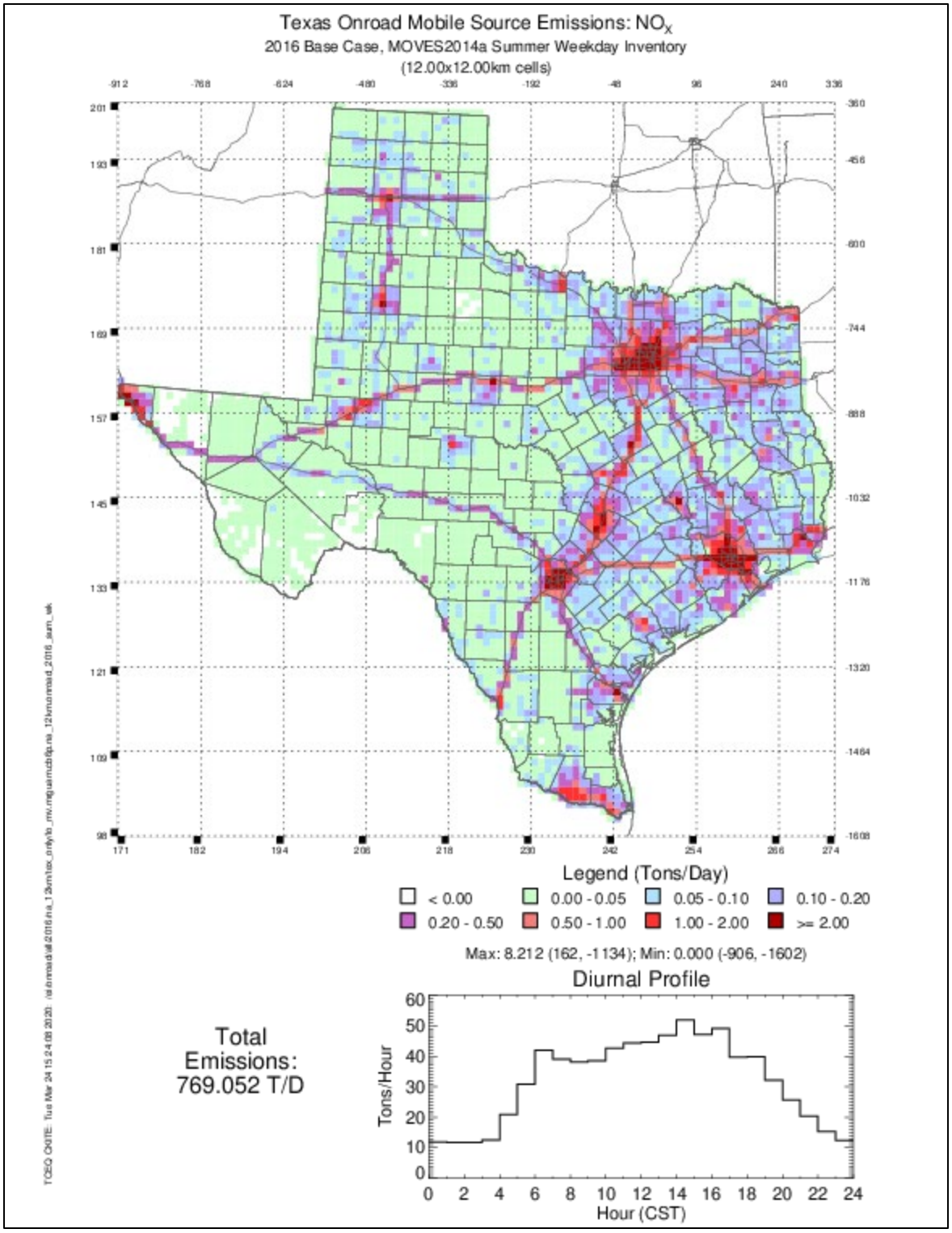

Figure 3-1: 2016 Summer Weekday Texas On-Road NO_x Emissions Distribution

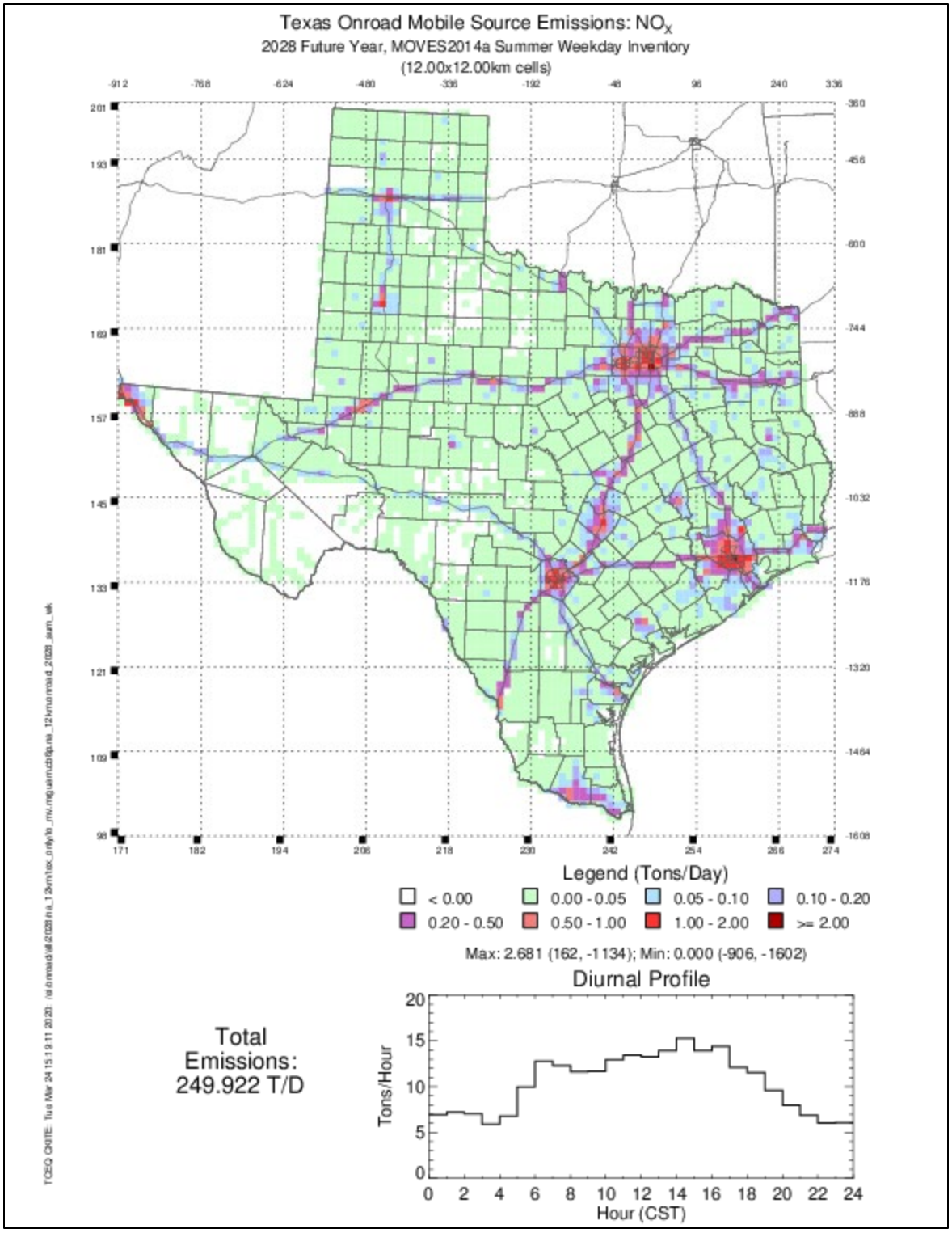

Figure 3-2: 2028 Summer Weekday Texas On-Road NO_x Emissions Distribution

3.2 OUTSIDE TEXAS

For the non-Texas North American portion of the modeling domains, the TCEQ used the 2016 National Emissions Inventory Collaborative (NEIC) platform Beta version (2016 NEIC platform vβ) inventories for the on-road mobile sources. Each day of 2016 is represented. The 2016 NEIC platform detailed development of the 2016 on-road emission inventory (NEIC, 2019).

CHAPTER 4: NON-ROAD, OFF-ROAD, AND AREA SOURCE MODELING EMISSIONS

4.1 OIL-AND-GAS PRODUCTION AND DRILLING EMISSIONS INVENTORY DEVELOPMENT

Oil-and-gas production emission estimates were developed based on activity data from the Railroad Commission of Texas (RRC) (available at http://www.rrc.state.tx.us/) multiplied by emission factors for specific operations and types of equipment according to an ERG project (ERG, 2010). Activity data from the RRC were obtained for production of natural gas, crude oil, and condensate, along with additional parameters such as the total number of operational gas wells, operational oil wells, etc. These activity values were multiplied by emission factors from the ERG study to obtain oil-and-gas production emission estimates. For example, compressor engine emissions are a function of natural gas production, so compressor engine emission rates were multiplied by total natural gas produced. Condensate storage tank emission estimates were calculated as a function of condensate production. In a similar manner, emissions from crude oil storage tanks are a function of crude oil production. The ERG study (ERG, 2010) contains a summary of how each calculation is performed.

4.1.1 Within Texas

Oil-and-gas emissions estimates for 2016 were developed by the TCEQ based on historical drilling and production data obtained from the RRC. For each Texas county where drilling and production occurred in 2016, calculations were performed for each type of equipment associated with oil-and-gas operations. The 2028 oil-and-gas emissions estimates were projected from an inventory based on 2017 historical RRC data. The drilling of new wells is summarized in Table 4-1: *2016 Texas Oil-and-Gas Drilling Activity* and Table 4-2: *2017 Texas Oil-and-Gas Drilling Activity*. There are different emission rates for vertical drilling less than 7,000 feet, vertical drilling greater than 7,000 feet, and the horizontal/directional drilling associated with fracking activity.

Table 4-1: 2016 Texas Oil-and-Gas Drilling Activity

Geographic Area	Horizontal/ Directional (thousands)	Vertical Feet <= 7000 (thousands)	Vertical Feet >7000 (thousands)	All Drilled Feet (thousands)
10-County DFW	1,105	62	40	1,207
Eight-County HGB	0	533	528	1,060
Bexar County in San Antonio	0	7	0	7
16-County Non-DFW Barnett	0	586	25	611
26-County Eagle Ford	30,236	386	1,340	31,962
10-County Haynesville	11	34	1,149	1,194
45-County Permian Basin	39,500	386	79	39,965
138-County Other	823	2,249	3,039	6,111
254-County Total	71,676	4,242	6,199	82,117

Table 4-2: 2017 Texas Oil-and-Gas Drilling Activity

Geographic Area	Horizontal/ Directional (thousands)	Vertical Feet <= 7000 (thousands)	Vertical Feet >7000 (thousands)	All Drilled Feet (thousands)
10-County DFW	240	7	7	254
Eight-County HGB	171	170	113	454
Bexar County in San Antonio	0	8	0	8
16-County Non-DFW Barnett	23	371	0	394
26-County Eagle Ford	19,249	134	389	19,772
10-County Haynesville	758	35	540	1,333
45-County Permian Basin	18,835	2,690	3,829	25,354
138-County Other	2,047	1,273	1,331	4,651
254-County Total	41,323	4,687	6,210	52,220

Table 4-1 and Table 4-2 provide the total feet drilled for the three categories for eight different geographical areas within Texas:

- 10-county Dallas-Fort Worth (DFW) comprised of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise Counties;
- 8-county Houston-Galveston-Brazoria (HGB) comprised of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties;
- Bexar County in San Antonio;
- 16 counties located within the Barnett Shale formation outside of DFW comprised of Archer, Clay, Comanche, Cooke, Eastland, Erath, Hamilton, Hill, Hood, Jack, Montague, Palo Pinto, Shackelford, Somervell, Stephens, and Young Counties;
- 26 counties located within the Eagle Ford Shale formation comprised of Atascosa, Bastrop, Bee, Brazos, Burleson, DeWitt, Dimmit, Fayette, Frio, Gonzales, Grimes, Karnes, La Salle, Lavaca, Lee, Leon, Live Oak, McMullen, Madison, Maverick, Milam, Robertson, Walker, Webb, Wilson, and Zavala Counties;
- 10 counties located within the Haynesville Shale formation comprised of Angelina, Gregg, Harrison, Marion, Nacogdoches, Panola, Rusk, Sabine, San Augustine, and Shelby Counties;

- 45 counties located within the Permian Basin comprised of Andrews, Borden, Cochran, Coke, Crane, Crockett, Crosby, Culberson, Dawson, Dickens, Ector, Fisher, Gaines, Garza, Glasscock, Hale, Hockley, Howard, Irion, Kent, Kimble, Lamb, Loving, Lubbock, Lynn, Martin, Midland, Mitchell, Nolan, Pecos, Reagan, Reeves, Schleicher, Scurry, Sterling, Stonewall, Sutton, Terrell, Terry, Tom Green, Upton, Val Verde, Ward, Winkler, and Yoakum Counties; and
- remaining 138 counties located within Texas.

Production of crude oil, condensate, and produced water is summarized for these same eight geographic areas in Table 4-3: *2016 Texas Crude Oil, Condensate, and Produced Water Activity* and Table 4-4: *2017 Texas Crude Oil, Condensate, and Produced Water Activity*.

Table 4-3: 2016 Texas Crude Oil, Condensate, and Produced Water Activity

Geographic Area	Crude Oil (barrels)	Condensate (barrels)	Produced Water (barrels)
10-County DFW	320,150	969,444	113,277,874
Eight-County HGB	10,350,863	1,490,572	325,878,642
Bexar County in San Antonio	92,603	0	11,417
16-County Non-DFW Barnett	8,737,616	1,669,166	443,739,860
26-County Eagle Ford	368,004,138	90,763,926	277,717,447
10-County Haynesville	4,238,415	3,226,493	312,260,320
45-County Permian Basin	571,332,119	25,826,127	4,986,044,648
138-County Other	49,950,080	21,082,559	1,530,054,130
254-County Total	1,013,025,984	145,028,287	7,988,984,338

Table 4-4: 2017 Texas Crude Oil, Condensate, and Produced Water Activity

Geographic Area	Crude Oil (barrels)	Condensate (barrels)	Produced Water (barrels)
10-County DFW	266,112	726,380	104,543,655
Eight-County HGB	9,871,816	1,411,745	293,767,370
Bexar County in San Antonio	83,240	0	11,603
16-County Non-DFW Barnett	8,031,336	1,204,850	435,289,176
26-County Eagle Ford	354,764,719	77,758,322	312,909,617
10-County Haynesville	4,153,925	2,768,632	332,201,576
45-County Permian Basin	682,541,193	48,934,171	5,348,601,712
138-County Other	47,879,142	17,699,165	1,415,067,778
254-County Total	1,107,591,483	150,503,265	8,242,392,487

Production of natural gas in units of million cubic feet (MCF) is summarized for these same eight geographic areas in Table 4-5: *2016 Texas Natural Gas Production Activity* and Table 4-6: *2017 Texas Natural Gas Production Activity*. The production is reported separately for gas wells and the casinghead gas that is produced along with crude oil from oil wells.

Table 4-5: 2016 Texas Natural Gas Production Activity

Geographic Area	Gas Wells (MCF)	Casinghead from Oil Wells (MCF)	Total (MCF)
10-County DFW	1,263,578,828	6,668,868	1,270,247,696
Eight-County HGB	55,160,663	6,754,101	61,914,764
Bexar County in San Antonio	0	24	24
16-County Non-DFW Barnett	172,624,337	43,379,311	216,003,648
26-County Eagle Ford	1,727,529,634	763,145,219	2,490,674,853
10-County Haynesville	793,524,547	8,778,691	802,303,238
45-County Permian Basin	517,874,570	1,454,851,643	1,972,726,213
138-County Other	1,170,789,218	184,448,163	1,355,237,381
254-County Total	5,701,081,797	2,468,026,020	8,169,107,817

Table 4-6: 2017 Texas Natural Gas Production Activity

Geographic Area	Gas Wells (MCF)	Casinghead from Oil Wells (MCF)	Total (MCF)
10-County DFW	1,119,341,468	4,854,593	1,124,196,061
Eight-County HGB	46,960,969	5,831,666	52,792,635
Bexar County in San Antonio	0	12	12
16-County Non-DFW Barnett	160,439,794	35,929,155	196,368,949
26-County Eagle Ford	1,625,746,583	720,270,784	2,346,017,367
10-County Haynesville	744,759,783	8,406,719	753,166,502
45-County Permian Basin	671,955,575	1,698,119,591	2,370,075,166
138-County Other	1,031,465,140	176,746,023	1,208,211,163
254-County Total	5,400,669,312	2,650,158,543	8,050,827,855

The number of oil-and-gas wells for these eight areas, along with the number of oil-and-gas well completions are summarized in Table 4-7: *2016 Texas Oil-and-Gas Well Counts and Completions* and Table 4-8: *2017 Texas Oil-and Gas Well Counts and Completions*. The completions reported here are for those that also reported some level of gas or oil production in the respective year. If a well was completed but no production was reported for that year, it is not reflected here.

Table 4-7: 2016 Texas Oil-and-Gas Well Counts and Completions

Geographic Area	Oil Well Count	Oil Well Completions	Gas Well Count	Gas Well Completions
10-County DFW	514	6	15,685	81
Eight-County HGB	1,888	98	705	12
Bexar County in San Antonio	1,476	4	0	0
16-County Non-DFW Barnett	14,985	90	7,074	30
26-County Eagle Ford	19,945	1,057	14,293	520
10-County Haynesville	5,280	8	13,063	68
45-County Permian Basin	98,027	2,483	18,337	95
138-County Other	33,566	447	32,230	209
254-County Total	175,681	4,193	101,387	1,015

Table 4-8: 2017 Texas Oil-and Gas Well Counts and Completions

Geographic Area	Oil Well Count	Oil Well Completions	Gas Well Count	Gas Well Completions
10-County DFW	491	0	15,714	24
Eight-County HGB	1,896	55	687	10
Bexar County in San Antonio	2,143	5	0	0
16-County Non-DFW Barnett	15,944	84	6,892	17
26-County Eagle Ford	21,693	870	14,476	358
10-County Haynesville	4,984	13	12,959	94
45-County Permian Basin	99,856	2,033	18,258	85
138-County Other	37,312	420	31,713	216
254-County Total	184,319	3,480	100,699	804

The 2028 future year emission estimates for oil-and-gas production were created from the 2017 emissions, which were projected to 2019 using RRC data and then to 2028 using 2019-to-2028 projection factors obtained from an ERG study entitled *Growth Factors for Area and Point Sources* (ERG, 2016). This study provides separate projection factors for the Barnett Shale, Eagle Ford Shale, Haynesville Shale, and Permian Basin formations. Emissions were estimated for the criteria pollutants: nitrogen oxides (NO_X), volatile organic compounds (VOC), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), ammonia (NH_3) and carbon monoxide (CO). The oil-and-gas summaries by season and criteria pollutant are presented in Table 4-9: *2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Seasonal Day* and Table 4-10: *2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Seasonal Day*.

Table 4-9: 2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Seasonal Day

Season and Day Type	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Day	632.99	2,924	446.62	64.24	0.00	8.88	8.92
Summer Day	629.18	2,924	446.62	64.24	0.00	8.88	8.92
Fall Day	631.53	2,924	446.62	64.24	0.00	8.88	8.92
Winter Day	634.76	2,924	446.62	64.24	0.00	8.88	8.92

Table 4-10: 2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Seasonal Day

Season and Day Type	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Day	519.38	2,290	342.92	42.35	0.00	5.34	5.35
Summer Day	517.50	2,290	342.92	42.35	0.00	5.34	5.35
Fall Day	518.64	2,290	342.92	42.35	0.00	5.34	5.35
Winter Day	520.26	2,290	342.92	42.35	0.00	5.34	5.35

The oil-and-gas inventories were prepared for photochemical model input with version 3 of the Emissions Preprocessor System (EPS3). The EPS3 SPCEMS module was used to separate the $PM_{2.5}$ emissions of primary organic aerosol (POA), primary elemental carbon (PEC), particulate sulfate (PSO_4), particulate nitrate (PNO_3), particulate ammonium (PNH_4), fine other primary (FPRM), particulate chloride (PCL), particulate sodium (PNA), particulate water (PH_2O), and/or fine crustal particulate (FCRS).

These are summarized in Table 4-11: *2016 Texas Oil-and Gas $PM_{2.5}$ Component Emissions by Seasonal Day* and Table 4-12: *2028 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Seasonal Day*.

Table 4-11: 2016 Texas Oil-and Gas $PM_{2.5}$ Component Emissions by Seasonal Day

Season and Day Type	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)
Spring Day	0.43	2.09	0.02	0.50	5.83	8.88
Summer Day	0.43	2.09	0.02	0.50	5.83	8.88
Fall Day	0.43	2.09	0.02	0.50	5.83	8.88
Winter Day	0.43	2.09	0.02	0.50	5.83	8.88

Table 4-12: 2028 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Seasonal Day

Season and Day Type	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)
Spring Day	0.26	1.25	0.01	0.30	3.51	5.34
Summer Day	0.26	1.25	0.01	0.30	3.51	5.34
Fall Day	0.26	1.25	0.01	0.30	3.51	5.34
Winter Day	0.26	1.25	0.01	0.30	3.51	5.34

Seasonal emissions totals can readily be obtained by multiplying the daily average emissions by the number of days within each season summarized in Table 3-11. For example, there are 92 days within both the Spring and Summer seasons, so the daily

average emissions for each are multiplied by 92. Since both 2016 and 2028 are leap years, the daily Winter average emissions totals are multiplied by 91 days. The results of these efforts are summarized in Table 4-13: *2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Season*, Table 4-14: *2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Season Emissions by Season*, Table 4-15: *2016 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Season*, Table 4-16: *2028 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Season.*

Table 4-13: 2016 Texas Oil-and-Gas Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	58,235	268,981	41,089	5,910	0.00	816.96	821.06
Summer	57,885	268,981	41,089	5,910	0.00	816.96	821.06
Fall	57,469	266,057	40,643	5,846	0.00	808.08	812.14
Winter	57,763	266,057	40,643	5,846	0.00	808.08	812.14
Annual	231,352	1,070,077	163,463	23,513	0.00	3,250	3,266

Table 4-14: 2028 Texas Oil-and-Gas Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	47,783	210,659	31,548	3,896	0.00	491.26	491.91
Summer	47,610	210,659	31,548	3,896	0.00	491.26	491.91
Fall	47,196	208,370	31,205	3,854	0.00	485.92	486.57
Winter	47,343	208,370	31,205	3,854	0.00	485.92	486.57
Annual	189,932	838,058	125,508	15,500	0.00	1,954	1,957

Table 4-15: 2016 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)
Spring	39.93	191.83	2.21	45.96	536.70	816.63
Summer	39.93	191.83	2.21	45.96	536.70	816.63
Fall	39.50	189.74	2.19	45.46	530.86	807.75
Winter	39.50	189.74	2.19	45.46	530.86	807.75

Table 4-16: 2028 Texas Oil-and-Gas $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)
Spring	23.99	115.32	1.33	27.63	322.69	490.96
Summer	23.99	115.32	1.33	27.63	322.69	490.96
Fall	23.73	114.06	1.32	27.33	319.18	485.62
Winter	23.73	114.06	1.32	27.33	319.18	485.62

Spatial allocation of these emission estimates was based on the latest available activity data from the RRC. For example, 2017 natural gas production data for each operational well were used to develop a weighted surrogate for allocating 2028 natural gas production emissions. A similar approach was used to develop separate weighted

surrogates for emissions associated with crude oil and condensate production. 2028 drilling rig emissions were allocated to locations where 2017 wells were drilled. Even though it is unlikely that 2028 drilling will occur in the exact same locations as 2017, low-level emissions are evenly distributed within 12-km grid cells for photochemical model input. Since 2028 production and drilling is likely to be concentrated near currently operational wells, this spatial allocation approach is reasonable. 2016 production and drilling rig emissions were allocated based on available RRC data specific to that year. The complete EPS3 processing streams for the oil-and-gas emissions are available for both 2016 and 2028 at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/base_2016/oil_gas/ and ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/future_2028/oil_gas/, respectively.

The temporal distribution of NO_X and SO_2 emissions is assumed to be constant. Drilling, processing, and transmission of crude oil and natural gas producing these emissions occurs nonstop. Plots of the spatial and temporal distribution of 2016 and 2028 oil-and-gas NO_X emissions for all of Texas are depicted in Figure 4-1: *2016 Texas Oil-and-Gas NO_X Emissions Distribution* and Figure 4-2: *2028 Texas Oil-and-Gas NO_X Emissions Distribution*. Plots for the other oil-and-gas pollutants are not provided because they have an emissions spatial distribution similar to NO_X.

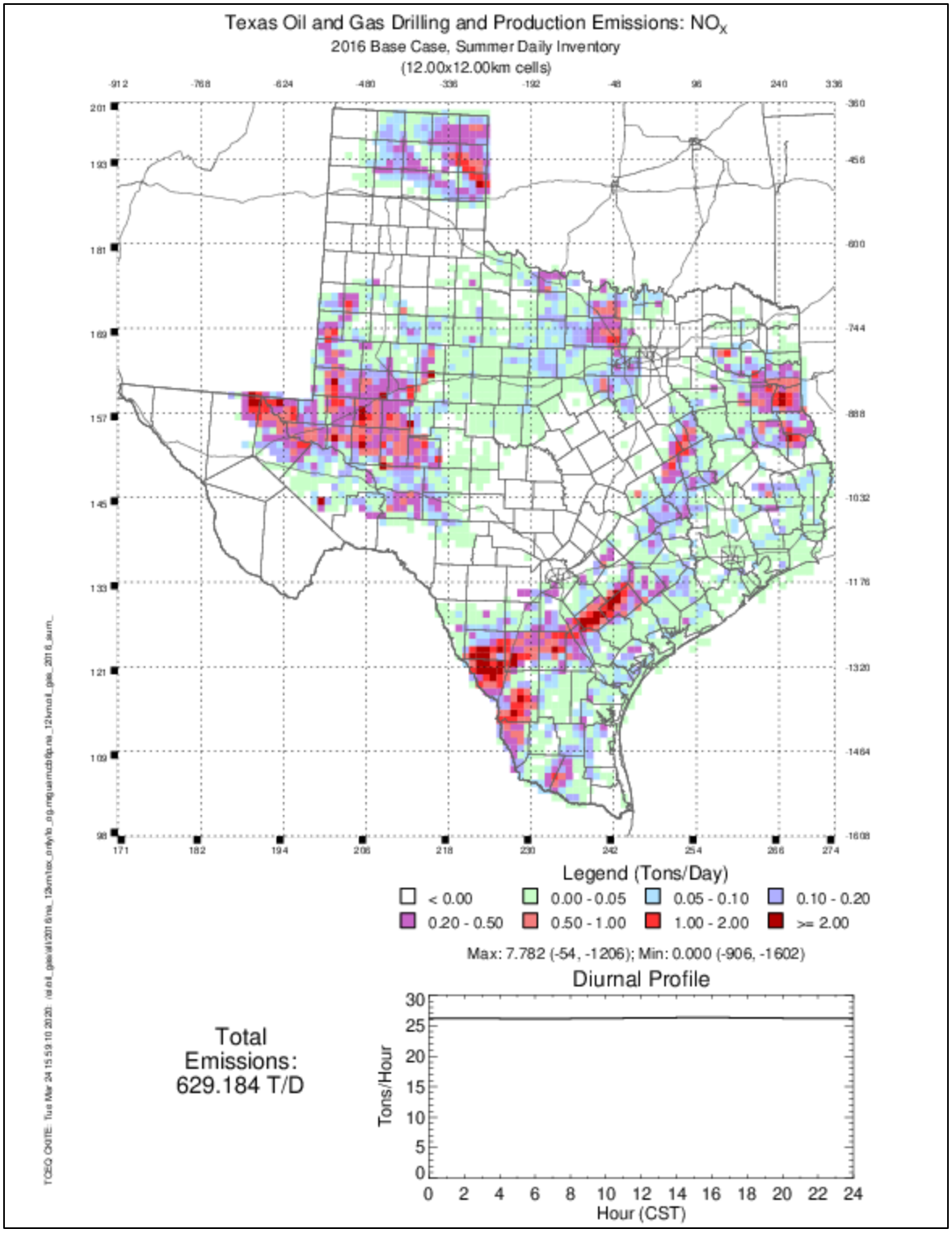

Figure 4-1: 2016 Texas Oil-and-Gas NO_x Emissions Distribution

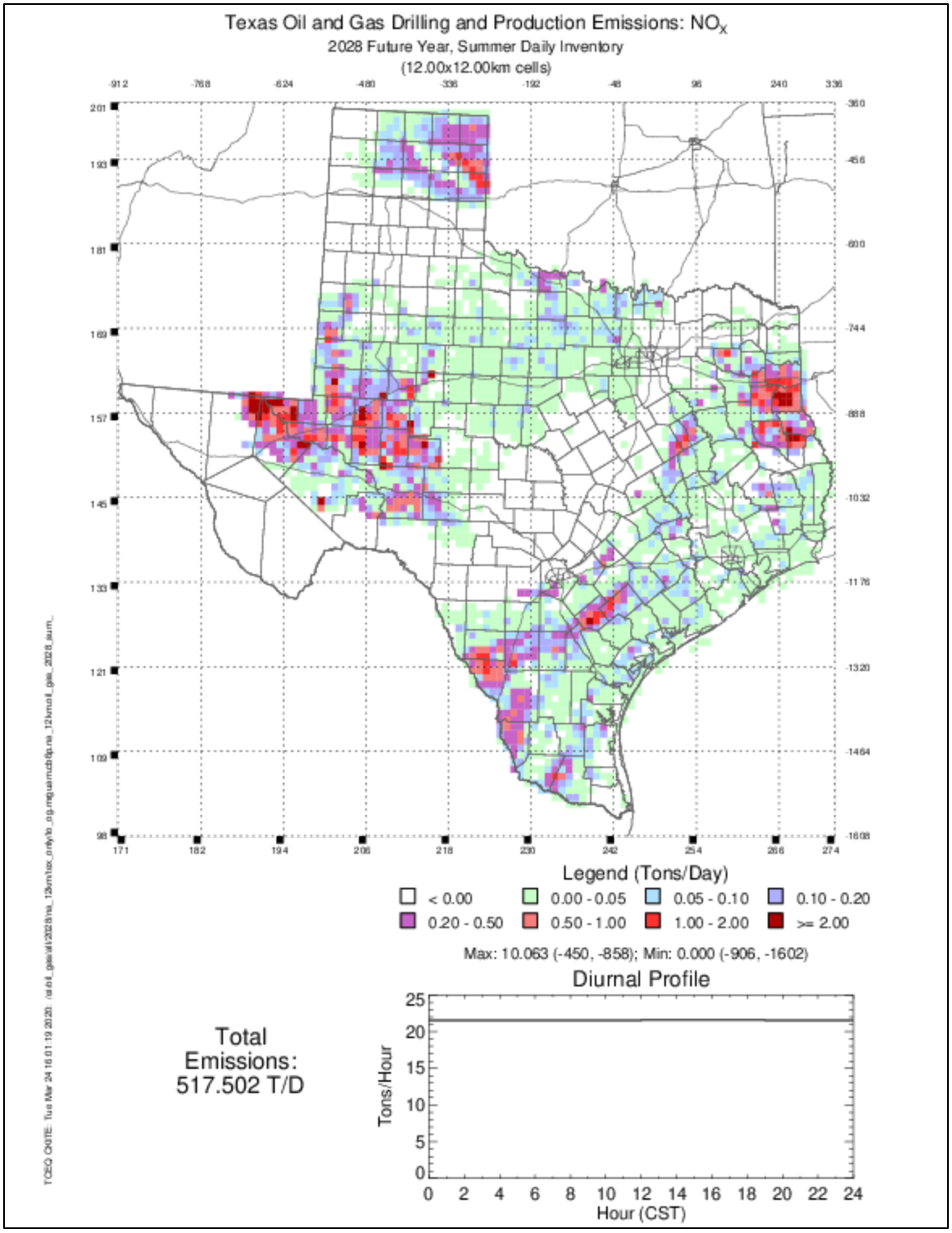

Figure 4-2: 2028 Texas Oil-and-Gas NO_x Emissions Distribution

4.1.2 Outside Texas

For the non-Texas U.S. states oil-and-gas sources, the 2016 National Emissions Inventory Collaborative (NEIC) platform Beta version (2016 NEIC platform vβ) inventories (2016ff and 2028fg) were used. The sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform detailed development of the 2016 Oil-and-gas emission inventory (NEIC, 2019).

4.2 AIRPORTS

Airport sources include aircraft engines, auxiliary power units (APU), and ground support equipment (GSE).

4.2.1 Within and Outside Texas

The TCEQ used the 2016 NEIC platform v1 inventories (2016fh and 2028fg) for the U.S. airport sources. The sources are represented by average days per week (Monday through Sunday) by month plus holidays. The 2016 NEIC platform detailed development of the 2016 airport emission inventory using the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) version 2d (NEIC, 2019).

4.2.2 Texas Summary

The 2016 and 2028 airport emissions in Texas by season are summarized in Table 4-17: *2016 Texas Airport Criteria Pollutant Emissions by Season*, Table 4-18: *2016 Texas Airport $PM_{2.5}$ Component Emissions by Season*, Table 4-19: *2028 Texas Airport Criteria Pollutant Emissions by Season*, and Table 4-20: *2028 Texas Airport $PM_{2.5}$ Component Emissions by Season*.

Table 4-17: 2016 Texas Airport Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	3951	1520	14677	573.73	0.00	188.08	212.55
Summer	4152	1597	15424	602.90	0.00	197.64	223.35
Fall	3821	1470	14195	554.87	0.00	181.90	205.56
Winter	3334	1282	12385	342.32	0.00	158.70	179.35
Annual	15259	5868	56681	2074	0.00	726.33	820.81

Table 4-18: 2016 Texas Airport $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	45.31	65.50	12.53	0.01	3.91	58.87	0.00	1.95	188.08
Summer	47.61	68.83	13.17	0.01	4.11	61.87	0.00	2.05	197.64
Fall	43.82	63.34	12.12	0.01	3.78	56.94	0.00	1.89	181.90
Winter	38.23	55.27	10.57	0.00	3.30	49.68	0.00	1.65	158.70
Annual	174.98	252.94	48.38	0.02	15.11	227.35	0.00	7.54	726.33

Table 4-19: 2028 Texas Airport Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	5,187	1,792	17,115	761.29	0.00	198.56	220.47
Summer	5,450	1,883	17,985	799.99	0.00	208.66	231.68
Fall	5,016	1,733	16,552	736.25	0.00	192.03	213.22
Winter	4,376	1,512	14,441	449.71	0.00	167.55	186.04
Annual	20,029	6,921	66,092	2,747	0.00	766.81	851.42

Table 4-20: 2028 Texas Airport $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	48.19	69.45	13.07	0.01	4.08	61.72	0.00	2.04	198.56
Summer	50.64	72.98	13.74	0.01	4.29	64.85	0.00	2.14	208.66
Fall	46.61	67.17	12.64	0.01	3.95	59.69	0.00	1.97	192.03
Winter	40.67	58.60	11.03	0.01	3.44	52.08	0.00	1.72	167.55
Annual	186.11	268.21	50.48	0.03	15.76	238.33	0.00	7.88	766.81

The 2016 and 2028 NO_X and SO_2 emissions from the airport sources are depicted in Figure 4-3: *2016 Airport NO_X Emissions Distribution,* Figure 4-4*: 2016 Airport SO_2 Emissions Distribution,* Figure 4-5: *2028 Airport NO_X Emissions Distribution, and Figure 4-6: 2028 Airport SO_2 Emissions Distribution.*

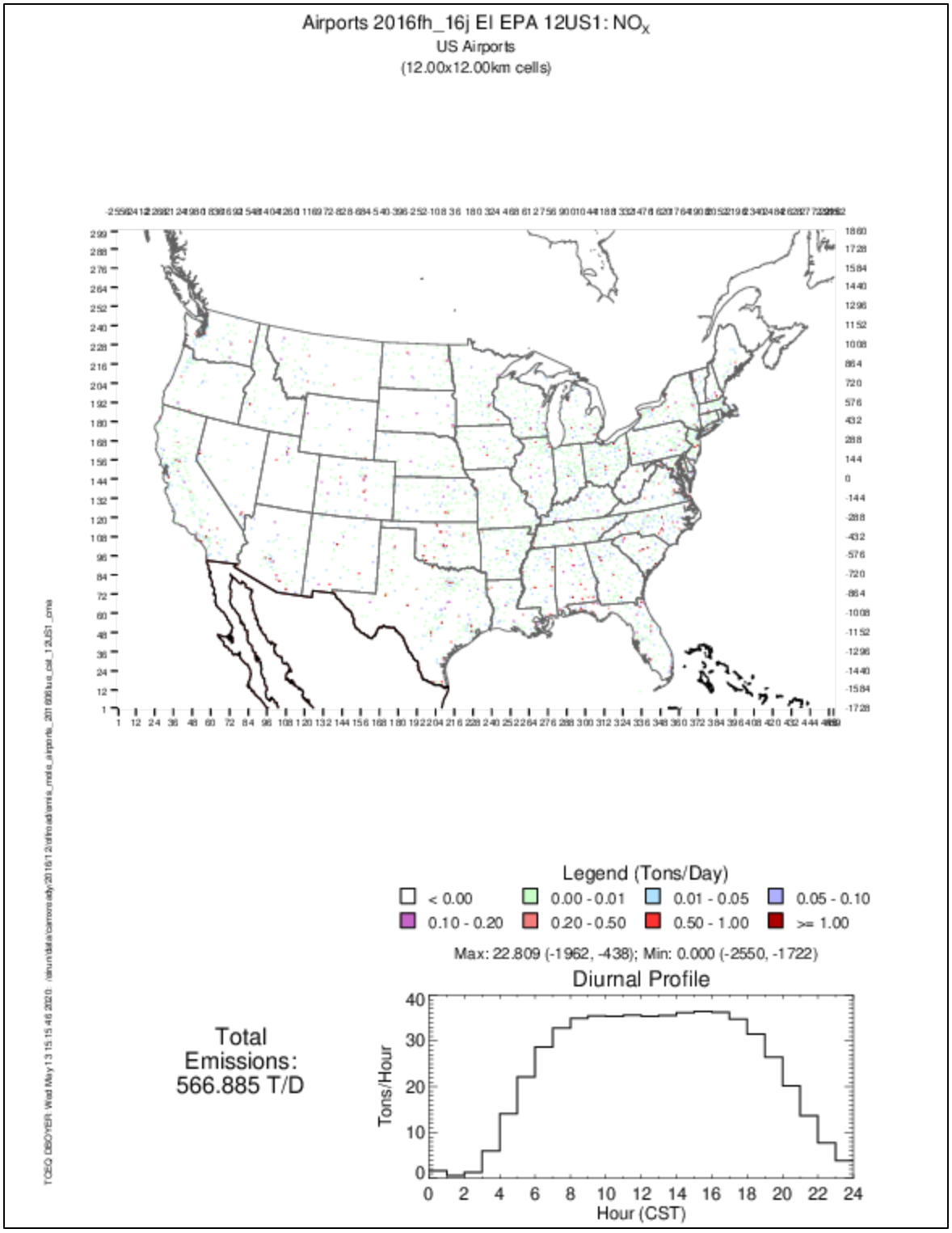

Figure 4-3: 2016 Airport NO_X Emissions Distribution

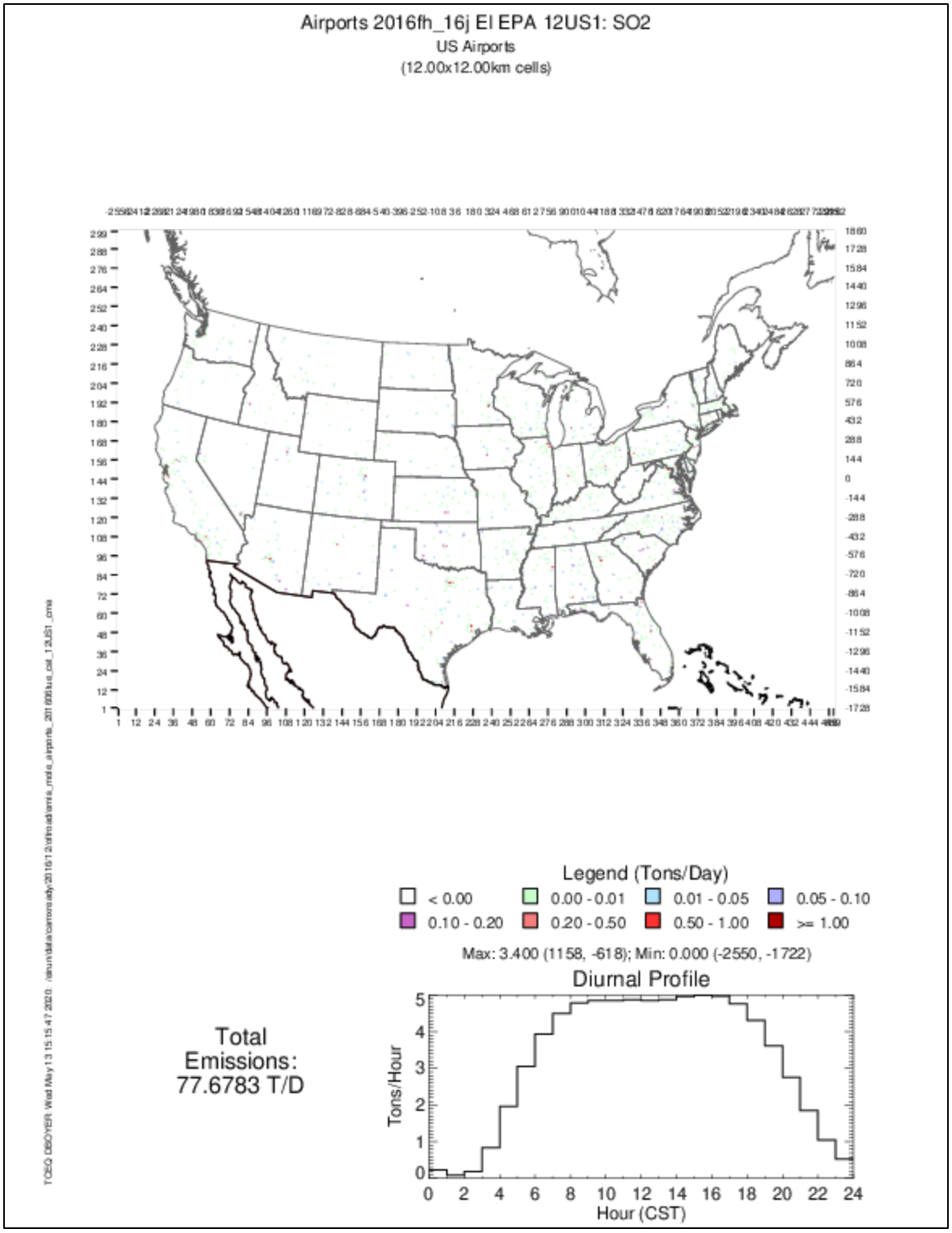

Figure 4-4: 2016 Airport SO_2 Emissions Distribution

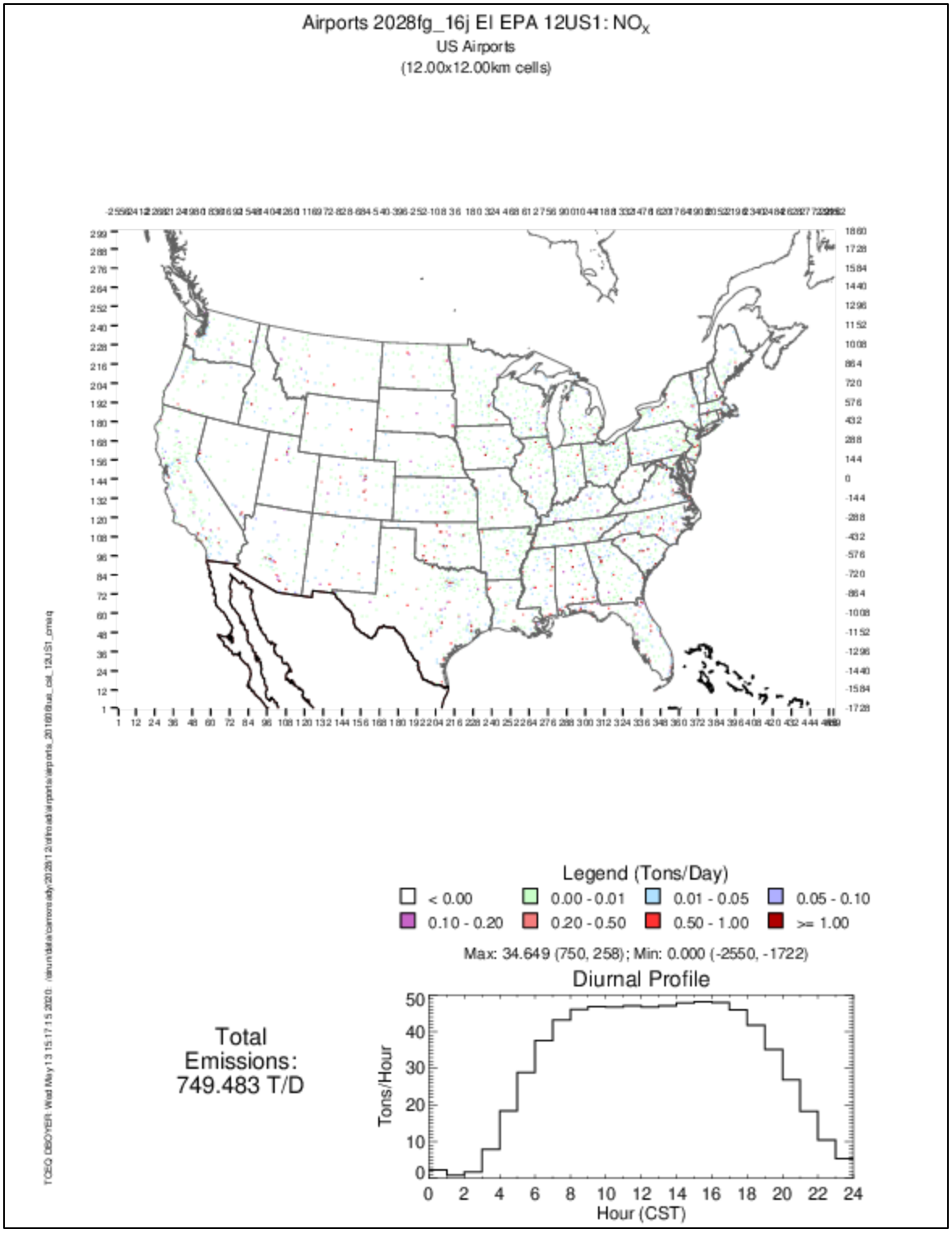

Figure 4-5: 2028 Airport NO_X Emissions Distribution

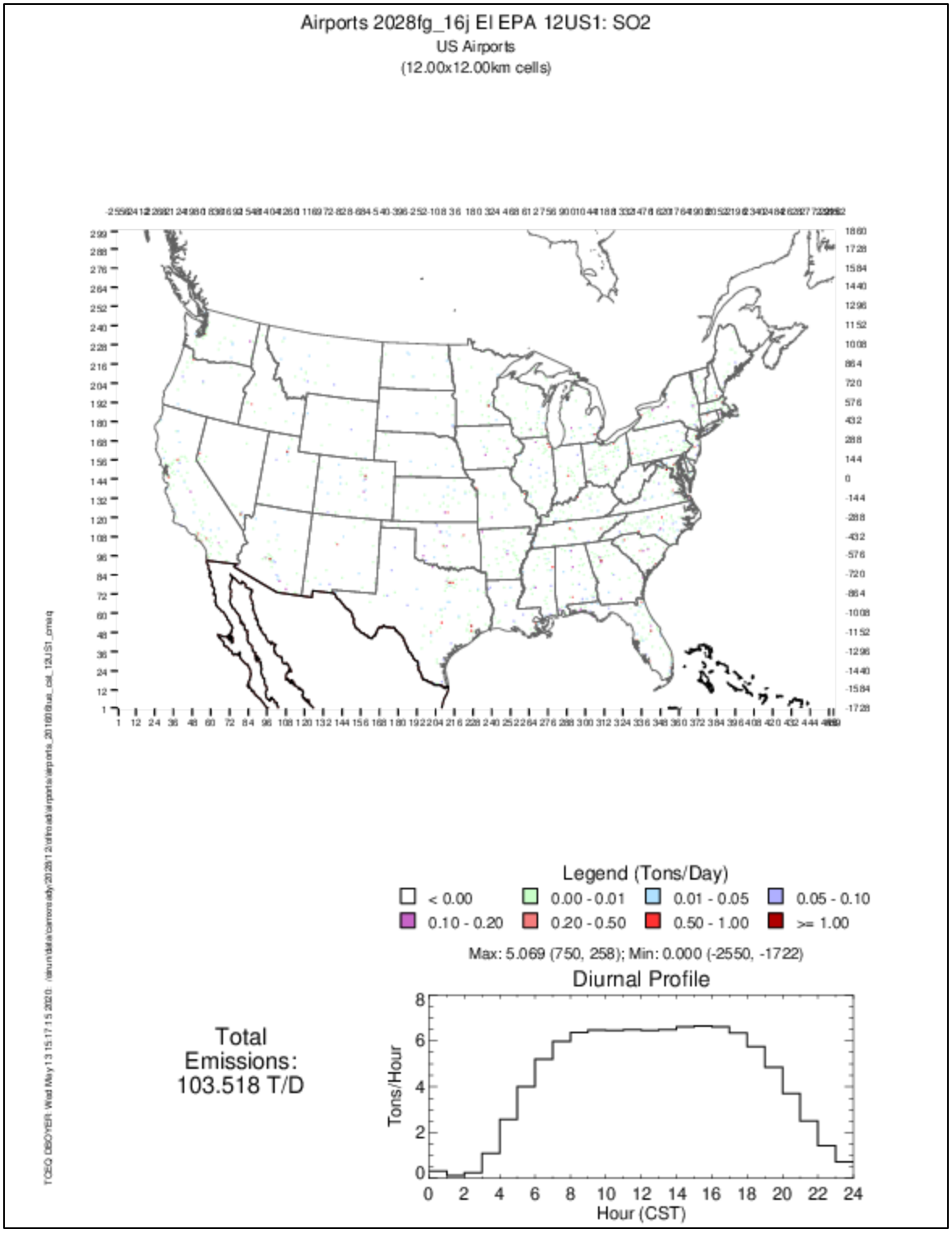

Figure 4-6: 2028 Airport SO_2 Emissions Distribution

4.3 LOCOMOTIVES

4.3.1 Within and Outside Texas

The TCEQ used the 2016 NEIC platform v1 inventories (2016fh and 2028fh) for the U.S. locomotive sources. The sources are represented by an average day per month. The 2016 NEIC platform detailed development of the 2016 locomotive emission inventory[11] according to locomotive operation category, (NEIC, 2019).

4.3.2 Texas Summary

The 2016 and 2028 locomotive emissions in Texas by season are summarized in Table 4-21: *2016 Texas Locomotive Criteria Pollutant Emissions by Season*, Table 4-22: *2016 Texas Locomotive $PM_{2.5}$ Component Emissions by Season*, Table 4-23: *2028 Texas Locomotive Criteria Pollutant Emissions by Season*, and Table 4-24: *2028 Texas Locomotive $PM_{2.5}$ Component Emissions by Season*.

Table 4-21: 2016 Texas Locomotive Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,175	523.75	2,109	7.44	6.60	322.91	332.89
Summer	11,702	548.41	2,209	7.79	6.91	338.10	348.54
Fall	11,871	556.30	2,241	7.90	7.01	342.95	353.55
Winter	11,236	526.61	2,121	7.48	6.63	324.67	334.70
Annual	45,985	2,155	8,679	30.61	27.15	1,329	1,370

Table 4-22: 2016 Texas Locomotive $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	70.88	249.04	0.95	0.37	0.00	1.32	0.07	0.29	322.91
Summer	74.21	260.75	1.00	0.39	0.00	1.38	0.07	0.30	338.10
Fall	75.28	264.49	1.01	0.39	0.00	1.40	0.07	0.30	342.95
Winter	71.27	250.39	0.96	0.37	0.00	1.33	0.07	0.29	324.67
Annual	291.64	1,025	3.92	1.52	0.00	5.44	0.27	1.18	1,329

Table 4-23: 2028 Texas Locomotive Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,722	549.58	2,211.05	7.80	6.92	338.87	349.34
Summer	12,275	575.39	2,315.71	8.17	7.25	354.77	365.73
Fall	12,452	583.64	2,349.34	8.28	7.35	359.84	370.96
Winter	11,659	546.55	2,199.13	7.76	6.88	337.00	347.41
Annual	48,108	2,255	9,075	32.00	28.39	1,390	1,433

[11] http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1a_mobile-nonroad-rail_Oct2019.pdf

Table 4-24: 2028 Texas Locomotive $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	74.38	261.35	1.00	0.39	0.00	1.39	0.07	0.30	338.87
Summer	77.87	273.61	1.05	0.40	0.00	1.45	0.07	0.31	354.77
Fall	78.99	277.52	1.06	0.41	0.00	1.47	0.07	0.32	359.84
Winter	73.97	259.90	0.99	0.38	0.00	1.38	0.07	0.30	337.00
Annual	305.22	1,072	4.10	1.59	0.00	5.69	0.29	1.23	1,390

The 2016 and 2028 locomotive emissions of NO_X are depicted in Figure 4-7: *2016 Locomotive NO_X Emissions Distribution* and Figure 4-8: *2016 Locomotive NO_X Emissions Distribution*. SO_2 emissions are not plotted because the emissions are very low due to low sulfur fuel rules. The temporal profile of locomotive emissions is constant because long-haul rail operates continuously.

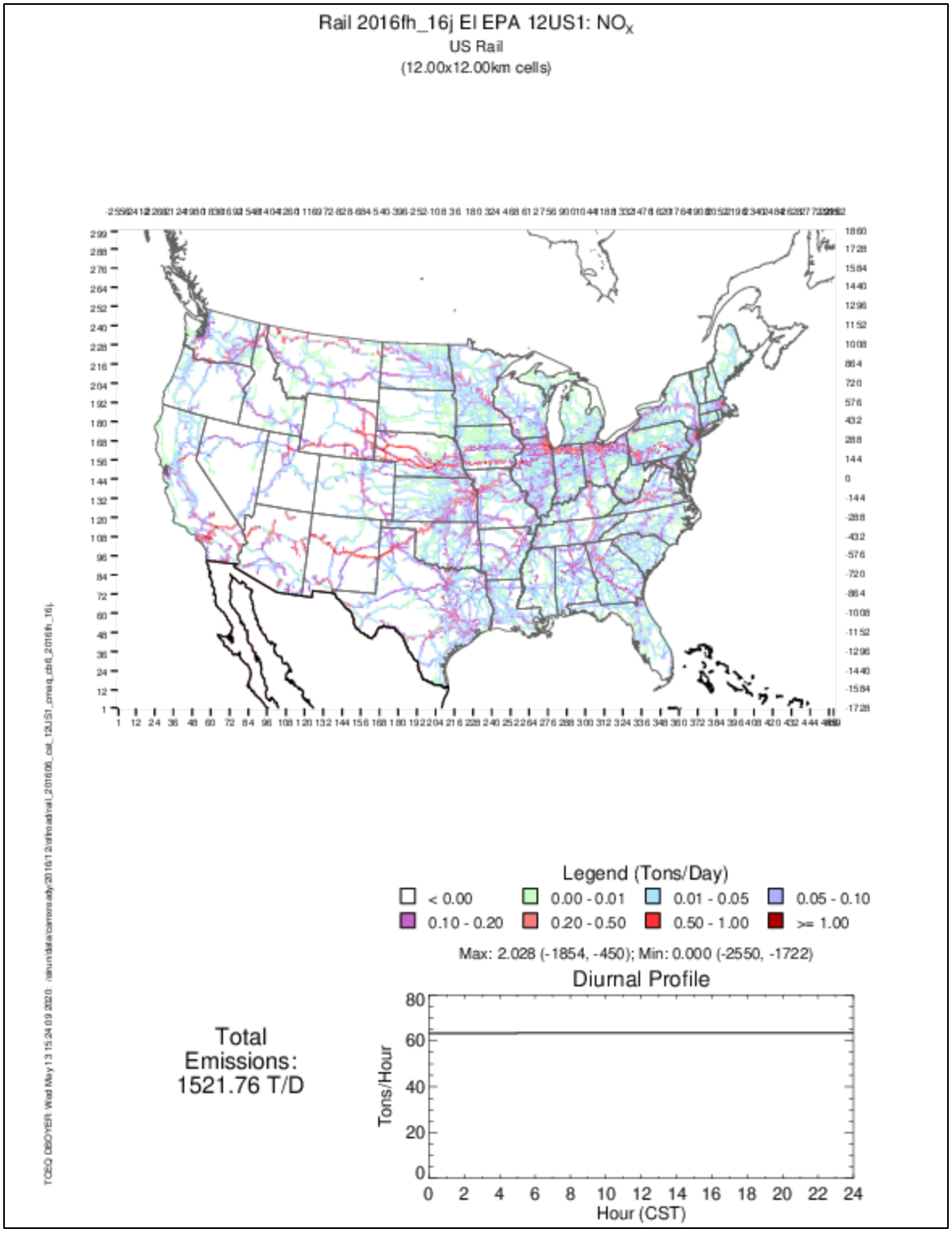

Figure 4-7: 2016 Locomotive NO_x Emissions Distribution

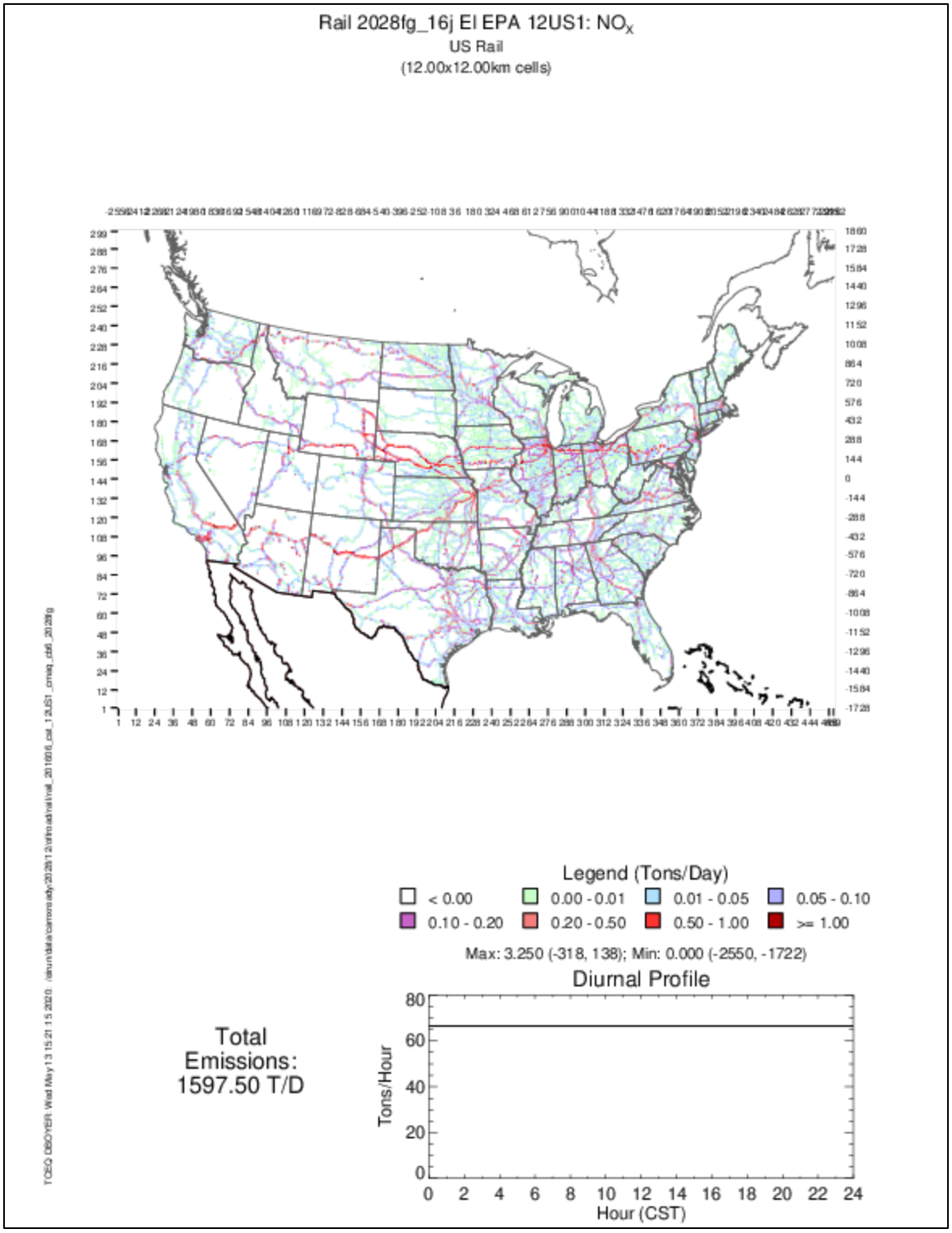

Figure 4-8: 2016 Locomotive NO_x Emissions Distribution

4.4 NON-ROAD/TEXN

4.4.1 Within Texas

Non-road mobile sources include vehicles, engines, and equipment used for construction, agriculture, recreation, and many other purposes. Non-road mobile source emissions for 2016 and 2028 were developed by the TCEQ using version 2 of the Texas NONROAD (TexN2) model. TexN2 is a customized tool that interfaces with the non-road emissions calculations performed by the MOVES2014b model. For each Texas county, TexN2 performs up to 25 separate runs of MOVES2014b that account for Texas-specific equipment population estimates for multiple diesel equipment subcategories.

The population by subcategory for all 254 Texas counties in both 2016 and 2028 is summarized in Table 4-25: *Non-Road Equipment Population Estimates by Diesel Subcategory*. The MOVES2014b model also categorizes non-road equipment by aggregate sector, and the 2016 and 2028 population for nine sectors is summarized in Table 4-26: *Non-Road Equipment Population Estimates by Sector*. The non-road equipment estimates for 2016 and 2028 are summarized by five fuel type/engine categories in Table 4-27: *Non-Road Equipment Population Estimates by Fuel and Engine Type*.

Table 4-25: Non-Road Equipment Population Estimates by Diesel Subcategory

Numeric Code	TexN2 Model Subsector Description (Diesel Construction Equipment for 1-24)	2016 Equipment Population	2028 Equipment Population
0	Other - Non-Diesel Construction Equipment	10,385,018	12,277,587
1	DCE - Agricultural Activities	3,963	3,740
2	DCE - Boring and Drilling Equipment	1,217	1,156
3	DCE - Brick and Stone Operations	353	420
4	DCE - City and County Road Construction	4,816	5,298
5	DCE - Commercial Construction	76,580	71,867
6	DCE - Concrete Operations	571	699
7	DCE - County-Owned Construction Equipment	1,292	1,460
8	DCE – Cranes	6,937	7,171
9	DCE - Heavy Highway Construction	8,383	7,204
10	DCE - Landfill Operations	550	642
11	DCE - Landscaping Activities	9,739	11,163
12	DCE - Manufacturing Operations	783	1,156
13	DCE - Municipal-Owned Construction Equipment	7,484	8,497
14	DCE - Transportation/Sales/Services	8,559	13,805
15	DCE - Residential Construction	7,458	8,976
16	DCE - Rough Terrain Forklifts	24,918	24,964
17	DCE - Scrap/Recycling Operations	677	775
18	DCE - Skid Steer Loaders	83,460	87,060
19	DCE - Special Trades Construction	8,627	7,739
20	DCE – Trenchers	22,305	22,215
21	DCE - TxDOT Construction Equipment	4,096	3,824
22	DCE - Utility Construction	18,389	22,262
23	DCE - Mining and Quarry Operation	8,936	8,075
25	DCE - Off-Road Tractors, Miscellaneous, And Equipment Under 25 Horsepower	24,320	29,797
0 - 25	Total	10,719,431	12,627,550

Table 4-26: Non-Road Equipment Population Estimates by Sector

MOVES Model Sector Description	2016 Equipment Population	2028 Equipment Population
Recreational	905,788	959,378
Construction	423,567	442,222
Industrial	138,367	167,970
Lawn/Garden	7,343,745	8,775,784
Agriculture	292,489	353,990
Commercial	904,779	1,153,822
Logging	19,012	24,256
Pleasure Craft	690,289	748,344
Railroad	1,395	1,785
Total	10,719,431	12,627,550

Table 4-27: Non-Road Equipment Population Estimates by Fuel and Engine Type

Non-Road Engine and Fuel Type Description	2016 Equipment Population	2028 Equipment Population
Diesel	803,487	932,222
Two-Stroke Gasoline	3,491,860	4,075,722
Four-Stroke Gasoline	6,318,236	7,486,445
Liquefied Petroleum Gas (LPG)	98,480	123,973
Compressed Natural Gas (CNG)	7,369	9,189
Total	10,719,431	12,627,550

For both 2016 and 2028, version 2 of TexN2 was run for the four seasons of Spring, Summer, Fall, and Winter for all 254 Texas counties. Within each season, separate emissions estimates were then developed for the three activity day types of weekday (Monday-Friday average), Saturday, and Sunday. The Texas Non-Road criteria pollutant emissions are summarized in Table 4-28: *2016 Statewide Non-Road Criteria Pollutant Emissions by Season and Day Type* and Table 4-29: *2028 Statewide Non-Road Criteria Pollutant Emissions by Season and Day Type*. The reduction in non-road emissions from 2016 to 2028 is due primarily to fleet turnover where older higher-emitting equipment is removed through attrition and replaced by newer lower-emitting equipment. 2016 was the last year when gasoline sulfur levels were required under federal rules to average 30 parts per million (ppm). Starting in 2017, a phase-in began that requires an average gasoline sulfur content of 10 ppm. The reduction in non-road SO_2 emissions from 2016 to 2028 is primarily the result of this change in gasoline sulfur concentration from 30 ppm to 10 ppm.

Table 4-28: 2016 Statewide Non-Road Criteria Pollutant Emissions by Season and Day Type

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Spring Weekday	321.83	146.29	1,807	0.48	0.66	27.66	28.82
Spring Saturday	290.87	265.79	2,625	0.50	0.62	25.87	27.08
Spring Sunday	260.71	249.46	2,327	0.44	0.56	23.45	24.55
Summer Weekday	342.44	193.64	2,150	0.55	0.75	32.26	33.62
Summer Saturday	332.87	405.43	3,504	0.64	0.76	31.80	33.36
Summer Sunday	303.20	386.25	3,164	0.57	0.69	29.22	30.65
Fall Weekday	265.24	167.65	2,195	0.71	0.57	23.97	25.00
Fall Saturday	227.01	318.22	3,261	0.68	0.54	22.11	23.21
Fall Sunday	197.62	297.09	2,889	0.58	0.47	19.65	20.64
Winter Weekday	227.24	95.93	1,402	0.57	0.45	18.01	18.75
Winter Saturday	179.32	149.82	1,628	0.47	0.37	14.98	15.65
Winter Sunday	151.47	140.32	1,501	0.39	0.32	12.99	13.59

Table 4-29: 2028 Statewide Non-Road Criteria Pollutant Emissions by Season and Day Type

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)	SO_2 (tpd)	NH_3 (tpd)	$PM_{2.5}$ (tpd)	PM_{10} (tpd)
Spring Weekday	154.41	113.53	1,858	0.39	0.76	11.11	11.75
Spring Saturday	148.98	181.31	2,697	0.41	0.72	11.04	11.74
Spring Sunday	132.16	166.19	2,389	0.37	0.65	9.76	10.38
Summer Weekday	165.70	142.53	2,185	0.45	0.87	12.85	13.59
Summer Saturday	178.86	255.04	3,495	0.52	0.88	13.44	14.30
Summer Sunday	162.35	237.25	3,140	0.47	0.80	12.06	12.83
Fall Weekday	132.81	128.73	1,827	0.35	0.66	10.16	10.77
Fall Saturday	127.95	215.61	2,667	0.37	0.62	10.10	10.76
Fall Sunday	111.14	196.86	2,358	0.33	0.55	8.81	9.38
Winter Weekday	113.34	75.03	1,170	0.27	0.52	7.18	7.58
Winter Saturday	94.23	105.49	1,355	0.24	0.43	6.24	6.62
Winter Sunday	79.11	97.67	1,262	0.21	0.38	5.36	5.70

The non-road inputs were prepared for photochemical model input with version 3 of the Emissions Preprocessor System (EPS3). The EPS3 SPCEMS module was used to separate the $PM_{2.5}$ emissions into components of POA, PEC, PSO_4, PNO_3, PNH_4, PCL, PNA and FPRM. These are summarized in Table 4-30: *2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Day Type* and Table 4-31: *2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Day Type*.

Table 4-30: 2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Day Type

Season and Day Type	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	PCL (tpd)	PNA (tpd)	FPRM (tpd)	$PM_{2.5}$ (tpd)
Spring Weekday	8.46	17.24	0.14	0.05	0.003	0.03	0.01	1.71	27.64
Spring Saturday	8.72	14.70	0.12	0.04	0.002	0.02	0.01	2.23	25.85
Spring Sunday	7.87	13.38	0.09	0.03	0.001	0.02	0.01	2.04	23.44
Summer Weekday	9.89	20.07	0.16	0.06	0.003	0.03	0.01	2.03	32.25
Summer Saturday	11.03	17.54	0.13	0.05	0.002	0.02	0.01	3.00	31.79
Summer Sunday	10.13	16.11	0.11	0.04	0.002	0.02	0.01	2.78	29.20
Fall Weekday	7.62	14.42	0.13	0.04	0.003	0.03	0.01	1.68	23.94
Fall Saturday	7.88	11.83	0.10	0.04	0.002	0.02	0.01	2.21	22.10
Fall Sunday	7.02	10.48	0.08	0.03	0.001	0.01	0.01	2.02	19.64
Winter Weekday	5.50	11.25	0.11	0.04	0.002	0.02	0.01	1.06	18.00
Winter Saturday	4.91	8.76	0.09	0.03	0.002	0.02	0.01	1.14	14.96
Winter Sunday	4.28	7.55	0.06	0.02	0.001	0.01	0.01	1.04	12.98

Table 4-31: 2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Day Type

Season and Day Type	POA (tpd)	PEC (tpd)	PSO_4 (tpd)	PNO_3 (tpd)	PNH_4 (tpd)	PCL (tpd)	PNA (tpd)	FPRM (tpd)	$PM_{2.5}$ (tpd)
Spring Weekday	4.96	4.25	0.11	0.03	0.003	0.03	0.02	1.69	11.09
Spring Saturday	5.20	3.75	0.09	0.03	0.003	0.02	0.01	1.93	11.02
Spring Sunday	4.54	3.38	0.06	0.02	0.002	0.02	0.01	1.71	9.74
Summer Weekday	5.65	5.08	0.12	0.04	0.003	0.03	0.02	1.91	12.84
Summer Saturday	6.28	4.64	0.09	0.03	0.003	0.02	0.01	2.34	13.42
Summer Sunday	5.58	4.24	0.07	0.02	0.002	0.02	0.01	2.10	12.05
Fall Weekday	4.73	3.57	0.10	0.03	0.003	0.03	0.02	1.67	10.15
Fall Saturday	4.97	3.06	0.08	0.03	0.002	0.02	0.01	1.92	10.08
Fall Sunday	4.31	2.69	0.05	0.02	0.002	0.01	0.01	1.69	8.78
Winter Weekday	3.29	2.63	0.10	0.03	0.003	0.03	0.01	1.09	7.18
Winter Saturday	2.98	2.07	0.07	0.02	0.002	0.02	0.01	1.06	6.24
Winter Sunday	2.58	1.83	0.05	0.02	0.002	0.01	0.01	0.95	5.45

Within each season, weekly non-road emissions totals were developed by multiplying the weekday estimates by a factor of five, and then summing this result with the Saturday and Sunday estimates. The results of these efforts are summarized in Table 4-32: *2016 Statewide Non-Road Criteria Pollutant Emissions by Season and Week*, Table 4-33: *2028 Statewide Non-Road Criteria Pollutant Emissions by Season and Week*, Table 4-34: *2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Week*, and Table 4-35: *2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Week*.

Table 4-32: 2016 Statewide Non-Road Criteria Pollutant Emissions by Season and Week

Season and Week	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Week	2,161	1,247	13,986	3.33	4.46	187.64	195.71
Summer Week	2,348	1,760	17,418	3.95	5.22	222.34	232.13
Fall Week	1,751	1,454	17,123	4.79	3.87	161.60	168.86
Winter Week	1,467	769.79	10,138	3.70	2.94	118.04	122.97

Table 4-33: 2028 Statewide Non-Road Criteria Pollutant Emissions by Season and Week

Season and Week	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring Week	1,053	915.13	14,376	2.72	5.20	76.33	80.89
Summer Week	1,170	1,205	17,560	3.23	6.04	89.76	95.10
Fall Week	903.12	1,056	14,160	2.43	4.47	69.71	73.99
Winter Week	740.06	578.32	8,466	1.77	3.39	47.49	50.20

Table 4-34: 2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Week

Season and Week	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	PCL (tons)	PNA (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring Week	58.89	114.26	0.93	0.32	0.02	0.18	0.08	12.80	187.49
Summer Week	70.60	133.98	1.04	0.37	0.02	0.19	0.09	15.94	222.23
Fall Week	53.02	94.41	0.81	0.28	0.02	0.16	0.08	12.65	161.43
Winter Week	36.69	72.58	0.71	0.24	0.02	0.15	0.07	7.46	117.93

Table 4-35: 2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season and Week

Season and Week	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	PCL (tons)	PNA (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring Week	34.55	28.39	0.70	0.22	0.02	0.19	0.10	12.06	76.24
Summer Week	40.11	34.26	0.76	0.24	0.02	0.20	0.11	13.98	89.68
Fall Week	32.91	23.58	0.65	0.21	0.02	0.18	0.10	11.98	69.63
Winter Week	22.01	17.06	0.60	0.18	0.02	0.17	0.09	7.43	47.57

Once weekly emissions totals are available by season, seasonal and annual totals can readily be obtained by using the numbers provided in Table 3-11. For example, since there are 13.14 weeks in the Spring and Summer, total seasonal emissions can readily be obtained by multiplying weekly totals by 13.14. Since both 2016 and 2028 are leap years, the Winter leap year adjustment factor of 13.00 was used instead of the 12.86 factor that would apply to non-leap years. Application of the appropriate factors from Table 3-11 to the weekly totals resulted in the seasonal on-road emissions totals provided in Table 4-36: *2016 Statewide Non-Road Criteria Pollutant Emissions by Season*, Table 4-37: *2028 Statewide Non-Road Criteria Pollutant Emissions by Season*,

Table 4-38: *2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season*, and Table 4-39: *2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season.*

Table 4-36: 2016 Statewide Non-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	28,398	16,385	183,813	43.80	58.66	2,466	2,572
Summer	30,863	23,130	228,923	51.93	68.60	2,922	3,051
Fall	22,761	18,897	222,595	62.28	50.32	2,101	2,195
Winter	19,071	10,007	131,795	48.08	38.25	1,535	1,599
Annual	101,093	68,420	767,125	206.09	215.83	9,024	9,417

Table 4-37: 2028 Statewide Non-Road Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	13,842	12,027	188,945	35.69	68.28	1,003	1,063
Summer	15,373	15,837	230,794	42.42	79.41	1,180	1,250
Fall	11,741	13,729	184,077	31.59	58.11	906.22	961.81
Winter	9,620	7,518	110,056	23.05	44.03	617.40	652.66
Annual	50,577	49,111	713,872	132.75	249.83	3,706	3,928

Table 4-38: 2016 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	PCL (tons)	PNA (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring	774.03	1,502	12.18	4.26	0.23	2.37	1.10	168.25	2,464
Summer	927.87	1,761	13.61	4.83	0.24	2.56	1.17	209.52	2,921
Fall	689.28	1,227	10.59	3.70	0.21	2.13	1.00	164.39	2,099
Winter	476.96	943.57	9.26	3.09	0.20	1.98	0.96	97.04	1,533
Annual	2,868	5,433	45.64	15.88	0.88	9.04	4.23	639.20	9,016

Table 4-39: 2028 Statewide Non-Road $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	PCL (tons)	PNA (tons)	FPRM (tons)	$PM_{2.5}$ (tons)
Spring	454.06	373.18	9.23	2.94	0.27	2.47	1.33	158.55	1,002
Summer	527.16	450.22	9.98	3.22	0.29	2.62	1.40	183.75	1,179
Fall	427.87	306.59	8.43	2.69	0.25	2.30	1.24	155.79	905.16
Winter	286.07	221.79	7.85	2.39	0.24	2.20	1.20	96.62	618.36
Annual	1,695	1,352	35.49	11.24	1.05	9.59	5.17	594.71	3,704

The 2016 gridded input files for Texas non-road emissions are provided along with the full EPS3 message streams at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/base_2016/nonroad/. The 2028 gridded input files for Texas on-road emissions are provided along with the full EPS3 message streams at ftp://amdaftp.tceq.texas.gov/EI/2016_episodes/future_2028/nonroad/.

The following pages contain graphical plots of the spatial and temporal distribution of 2016 and 2028 non-road Summer weekday emissions for all of Texas at a resolution of 12 kilometers (km). These plots are titled Figure 4-9: *2016 Summer Weekday Texas Non-Road NO_X Emissions Distribution* and Figure 4-10: *2028 Summer Weekday Texas Non-Road NO_X Emissions Distribution*. Similar plots for the other non-road pollutants are not provided because they have an emissions spatial distribution similar to that for NO_X.

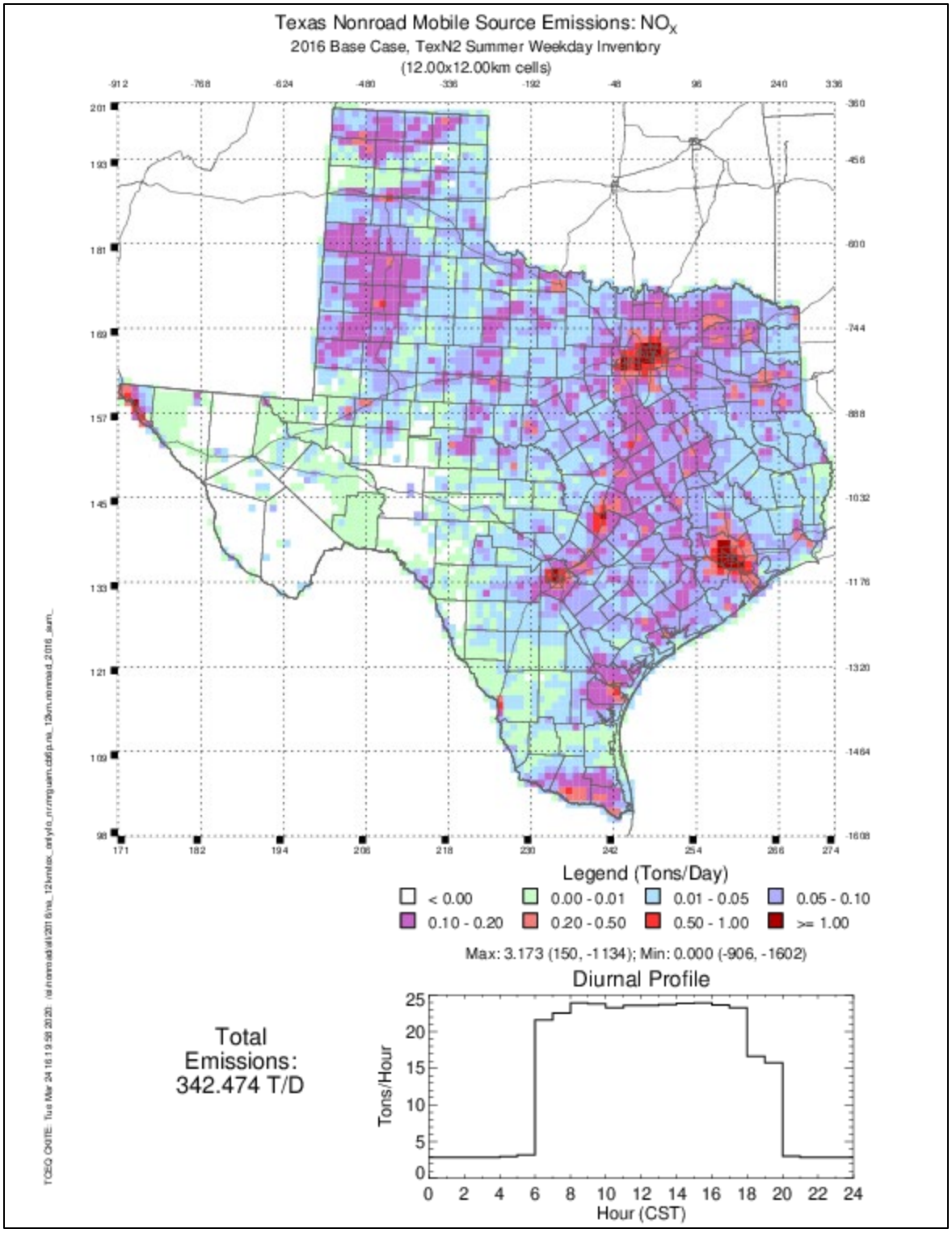

Figure 4-9: 2016 Summer Weekday Texas Non-Road NO_X Emissions Distribution

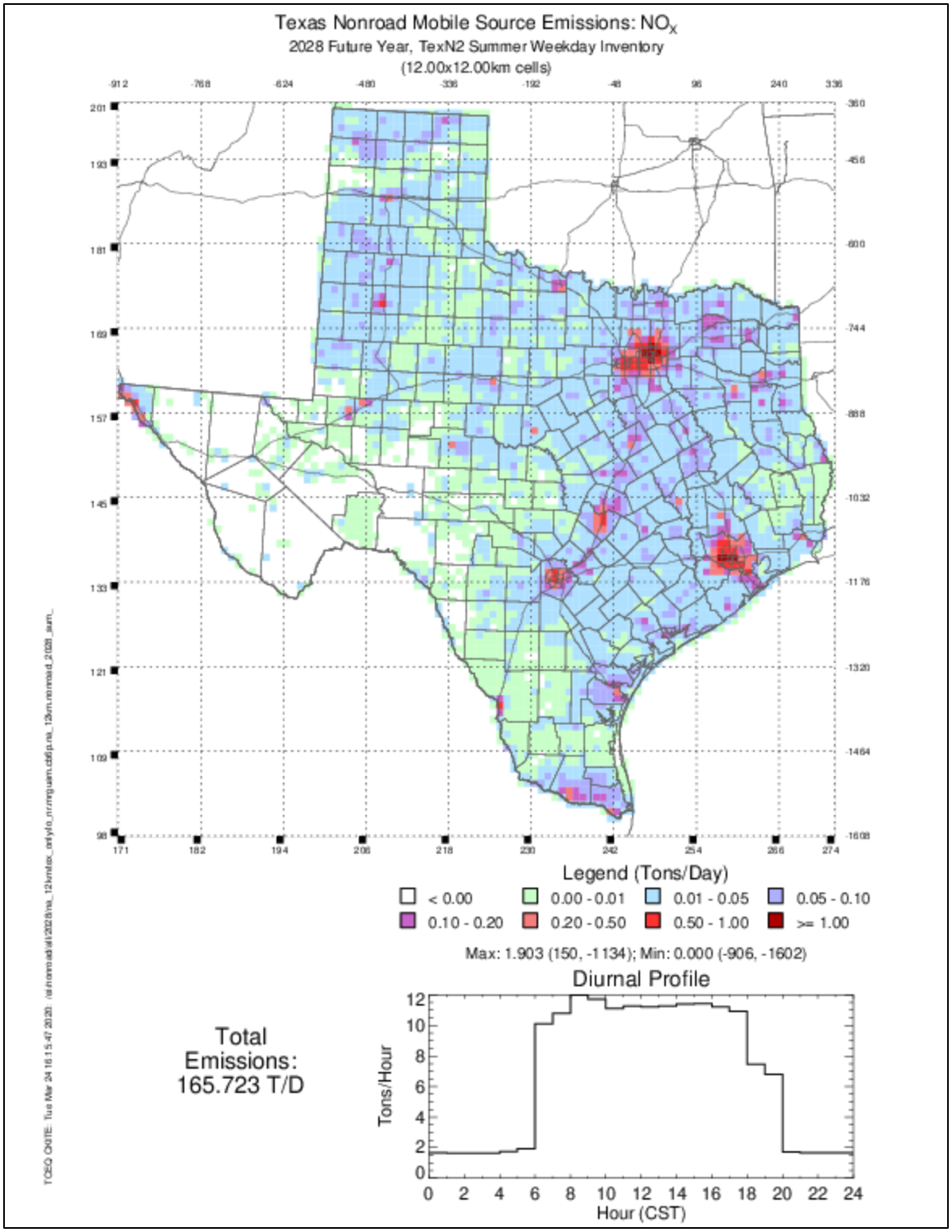

Figure 4-10: 2028 Summer Weekday Texas Non-Road NO_x Emissions Distribution

4.4.2 Outside Texas

For the non-Texas North American portion of the modeling domains, the TCEQ used the 2016 NEIC platform vβ inventories (2016ff) from for the non-road mobile sources. The sources are represented by an average weekday and weekend day per month plus holidays. The 2016 NEIC platform detailed development of the 2016 non-road emission inventory[12] (NEIC, 2019).

[12]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad_06Mar2019.pdf

4.5 AREA SOURCES

Area sources include commercial, small-scale industrial, and residential activities that use materials or operate processes that can generate emissions. These sources of emissions fall below the point source reporting levels and are either too numerous or too small to identify individually. Emissions from these sources are estimated on a source category basis per county. Area source VOC emissions can result from either evaporation or fuel combustion. Examples of sources of evaporative losses include printing operations, industrial coatings, degreasing solvents, house paints, underground storage tanks, underground tank filling at gasoline service stations, and vehicle refueling operations. Fuel combustion sources include stationary source fossil fuel combustion at residences and businesses, along with outdoor burning and structural fires. With some exceptions, area source emission estimates are obtained by multiplying an established emission factor by the appropriate activity or activity surrogate responsible for generating the emissions. Human population is the most common activity surrogate for many area source categories, while other activity data include the amount of gasoline sold in an area, employment by industry type, acres of cropland, etc.

4.5.1 Within and Outside Texas

The TCEQ used 2016 NEIC platform vβ and v1 inventories for the U.S. area sources, including Texas. Oil-and-gas emissions are not included in this area source category. The sub-categories of the area sources, the 2016 NEIC platform versions, and the inventory development documentation is shown in Table 4-40: *2016 Area Source Inventory Version and Documentation*.

Table 4-40: 2016 Area Source Inventory Version and Documentation

Area Source Sub-Category	2016 NEIC Platform Version	2028 NEIC Inventory Version	Documentation (Reference)
Non-Point Sources	2016v1 (2016fh)	2028 vβ-prime (2028fg)	NEIC, 2019[13]
Residential Wood Combustion	2016 vβ (2016ff)	2016 vβ-prime (2028fg)	2016ff: NEIC, 2019[14] 2028fg: NEIC, 2019[15]
Agricultural Activities	2016v1 (2016fh)	2016 vβ-prime (2028fg)	NEIC, 2019[16]
Fugitive Dust (adjusted)	2016v1 (2016fh)	2016v1 (2028fh)	NEIC, 2019[17]

[13]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint_15Oct2019.pdf
[14]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_nonpoint-rwc_31May2019.pdf
[15]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-rwc_15Oct2019.pdf
[16]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-ag_15Oct2019.pdf
[17]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_nonpoint-afdust_15Oct2019.pdf

4.5.2 Texas Summary

The 2016 and 2028 area source emissions by season in Texas are shown in Table 4-41: *2016 Texas Area Source Criteria Pollutant Emissions by Season*, Table 4-42: *2016 Texas Area Source $PM_{2.5}$ Component Emissions by Season*, Table 4- 43: *2028 Texas Area Source Criteria Pollutant Emissions by Season*, and Table 4-44: *2028 Texas Area Source $PM_{2.5}$ Component Emissions by Season.*

Table 4-41: 2016 Texas Area Source Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,219	74,871	54,416	1,112	106,168	27,640	149,785
Summer	8,186	78,140	51,721	1,078	148,829	34,610	195,141
Fall	10,700	75,491	52,133	1,093	99,925	30,760	174,369
Winter	15,951	75,521	74,016	874	45,472	27,347	135,962
Annual	46,056	304,022	232,286	4,157	400,394	120,357	655,257

Table 4-42: 2016 Texas Area Source $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	7,805	747.21	338.91	334.70	188.28	10,530	407.95	7,288	27,640
Summer	8,436	813.38	439.49	513.20	253.60	13,961	421.40	9,772	34,610
Fall	8,032	768.71	383.58	400.79	211.93	12,203	410.26	8,350	30,760
Winter	9,965	865.14	305.87	249.09	158.61	9,201	407.44	6,195	27,347
Annual	34,237	3,194	1,468	1,498	812.42	45,895	1,647	31,605	120,357

Table 4-43: 2028 Texas Area Source Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	11,093	80,523	55,289	1,000	111,112	28,346	151,567
Summer	8,157	83,362	53,386	965	100,671	35,401	197,128
Fall	10,574	81,054	53,032	982	64,365	31,527	176,403
Winter	15,750	81,249	74,168	804	35,527	27,838	136,615
Annual	45,573	326,187	235,875	3,751	311,674	123,111	661,713

Table 4-44: 2028 Texas Area Source $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	8,190	765.14	343.80	336.57	188.71	10,708	411.93	7,403	28,346
Summer	8,872	833.81	444.65	515.15	254.04	14,157	425.63	9,898	35,401
Fall	8,426	787.33	388.84	402.68	212.39	12,411	414.36	8,485	31,527
Winter	10,258	877.60	308.81	248.42	158.09	9,310	410.91	6,266	27,838
Annual	35,745	3,264	1,486	1,503	813.23	46,585	1,663	32,052	123,112

The 2016 and 2028 Area Source emissions of NO_X and SO_2 are depicted in Figure 4-11: *2016 Area Source NO_X Emissions Distribution*, Figure 4-12: *2016 Area Source SO_2*

Emissions Distribution, Figure 4-13: *2028 Area Source NO_X Emission Distribution*, and Figure 4-14: *2028 Area Source SO_2 Emissions Distribution.*

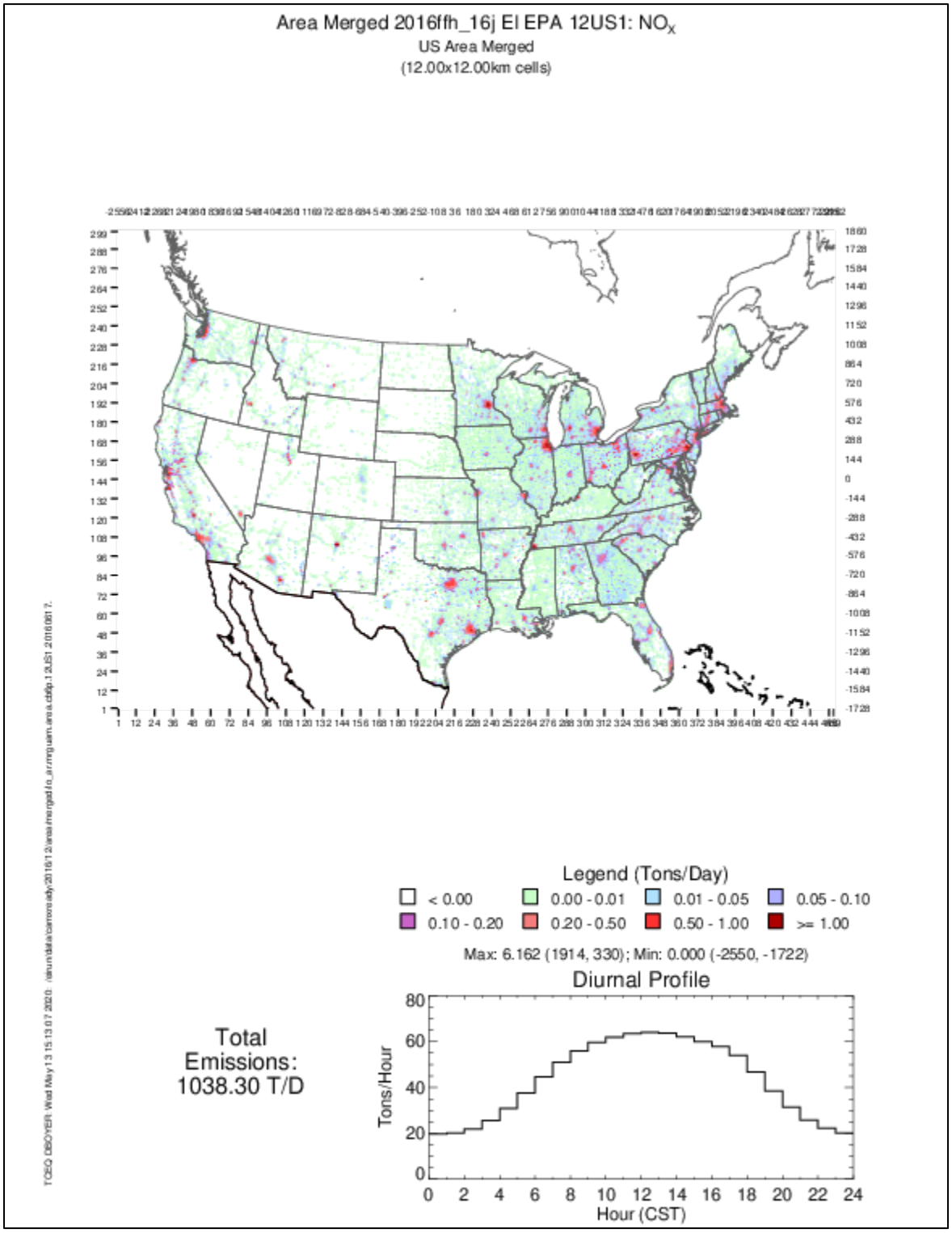

Figure 4-11: 2016 Area Source NO_X Emissions Distribution

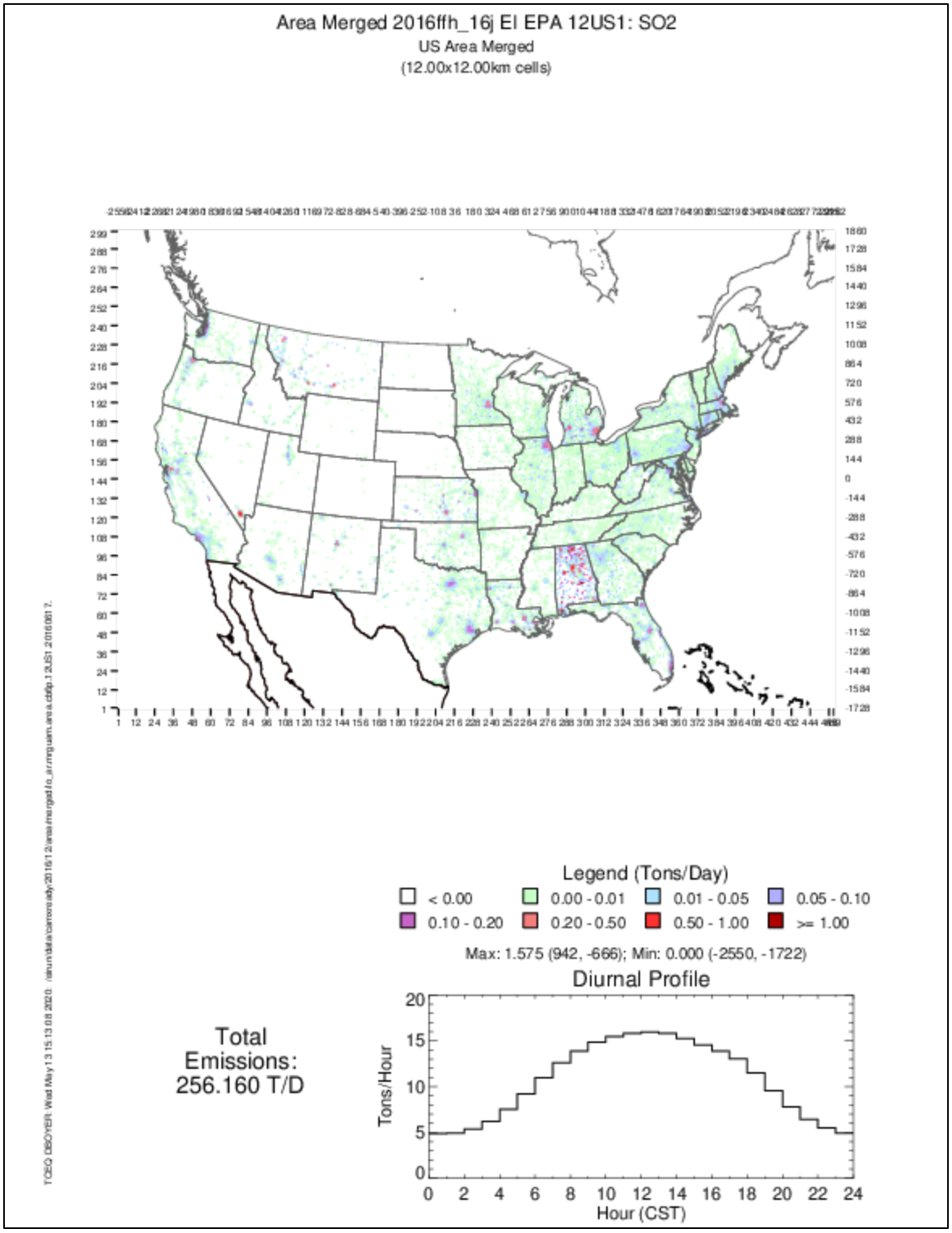

Figure 4-12: 2016 Area Source SO_2 Emissions Distribution

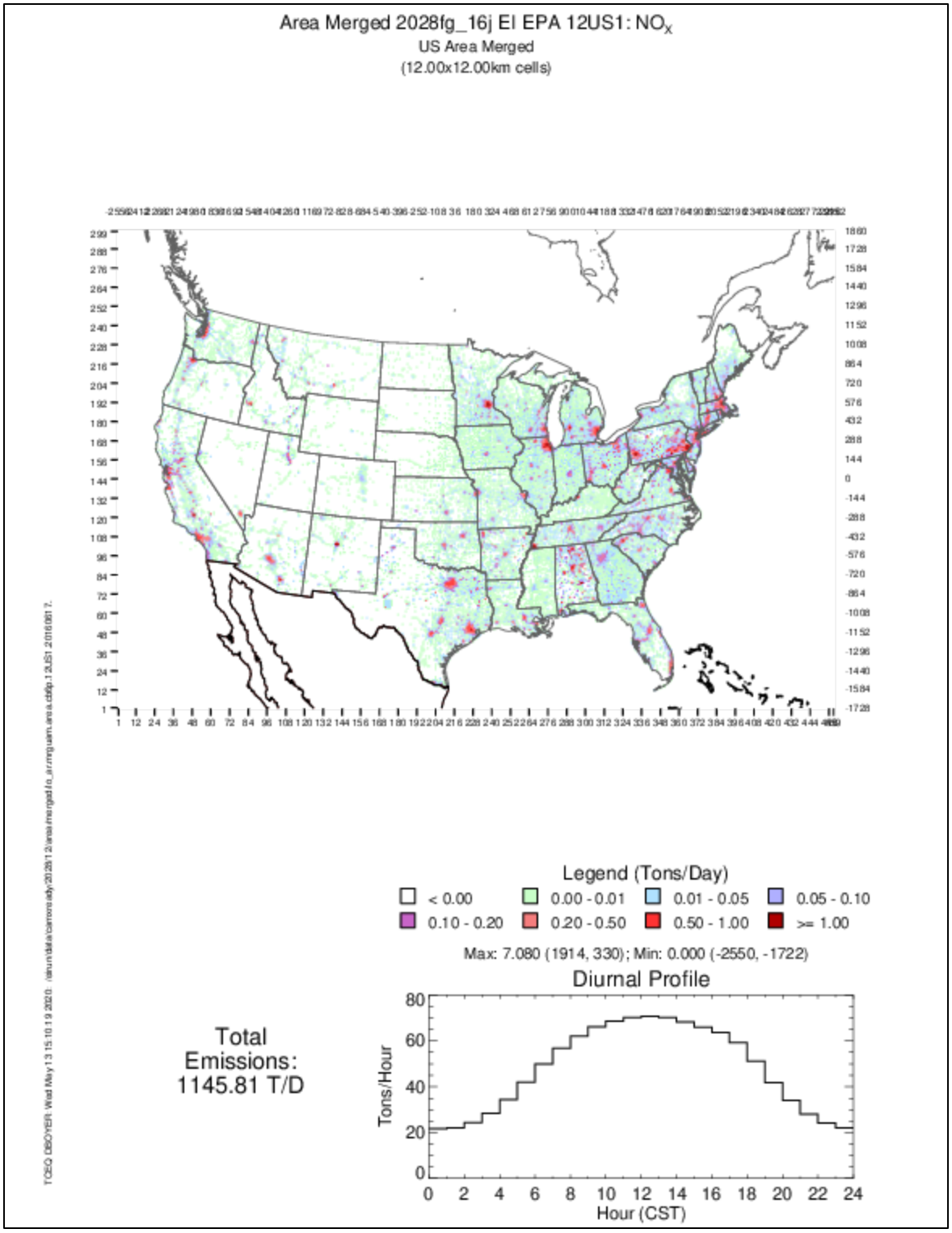

Figure 4-13: 2028 Area Source NO_x Emission Distribution

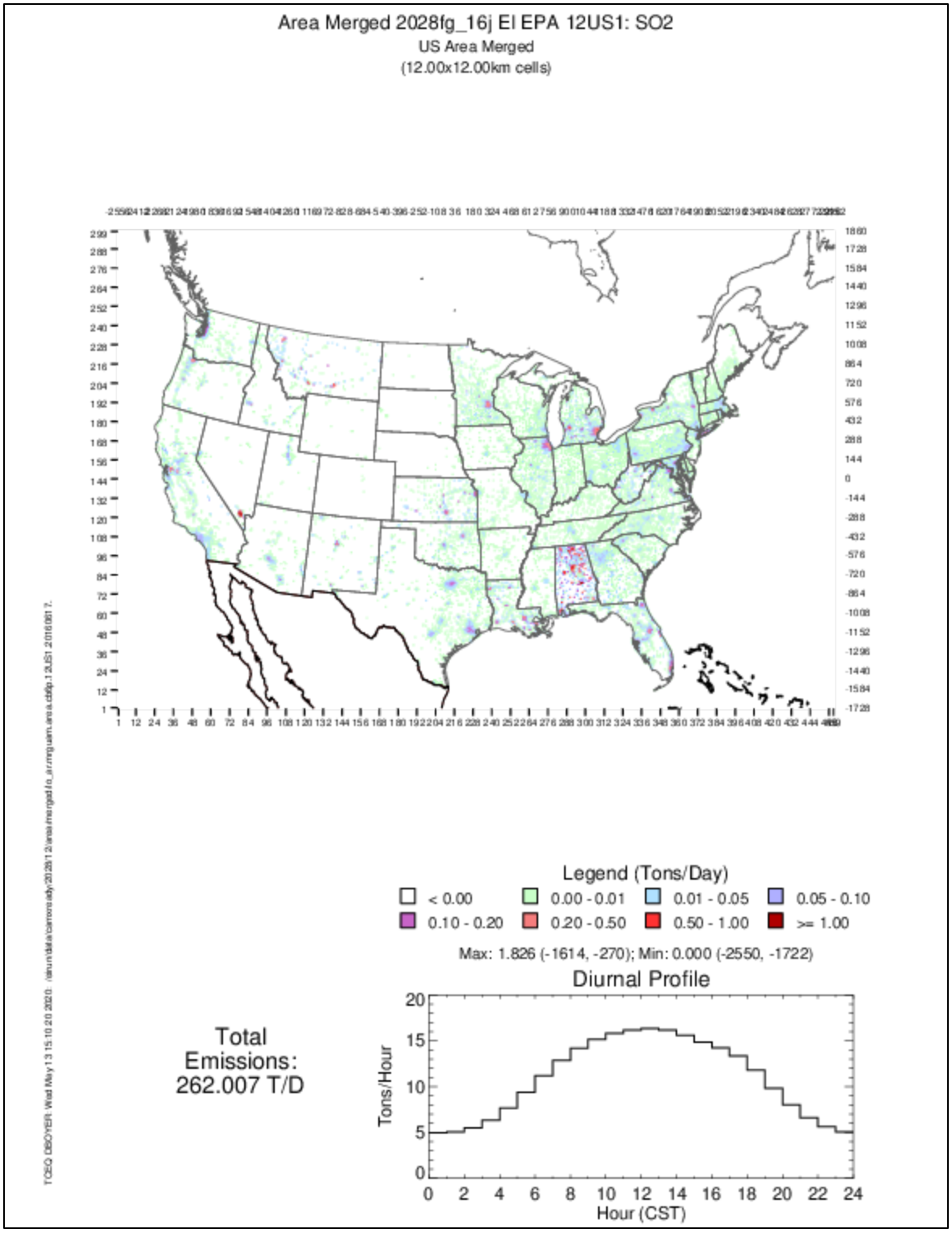

Figure 4-14: 2028 Area Source SO_2 Emissions Distribution

4.6 COMMERCIAL MARINE EMISSIONS

The TCEQ used the 2016 NEIC platform vβ inventories (2016ff and 2028fg) for the class 1 and class 2 (C1C2) commercial marine vessels (CMV). Class 3 (C3) CMV sources

are included in the point source inventory. The C1C2 CMV sources are represented by an average day per month. The 2016 NEIC detailed development of the 2016 C1C2 CMV emission inventory[18] using Automated Identification System (AIS) data (NEIC, 2019).

The 2016 and 2028 commercial marine emissions in Texas by season are summarized in Table 4-45: *2016 Texas C1C2 CMV Criteria Pollutant Emissions by Season*, Table 4-46: *2016 Texas C1C2 CMV $PM_{2.5}$ Component Emissions by Season*, Table 4-47: *2028 Texas C1C2 CMV Criteria Pollutant Emissions by Season*, and Table 4-48: *2028 Texas C1C2 CMV $PM_{2.5}$ Component Emissions by Season*.

Table 4-45: 2016 Texas C1C2 CMV Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	1,920	38.73	605.84	4.84	0.63	29.23	30.13
Summer	1,920	38.73	605.84	4.84	0.63	29.23	30.13
Fall	1,899	38.31	599.25	4.79	0.62	28.91	29.80
Winter	1,899	38.31	599.25	4.79	0.62	28.91	29.80
Annual	7,637	154.08	2,410	19.25	2.49	116.28	119.87

Table 4-46: 2016 Texas C1C2 CMV $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	6.42	22.54	0.09	0.03	0.00	0.12	0.01	0.03	29.23
Summer	6.42	22.54	0.09	0.03	0.00	0.12	0.01	0.03	29.23
Fall	6.35	22.30	0.09	0.03	0.00	0.12	0.01	0.03	28.91
Winter	6.35	22.30	0.09	0.03	0.00	0.12	0.01	0.03	28.91
Annual	25.52	89.67	0.34	0.13	0.00	0.48	0.02	0.10	116.28

Table 4-47: 2028 Texas C1C2 CMV Criteria Pollutant Emissions by Season

Season	NO_X (tons)	VOC (tons)	CO (tons)	SO_2 (tons)	NH_3 (tons)	$PM_{2.5}$ (tons)	PM_{10} (tons)
Spring	1,063	20.45	607.83	1.65	0.63	16.56	17.07
Summer	1,063	20.45	607.83	1.65	0.63	16.56	17.07
Fall	1,052	20.22	601.22	1.63	0.62	16.38	16.88
Winter	1,040	20.00	594.62	1.61	0.61	16.20	16.70
Annual	4,218	81.12	2,412	6.55	2.48	65.69	67.72

[18]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016beta_0919/National-Emissions-Collaborative_2016beta_mobile-nonroad-cmv-c1c2_19Sep2019.pdf

Table 4-48: 2028 Texas C1C2 CMV $PM_{2.5}$ Component Emissions by Season

Season	POA (tons)	PEC (tons)	PSO_4 (tons)	PNO_3 (tons)	PNH_4 (tons)	FPRM (tons)	PCL (tons)	FCRS (tons)	$PM_{2.5}$ (tons)
Spring	3.63	12.77	0.05	0.02	0.00	0.07	0.00	0.01	16.56
Summer	3.63	12.77	0.05	0.02	0.00	0.07	0.00	0.01	16.56
Fall	3.59	12.63	0.05	0.02	0.00	0.07	0.00	0.01	16.38
Winter	3.56	12.49	0.05	0.02	0.00	0.07	0.00	0.01	16.20
Annual	14.42	50.66	0.19	0.07	0.00	0.27	0.01	0.06	65.69

The 2016 and 2028 C1C2 CMV NO_X and SO_2 emissions are depicted in Figure 4-15: *2016 C1C2 CMV NO_X Emissions Distribution*, Figure 4-16: *2016 C1C2 CMV SO_2 Emissions Distribution*, Figure 4-17: *2028 C1C2 CMV NO_X Emissions Distribution*, and Figure 4-18: *2028 C1C2 CMV SO_2 Emissions Distribution.*

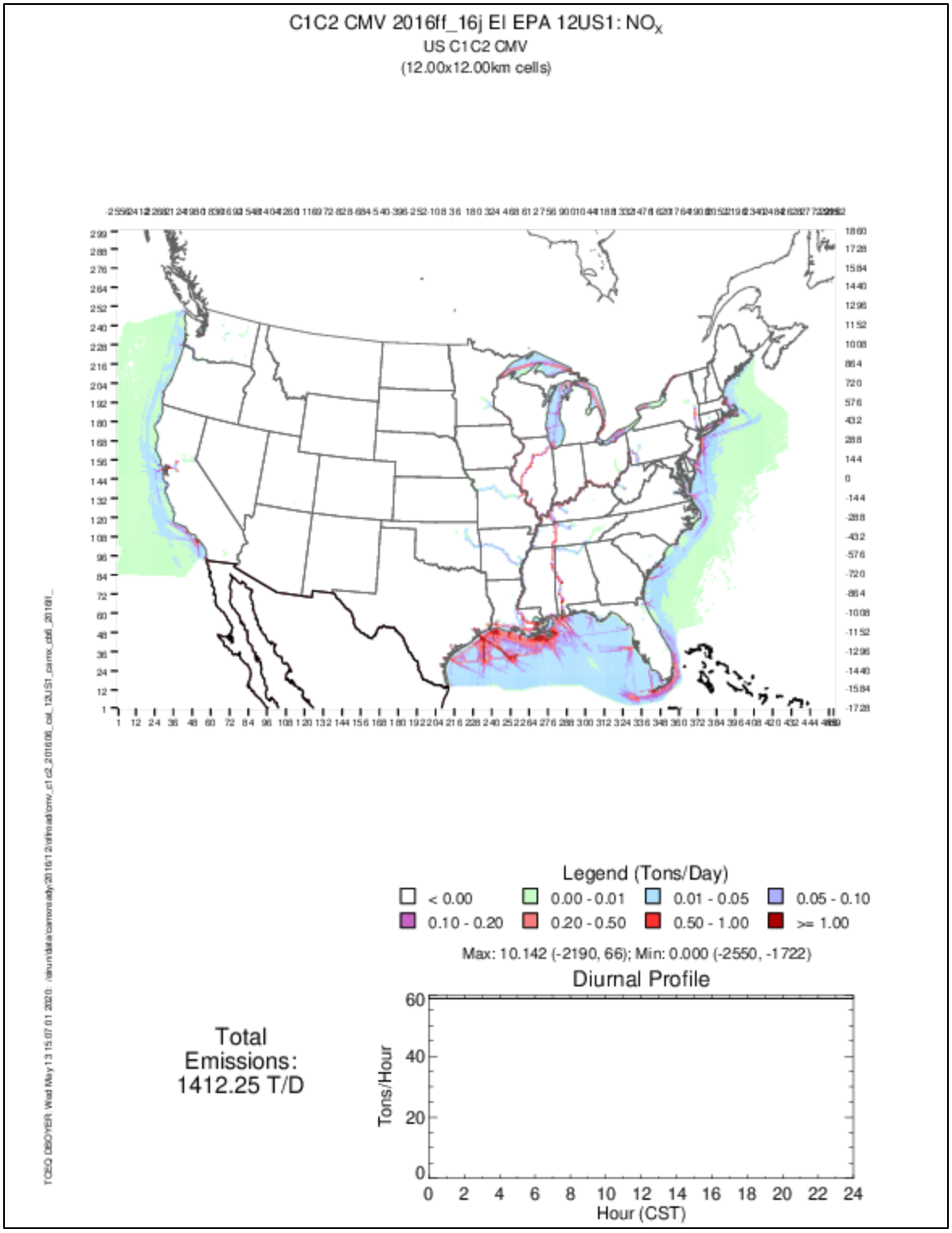

Figure 4-15: 2016 C1C2 CMV NO_x Emissions Distribution

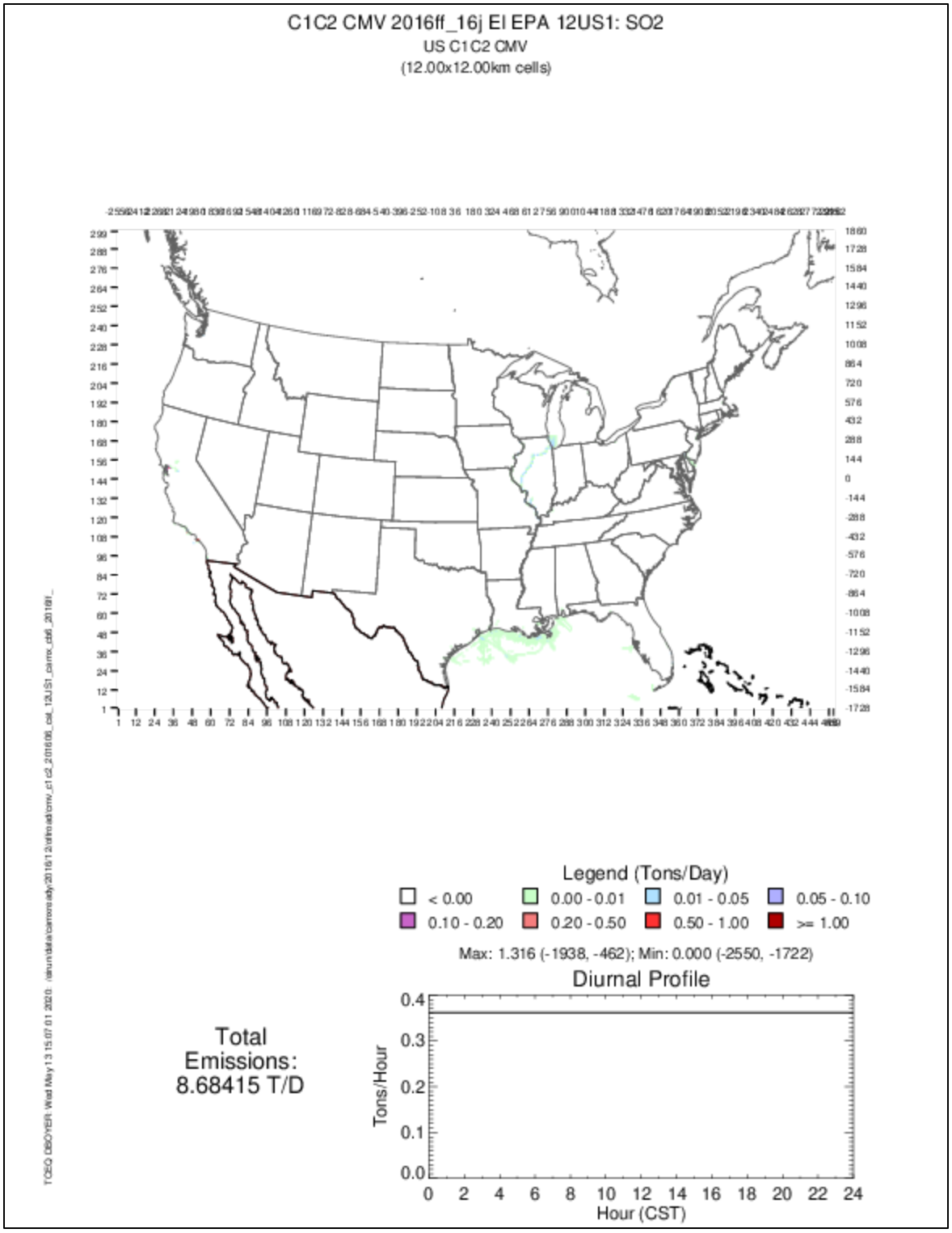

Figure 4-16: 2016 C1C2 CMV SO_2 Emissions Distribution

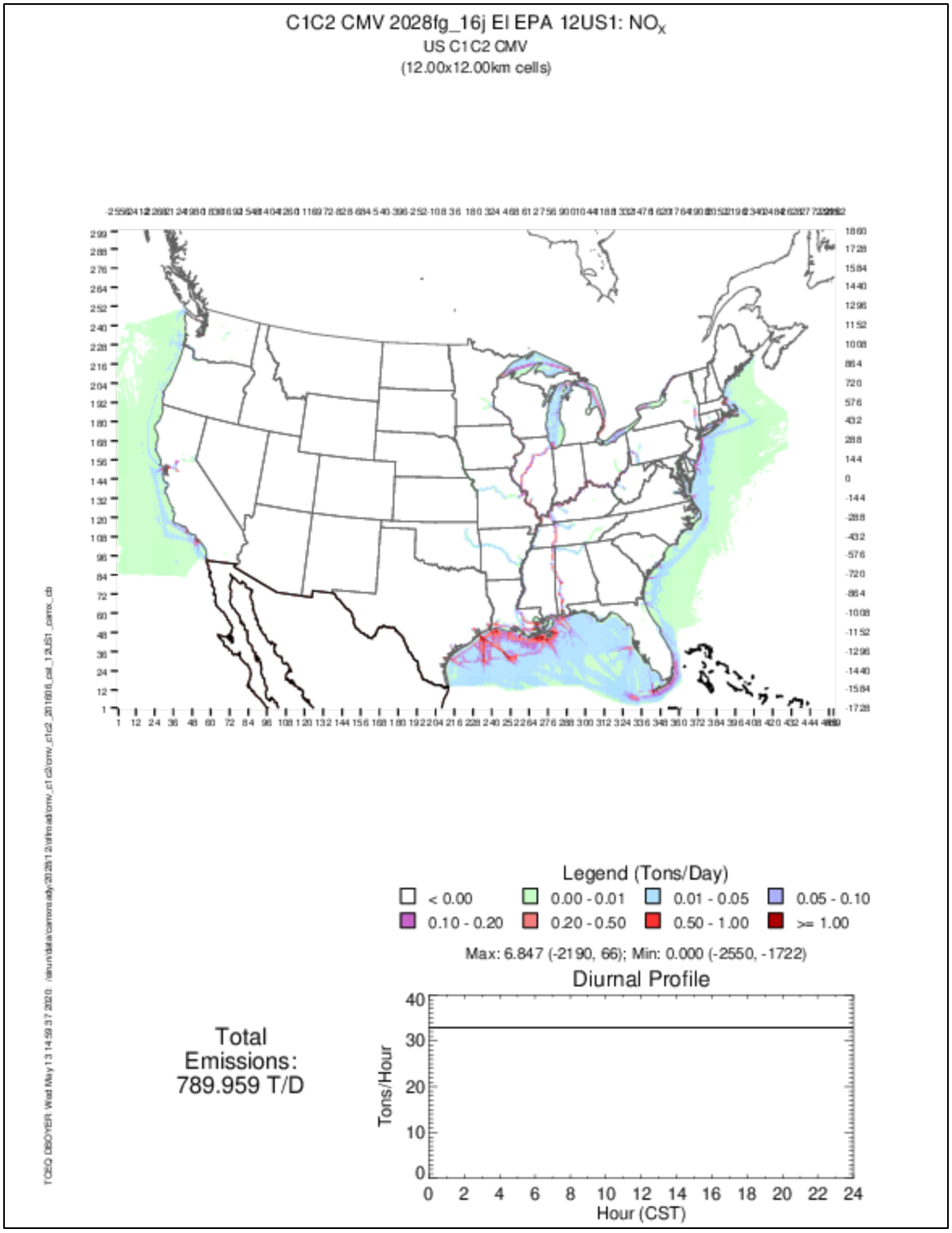

Figure 4-17: 2028 C1C2 CMV NO_x Emissions Distribution

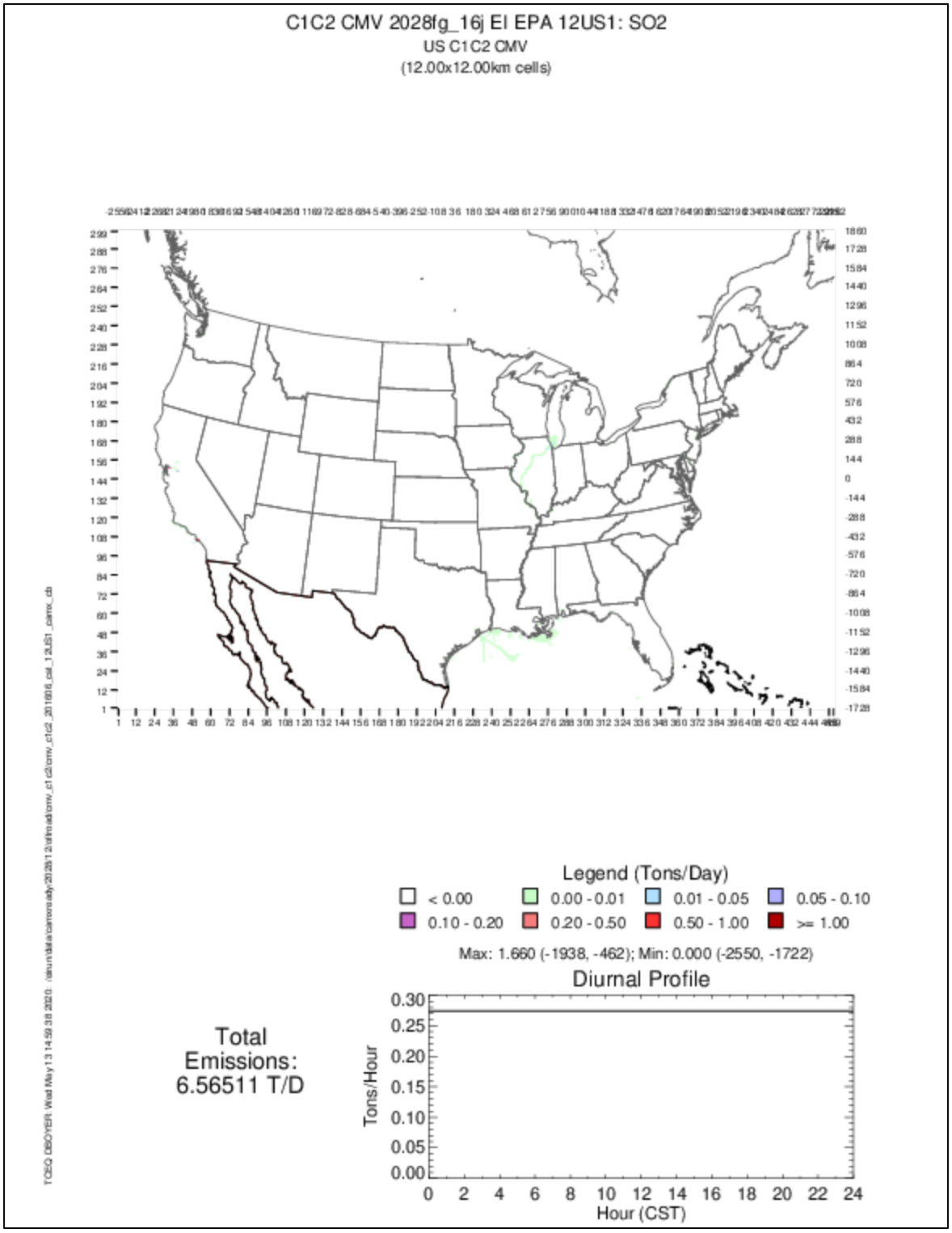

Figure 4-18: 2028 C1C2 CMV SO_2 Emissions Distribution

CHAPTER 5: CANADA, MEXICO, AND OTHER AREAS

5.1 CANADA

The 2016 National Emissions Inventory Collaborative (NEIC) platform Beta version (vβ) and version one (v1) inventories were used for the Canadian emission sources for 2016 and 2028 (NEIC, 2019) as shown in Table 5-1: *2016 and 2028 Canadian Low-Level Point Source Inventory Version and Documentation.*

Table 5-1: 2016 and 2028 Canadian Low-Level Point Source Inventory Version and Documentation

Canadian Source Sub-Category	2016 NEIC Platform Version	2028 NEIC Platform Version
On-road	vβ (2016ff)	vβ (2028ff)
Area Fugitive Dust	vβ (2016ff)	vβ (2028fg)
Nonpoint	vβ (2016ff)	vβ (2028ff)
Point Source Dust (adjusted)	v1 (2016fh)	vβ (2028fg)

5.2 MEXICO

The 2016 NEIC platform inventories were used for the Mexican emission sources for 2016 and 2028 (NEIC, 2019) as shown in Table 5-2: *2016 and 2028 Mexican Low-Level Point Source Inventory Version and Documentation.*

Table 5-2: 2016 and 2028 Mexican Low-Level Point Source Inventory Version and Documentation

Mexican Source Sub-Category	2016 NEIC Platform Version	2028 NEIC Platform Version
On-road	vβ (2016ff)	vβ (2028fg)
Nonpoint	vβ (2016ff)	vβ (2028ff)

5.3 OTHER AREAS

The 2010 Emission Database for Global Atmospheric Research (EDGAR) version 4.2 inventories were used for the Central American, Caribbean, and other non-North American areas of the modeling domain for the base 2016 and future 2028 inventories. Ramboll processed the EDGAR inventory with the Sparse Matrix Operation Kernel Emissions (SMOKE) processor version 4.0 (Ramboll, 2019).

CHAPTER 6: BIOGENIC MODELING EMISSIONS

The TCEQ used version 3.61 of the Biogenic Emission Inventory System (BEIS)[19] (Bash, et al., 2016) within Sparse Matrix Operation Kernel Emissions (SMOKE) System version 3.7 (available at https://www.cmascenter.org/smoke/) to generate daily emissions for December 16, 2015 through December 31, 2016 for the North America 12-km domain (na_12km).

[19] https://www.epa.gov/air-emissions-modeling/biogenic-emission-inventory-system-beis

The SMOKE emissions factors for each vegetation type (B360FAC) and chemical mechanism model speciation profiles (GSPRO) input files used were obtained from the Biogenic Workgroup of the 2016 Emissions Inventory Collaborative[20] . The Spatial Allocator tool (https://github.com/CMASCenter/Spatial-Allocator) was used to derive the grid-specific na_12km Biogenic Emission Land Use Data (BELD4) input file from the Biogenic Workgroup's Biogenic Emission Land-use Database version 4.1 with water fix (BELD4.1 water fix).

The TCEQ's Weather Research and Forecasting (WRF) modeling provided the meteorological data needed to run the BEIS model for each episode day. Since biogenic emissions are dependent upon the meteorological conditions on a given day, the same episode-specific emissions were used in the 2016 base case and 2028 future case modeling scenarios. WRF results were processed with the Meteorology-Chemistry Interface Processor (MCIP) to obtain the meteorological inputs for BEIS and Metscan. The Metscan SMOKE utility produces the daily gridded ramp-up 2015 (December 16, 2015 – December 31, 2015) and full-year 2016 BIOSEASON files that contain a growing season variable to indicate summer or winter conditions.

CMAQ-ready Hourly, gridded biogenic emissions files (BGTS_L) ready for the Community Multi-scale Air Quality (CMAQ) model were output from BEIS and then converted to CAMx-ready binary format with the Input/Output Applications Programming Interface to Urban Airshed Model (IOAPI2UAM) utility. The time zone shift from Greenwich Mean Time (GMT) to local Central Standard Time (CST) was also completed via the IOAPI2UAM processing.

The BEIS model flow is depicted in Figure 6-1: *BEIS Flow Diagram*. Rectangles are programs or processing steps, with BEIS in green, the land-use database in gray, and all others in tan. Rounded corner polygons are input files, with light pink for TCEQ-generated files and yellow from the 2016 National Emissions Inventory Collaborative Biogenic workgroup (NEIC, 2019). The CMAQ and Comprehensive Air Quality Model with Extensions (CAMx) model-ready emissions are shown as dark pink, corner-clipped polygons.

[20]http://views.cira.colostate.edu/wiki/Attachments/Inventory%20Collaborative/Documentation/2016v1/National-Emissions-Collaborative_2016v1_biogenic-beis_15Oct2019.pdf

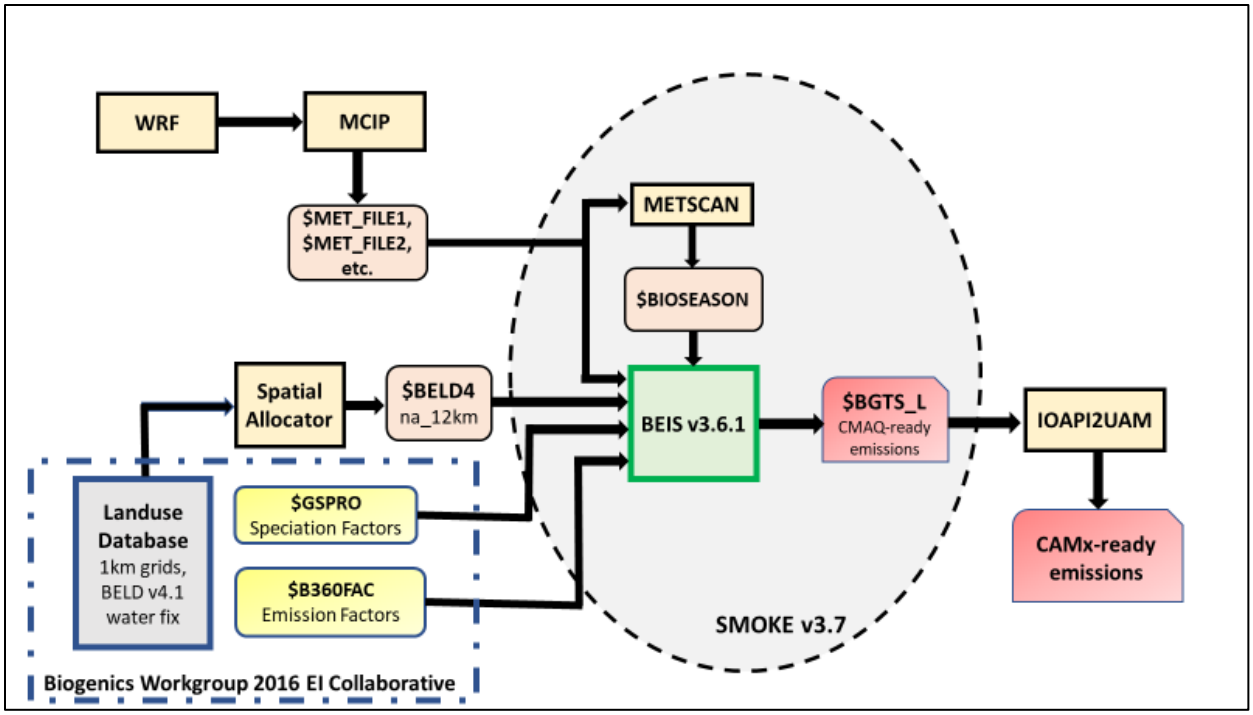

Figure 6-1: BEIS Flow Diagram

Figure 6-2: *2016 BEIS Biogenic Isoprene Emissions Distribution* provides a graphical plot of biogenic isoprene emissions distribution for the na_12km domain on June 15, 2016.

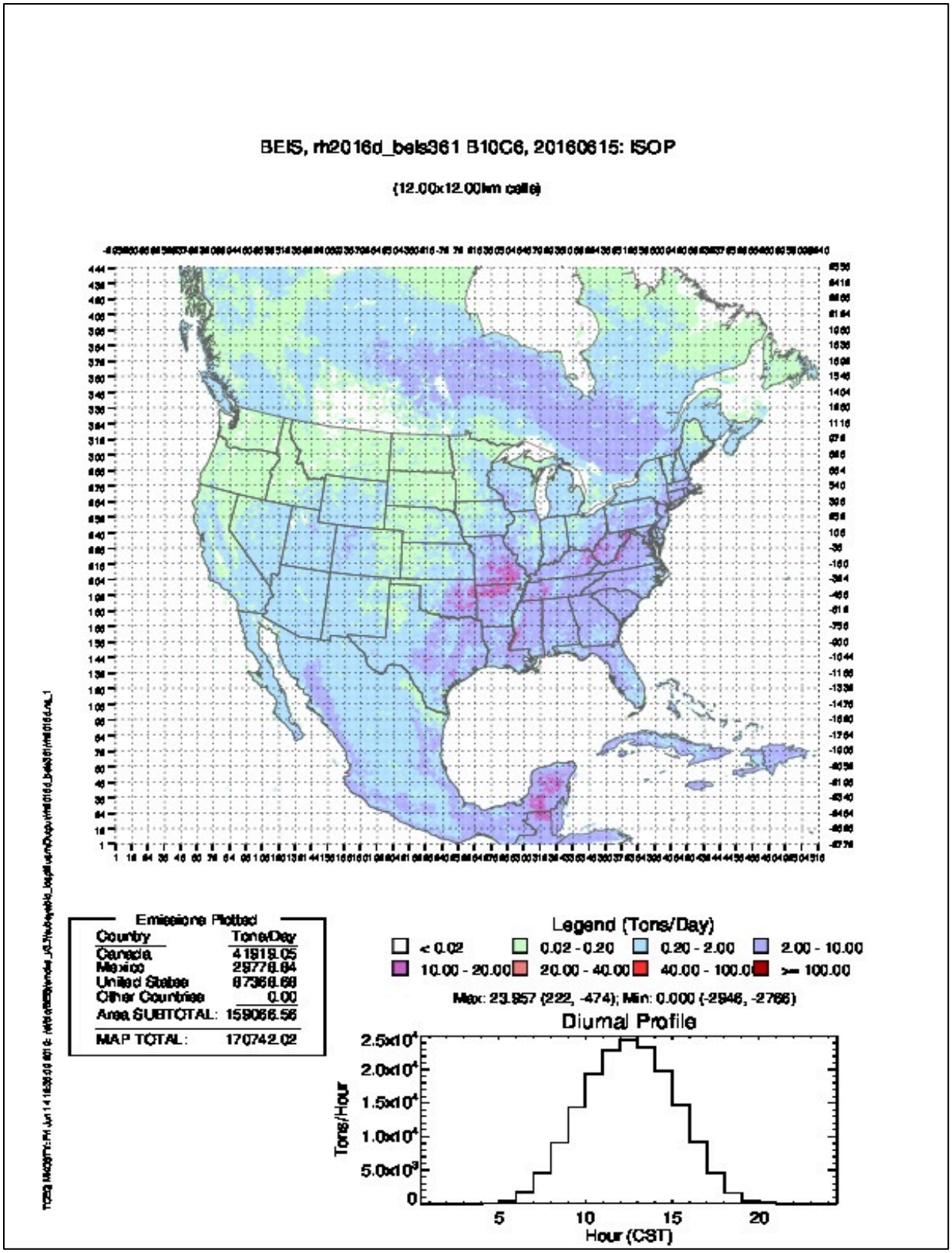

Figure 6-2: 2016 BEIS Biogenic Isoprene Emissions Distribution

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