# APPENDIX B

## EMISSIONS MODELING FOR THE HGB ATTAINMENT DEMONSTRATION SIP REVISION FOR THE 2008 EIGHT-HOUR OZONE STANDARD

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# 1. GENERAL MODELING EMISSIONS DEVELOPMENT

The EPA's *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze* (EPA, 2014b), specifies a procedure for demonstrating attainment through modeling. Instead of using the model results in an absolute sense, the eight-hour ozone procedure uses the modeling results in a relative sense. This relative approach is based on how the model responds to the change in emissions between a baseline and a future year. Therefore, the photochemical modeling process for attainment demonstration requires four modeling emissions data sets:

- base case emissions;
- baseline emissions;
- future year emissions; and
- future year control strategy and/or sensitivity analyses emissions.

## 1.1 Base Case Modeling Emissions

In order for the photochemical model to be used in the attainment demonstration, the model needs to be capable of adequately replicating historical episodes (base cases) for which high eight-hour ozone was measured. To maximize model performance, base case emission inputs are estimated as accurately as possible. In the development of the base case modeling emissions, a number of quality assurance techniques are used to evaluate the reasonableness of the emission magnitudes, along with their spatial distribution and temporal profile. Using the quality assured episode-specific emissions along with other modeling inputs (e.g., meteorology), the photochemical model is run and the simulated concentrations of both ozone and ozone precursors of nitrogen oxides ($NO_X$) and volatile organic compounds (VOC) are compared to the measured concentrations to evaluate the adequacy of the photochemical model in replicating the base case. If the evaluation indicates that the base case is not adequately replicated, then diagnostics are conducted to determine which modeling inputs are unsatisfactory. When the emissions are implicated, the modeling emissions are reviewed and pertinent revisions are made. If the evaluation implicated other inputs, or once the photochemical model adequately replicates the base case, then the modeling emissions are considered to be representative of the episode.

A summary of the primary data sources for the development of the base case modeling emissions is 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, 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** | 2012 State of Texas Air Reporting System (STARS) |
| **Regional** | 2011 National Emissions Inventory (NEI) v6.2 based EPA Modeling Platform |
| **All States** | 2012 EPA Clean Air Markets Division (CAMD) Air Markets Program Data (AMPD) hourly data |
| **Offshore** | 2011 Bureau of Ocean Energy Management (BOEM) Gulf-Wide Emission Inventory (GWEI) platforms of western Gulf of Mexico |
| **Mexico** | 2012 Interpolation from EPA's Modeling Platform |
| **Canada** | 2006 National Pollutant Release Inventory (NPRI) |

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

| Region | Data Source |
|---|---|
| **HGB** | 2012 based on MOVES2014 emission rates and Highway Performance Monitoring System (HPMS) for vehicle miles traveled (VMT) activity estimates. |
| **Other Texas** | 2012 based on MOVES2014 emission rates and HPMS for VMT activity estimates. |
| **Outside Texas** | 2012 based on MOVES2014 July default runs. |

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

| Region | Non-Road Mobile Sources | Area Sources | Oil and Gas Sources | Biogenics |
|---|---|---|---|---|
| **Texas** | 2012 run of Texas NONROAD (TexN) model | 2011 Texas Air Emissions Repository TexAER | Texas Railroad Commission data and equipment-specific emission rates. | Model of Emissions of Gases and Aerosols from Nature (MEGAN) 2.1 |
| **Outside Texas** | 2012 run of National Mobile Inventory Model (NMIM) | 2011 EPA NEI | 2011 EPA NEI | MEGAN 2.1 |

Emissions modeling uses a hierarchical approach, such that the closer the area is to the nonattainment area of interest, the more detailed the resolution of the emissions. For example, Canadian emissions are expected to have very little influence on model performance in Texas, so the TCEQ does not attempt to gather hourly power plant emissions from Canada. Emissions are developed for ozone precursors of $NO_X$, VOC, and carbon monoxide (CO), although CO is a minimal contributor in the production of ozone. The emission inventories (EIs) are prepared for photochemical modeling input using Version 3 of the Emissions Processing System (EPS3).

## 1.2 Baseline Modeling Emissions

The EPA procedure for demonstrating attainment requires the development of modeling emissions for a baseline year to be used with similarly developed future year emissions. In order to keep the baseline and future year modeling emissions commensurate, more generic non-episodic ozone season day (OSD) emissions are developed for the baseline year. The OSD modeling emissions for the baseline and future years are developed using the same averaging and estimating procedures, which provides an appropriate basis for assessing the photochemical model response to emission changes.

The major difference between the base case and baseline modeling emissions is the treatment of the hourly-specific emissions for elevated point sources, such as electric generating units (EGUs). Emissions for the other source categories are identical between the base cases and baseline modeling emissions. 2012 was chosen as the baseline year and Section 2.2 describes the averaging processes used in the development of the baseline inventory.

## 1.3 Future Year Modeling Emissions

The eight-county HGB area is classified as moderate nonattainment under the 2008 eight-hour ozone standard. The attainment date for HGB is July 20, 2018, with a 2017 attainment year. In general, 2017 future year emissions were estimated by applying growth projections and accounting for existing federal, state, and local controls on the baseline (in most cases) emissions. The 2017 modeling emissions include the benefits of the Federal Tier 3 Vehicle Emission and Fuel Standards Program, the Mass Emissions Cap-and-Trade (MECT) Program in the HGB area, the Highly Reactive VOC Emission Cap-and-Trade (HECT) Program in Harris County, and the EPA's Cross-State Air Pollution Rule (CSAPR).

### 1.4 Future Year Control Strategy and/or Sensitivity Analyses Emissions

For the current Attainment Demonstration (AD) State Implementation Plan (SIP) revision, due to time constraints no sensitivities were performed. Emissions reductions due to the RACT update rule are not included due to the compliance deadline associated with the rule.

## 2. POINT SOURCE MODELING EMISSIONS DEVELOPMENT

Point source emissions development began with the emission inventory from the July 2016 DFW AD SIP Revision for the 2008 Eight-Hour Ozone Standard. Point source emissions were developed for the May 1 through September 30, 2012 modeling period. The data sources for development of the point source modeling emissions are summarized in Table 2-1: *Sources of Point Source Emissions Data*. The data was compiled and formatted to generate modeling datasets for the base case, the baseline, and the future case studies as detailed in subsequent sections.

**Table 2-1: Sources of Point Source Emissions Data**

| Sources of Data | Calendar Year(s) Used |
|---|---|
| TCEQ STARS | 2012, 2014 |
| TCEQ MECT Allocations for sources in HGB | 2017 |
| TCEQ HECT Allocations for sources in Harris County | 2017 |
| EPA CAMD AMPD of power plant Continuous Emissions Monitors (CEMs) for all states | 2012, 2015 |
| EPA CSAPR allocations for entire modeling domain | 2017 |
| Electric Reliability Council of Texas (ERCOT) Capacity, Demand, and Reserve report | 2017 |
| TCEQ Air Permits for proposed EGUs | 2017 |
| U.S. Department of the Interior, BOEM GWEI of Offshore Platforms | 2011 |
| EPA Emissions Modeling Clearinghouse (EMCH) Modeling Platforms for NEI data | 2011, 2017 |
| Environment Canada National Pollutant Release Inventory (NPRI) | 2006 |
| Mexican NEI and future case projection from EPA's 2011 Modeling Platform | 2008, 2018 |

### 2.1 2012 Base Case Point Source Modeling Emissions Development

The following sections describe development of the base case point source modeling emissions for all portions of the domain used for May through September 2012.

#### 2.1.1. Texas Point Sources

Emissions modeling data files for the 2012 base case for Texas EGUs (power plants) were extracted from EPA's AMPD, and the Texas non-EGUs were extracted from the TCEQ's STARS database. The following subsections describe the development of point source modeling emissions for each of the components.

#### 2.1.1.1. State of Texas Air Reporting System (STARS)

Point source emissions and industrial process operating data are collected annually from sites that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. Subject entities, approximately 2000, are required to report emissions annually from all sources and emissions exhaust points with representative calculations of emission estimates. Descriptive information is also required on process equipment, including operating schedules, emission control devices, abatement device control efficiencies, and emission point discharge parameters such as location, height, diameter, temperature, and exhaust gas flow rate. All data submitted in the annual Emissions Inventory questionnaires (EIQs) are subjected to TCEQ quality assurance (QA) procedures. The data are then stored in the STARS database. The TCEQ reports point source emissions data to the EPA for inclusion in the National Emissions Inventory (NEI). 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 http://www.tceq.texas.gov/implementation/air/industei/psei/psei.html.

Development of the Texas point source emission modeling files began with queries of the quality-assured data of the STARS database. Updated modeling query reports are typically run when significant STARS updates are completed. The STARS modeling extract report ("STARS "") is a snapshot of Texas emissions, since regulated entities can update their information at any time.

SAS computer programming code was used to parse the STARS extract, perform various logical checks and comparisons, assign defaults for missing data, apply rule effectiveness to VOC emissions paths with control devices, and format the data into an AIRS Facility Subsystem (AFS) file that can be processed with the modules of Version 3 of the Emissions Processor System.

The STARS extract contains four types of emission rates: annual, OSD, emission events (EE), and scheduled maintenance startup and shutdown (SMSS). When supplied, the OSD emissions in tons per day (tpd) are modeled, plus any EE/SMSS for the source (after conversion to tpd). When OSD is not provided by the source, an OSD is computed from the reported summer use percentage, operational parameters, and any EE/SMSS reported. The modeled OSD emission rate is representative of average daily emissions during the summer, when monitored ozone concentrations are typically highest. An example of STARS extract data is available in Section 2.1.1 of Appendix B of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision.

#### 2.1.1.2. 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 are in compliance 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 1997 Eight-Hour Ozone AD SIP Revision. Applying RE to the 2012 point sources adds approximately 31% more VOC to HGB and approximately 21% more to the statewide VOC, as compared to the 2012 reported (STARS) VOC total emissions.

#### 2.1.1.3. Preparation of AFS File for EPS3 Input

The resultant OSD AFS file is in a format ready for input to EPS3. The STARS-derived AFS file for all criteria pollutants typically has more than 200,000 records. Each point source emissions path contains references for the TCEQ account (RN), equipment (FIN), and exhaust point (EPN). For ozone modeling purposes, values for the ozone precursors of $NO_X$, VOC, and CO are retained in the AFS file for EPS3 input. The AFS file format used by the TCEQ, including expanded field descriptions and options, can be found on the [TCEQ FTP modeling](ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/point/basecase/AFS/AFS-EPS3-v3.docx) webpage, ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/point/basecase/AFS/AFS-EPS3-v3.docx.

#### 2.1.1.4. Preparation of Photochemical Model-Ready Files with EPS3

EPS3 is used to process the emissions in the AFS file into a format ready for photochemical model input. Photochemical model inputs require that the emissions be (in EPS3 order performed by the TCEQ):

- chemically speciated into groups of compounds with similar reactivity for the formation of ozone;
- temporally allocated by hour of day, day of week, etc.; 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.

##### 2.1.1.4.1. *Chemical Speciation with EPS3*

VOC emissions in STARS can be reported as individual compounds, mixtures, classes of compounds, total VOC, and unclassified VOC. The VOC values that are included in the AFS file are speciated into carbon bond groups for the specific chemical mechanism of the photochemical model. The TCEQ used the sixth generation Carbon Bond (CB6) chemical mechanismand is implemented via the EPS3 module SPCEMS (Speciate Emissions) (Yarwood et al, 2010).

The majority of TCEQ EIQ responses include constituent VOC emission rates, which are used to develop point-specific speciation profiles. When the composition of the VOC reported for a specific source is unknown or not fully-speciated, the default speciation profile is applied based on the source classification code (SCC) and the default speciation from EPA's SPECIATE database software program (EPA, 2014b). More detail on the TCEQ source-specific speciation approach is available in an international emission inventory conference paper (Thomas, 2008).

Ethane and acetone, which are technically not VOCs by the EPA's definition, are also extracted from STARS and processed in the emissions model, and are subjected to the same speciation as all of the other STARS compounds. Ethane and acetone are now included in VOC totals in tables and tile plots in subsections below because the photochemical model can use these compounds as CB6 lumped species categories of their own, along with all the other VOC species. Because ethane and acetone are additive to the VOC, the modeled and tabulated VOC will almost always be greater than reported (STARS) VOC.

*2.1.1.4.2. Temporal Allocation with EPS3*

Even though OSD is typically used for processing of photochemical modeling emissions, EPS3 can temporally distribute emissions by month, day of the week, and hour of a specific episode when sufficient detail is provided by the regulated entity in its EIQ. Previous AD SIP revision documentation provides detail about temporal allocation, along with examples of the cross reference and profile records.

*2.1.1.4.3. Spatial Allocation with EPS3*

Photochemical models generally rely on 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 and are released at the same time 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, 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 photochemical model input, whereas elevated point sources are kept at their reported X-Y locations and assumed to emit from the calculated effective plume height (above the reported stack height) of Z 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, which provides better simulation of how elevated emissions are distributed prior to mixing and reacting with surface emissions. The drawbacks of using the dual regimes are more complicated EPS3 processing and longer photochemical model run times.

The photochemical model inputs for point sources consist of a single low-level gridded merged file and a single file of elevated sources. A plume cutoff height of 30 meters was chosen to divide the point sources into low-level and elevated categories, which essentially matches the 34-meter height of the first CAMx model layer. The emissions from elevated sources can be individually tracked, and $NO_X$ reaction chemistry can be enhanced by treating these plumes as Lagrangian puffs by use of the optional Plume-in-Grid (PiG) treatment within CAMx. The Greatly Reduced Execution and Simplified Dynamics (GREASD) PiG option was used in CAMx, which is most applicable to large $NO_X$ plumes (Ramboll Environ, 2016). More detail on the GREASD PiG approach is provided below in Section 2.1.3.

Figure 2-1: *Tile Plot of HGB eight-county OSD Non-EGU Low-Level $NO_X$ Emissions for a Day in 2012* is a tile plot of the gridded low-level OSD (non-EGU) $NO_X$ emissions for the HGB eight-county area at the 4 km grid cell resolution. Each modeled day of OSD emissions is identical, an average day during the ozone season.

Figure 2-2: *Tile Plot of HGB Eight-County OSD Non-EGU Elevated $NO_X$ Emissions for a Day in 2012* is a plot of the elevated OSD (non-EGU) $NO_X$ emissions for the HGB eight-county area. The vast majority of the $NO_X$ emissions are from elevated sources (mainly combustion sources with hot exit gas and taller stacks). The diurnal profiles of the OSD sources are generally flat (do not vary across the day), indicating that the non-EGUs are dominated by sources that operate continuously.

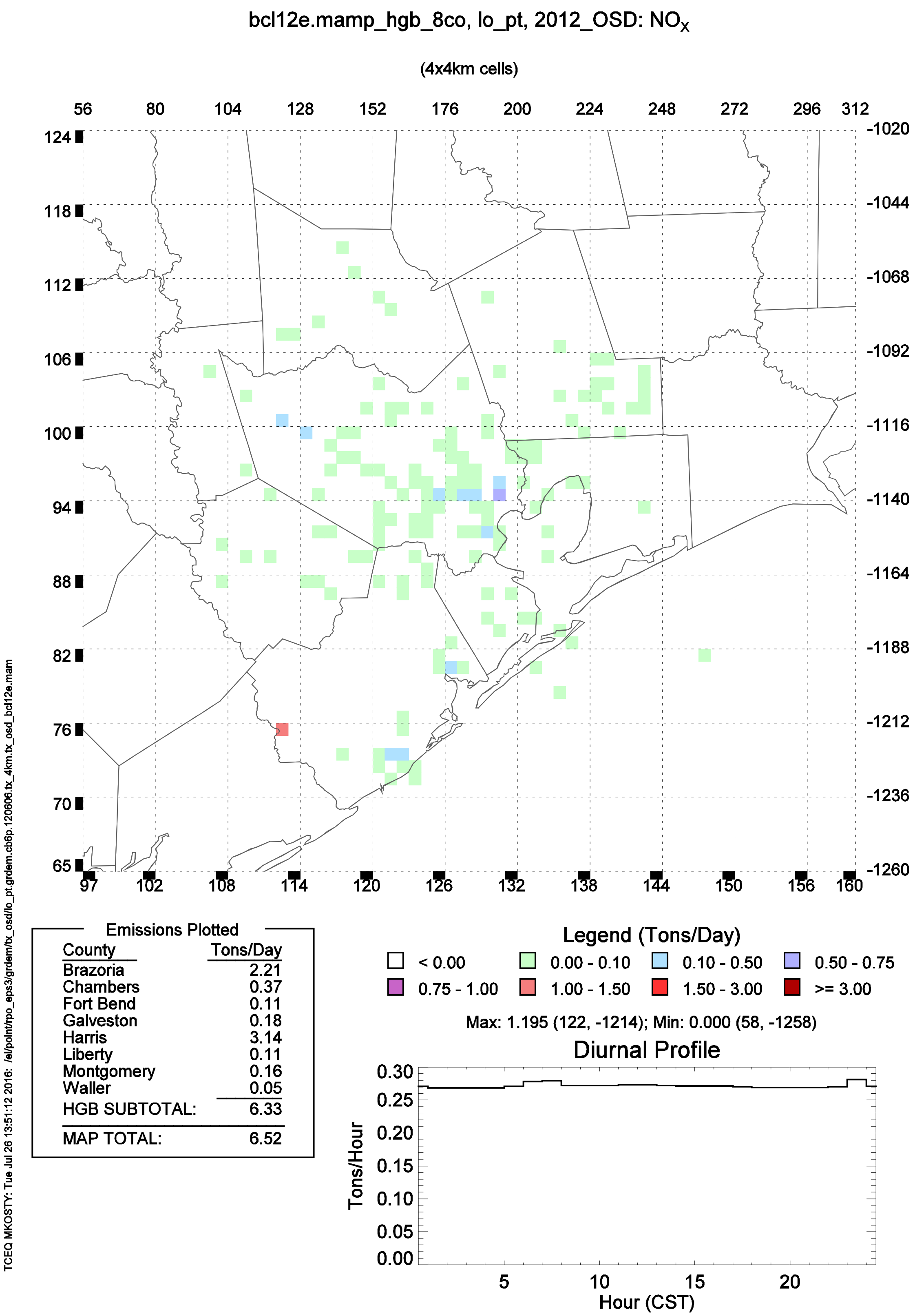
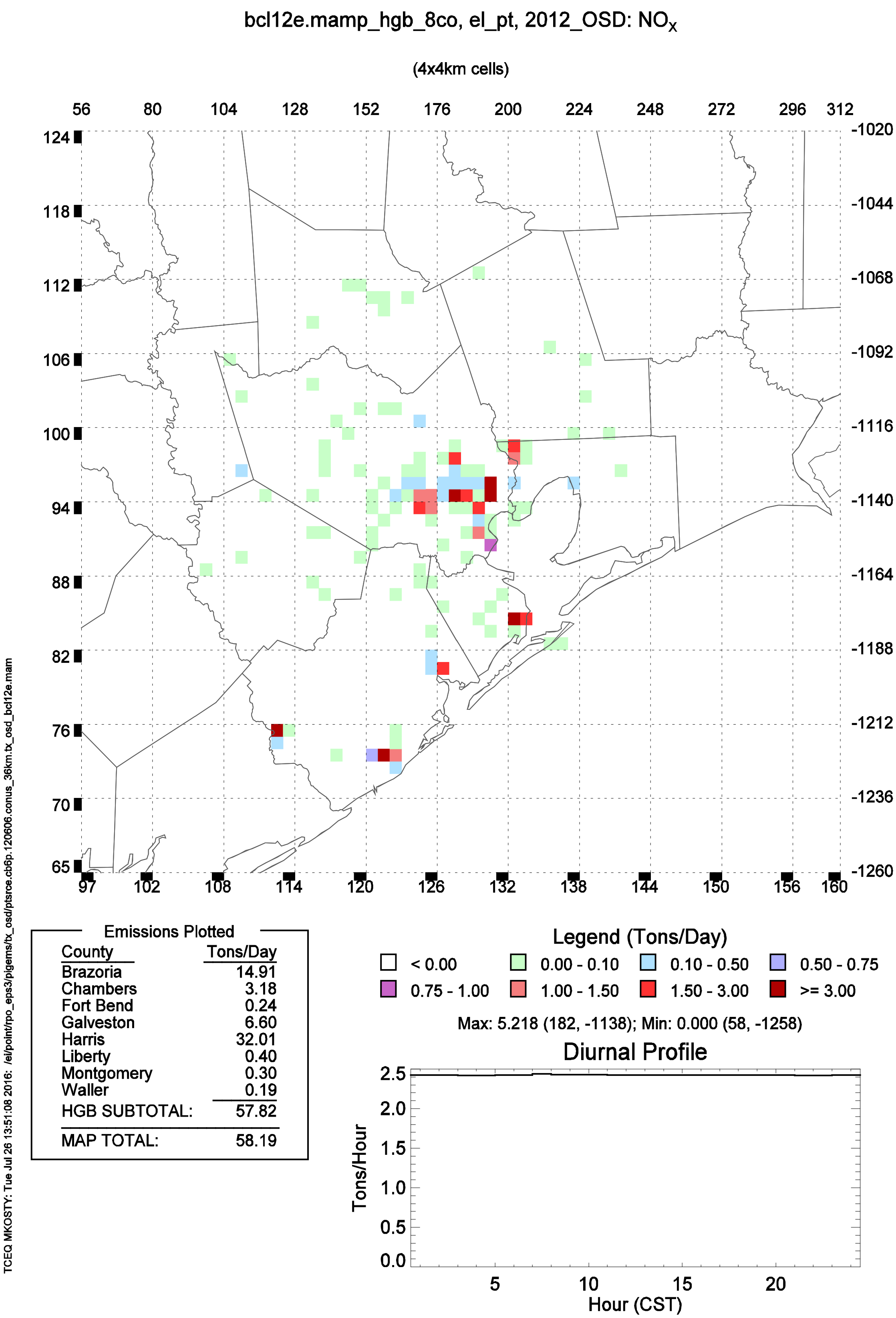



**Figure 2-1: Tile Plot of HGB Eight-County OSD Non-EGU Low-Level $NO_X$ Emissions for a Day in 2012**




| County | Tons/Day |
|---|---|
| Brazoria | 14.91 |
| Chambers | 3.18 |
| Fort Bend | 0.24 |
| Galveston | 6.60 |
| Harris | 32.01 |
| Liberty | 0.40 |
| Montgomery | 0.30 |
| Waller | 0.19 |
| HGB SUBTOTAL: | 57.82 |
| MAP TOTAL: | 58.19 |

**Figure 2-2: Tile Plot of HGB Eight-County OSD Non-EGU Elevated $NO_X$ Emissions for a Day in 2012**

### 2.1.1.5. Hourly Air Markets Program Data (AMPD)

To enhance emissions accuracy for the base case, data sources with monthly, daily, or hourly temporal resolution are used if available (Thomas et al, 2008). For the EGUs in the state, hourly records from the EPA's AMPD database are substituted for the STARS OSD records. SAS computer programming code removes the source from the OSD file while adding in AMPD hourly records for the source, to avoid any double counting of emissions.

Under the Clean Air Act's Acid Rain Program and the other budget/cap programs for EGUs, each unit reports its emissions of sulfur dioxide ($SO_2$), nitrogen oxides ($NO_X$), and carbon dioxide ($CO_2$), along with other parameters such as heat input. The EPA quality controls the reported raw hourly data and provides datasets and a query wizard on the AMPD website for downloading the data. Missing or invalid hourly data that arise from CEM equipment problems are generated by the EPA using specific punitive substitution criteria[1]. EGU-reported data (such as input to STARS or the NEI) do not always match that from EPA's AMPD.

Hourly data were downloaded from the EPA's AMPD website for Texas and the rest of the country for the 2012 episode. The AMPD database uniquely identifies point sources by FACILITY ID/ORIS (Office of Research Information Systems) number and UNIT ID/BLRID (boiler identification). FACILITY ID/ORIS identifies the site and UNIT ID/BLRID specifies the source (not the emission stack) within the site. FACILITY ID and UNIT ID appear to be the most current field names used by the EPA's AMPD, whereas, ORIS and BLRID are older terms, which are often still used in regards to the NEI. The TCEQ maintains an internal cross reference that links the FACILITY ID and UNIT ID to an NEI and STARS FIPS/plant/stack/point emissions "path," which provides location, stack, and other parameters needed to model the point source.

For base case and baseline emissions of EGUs, corresponding hourly VOC and CO records were generated using their STARS OSD VOC-to-$NO_X$ and CO-to-$NO_X$ ratios. For the future case EGUs, hourly emissions were based on the hourly heat input instead of the hourly $NO_X$ emissions. Figure 2-3: *Tile Plot of HGB Eight-County EGU $NO_X$ Emissions for August 7, 2012* is used to graphically QC the modeled emissions. Reported on the tile plots are the emissions totals by county in the lower left hand corner and the corresponding total diurnal profile of the sources in the lower right corner. A colored/shaded tile represents the total quantity of EGU $NO_X$ tons for a modeled day's 4 km grid cell within the eight-county HGB area. Elevated point sources are not gridded when modeled.

Figure 2-4: *Tile Plot of Texas EGU* $NO_X$ *Emissions for August 7, 2012* is a map of EGU $NO_X$ emissions for Texas on the 12km grid for a representative day in August 2012. The diurnal profile of Texas EGU $NO_X$ emissions in Figure 2-4 varies less than the profile of HGB EGU $NO_X$ emissions in Figure 2-3, indicative of baseload EGUs that run almost continuously.

[1] EPA's Plain English Guide to the Part 75 Rule, June 2009, p. 80, http://www.epa.gov/airmarkets/documents/monitoring/plain_english_guide_part75_rule.pdf

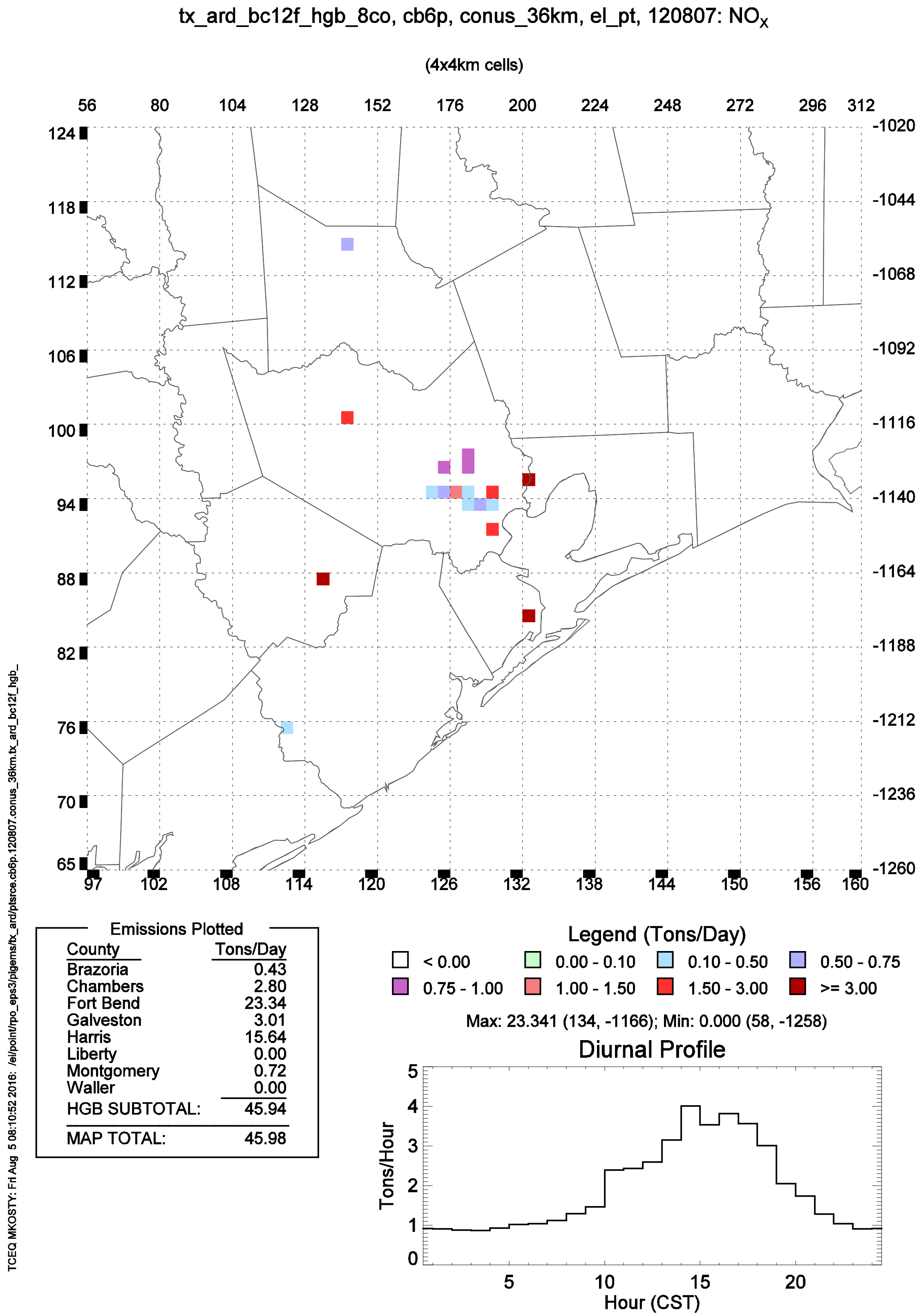



**Figure 2-3: Tile Plot of HGB Eight-County EGU $NO_X$ Emissions for August 7, 2012**

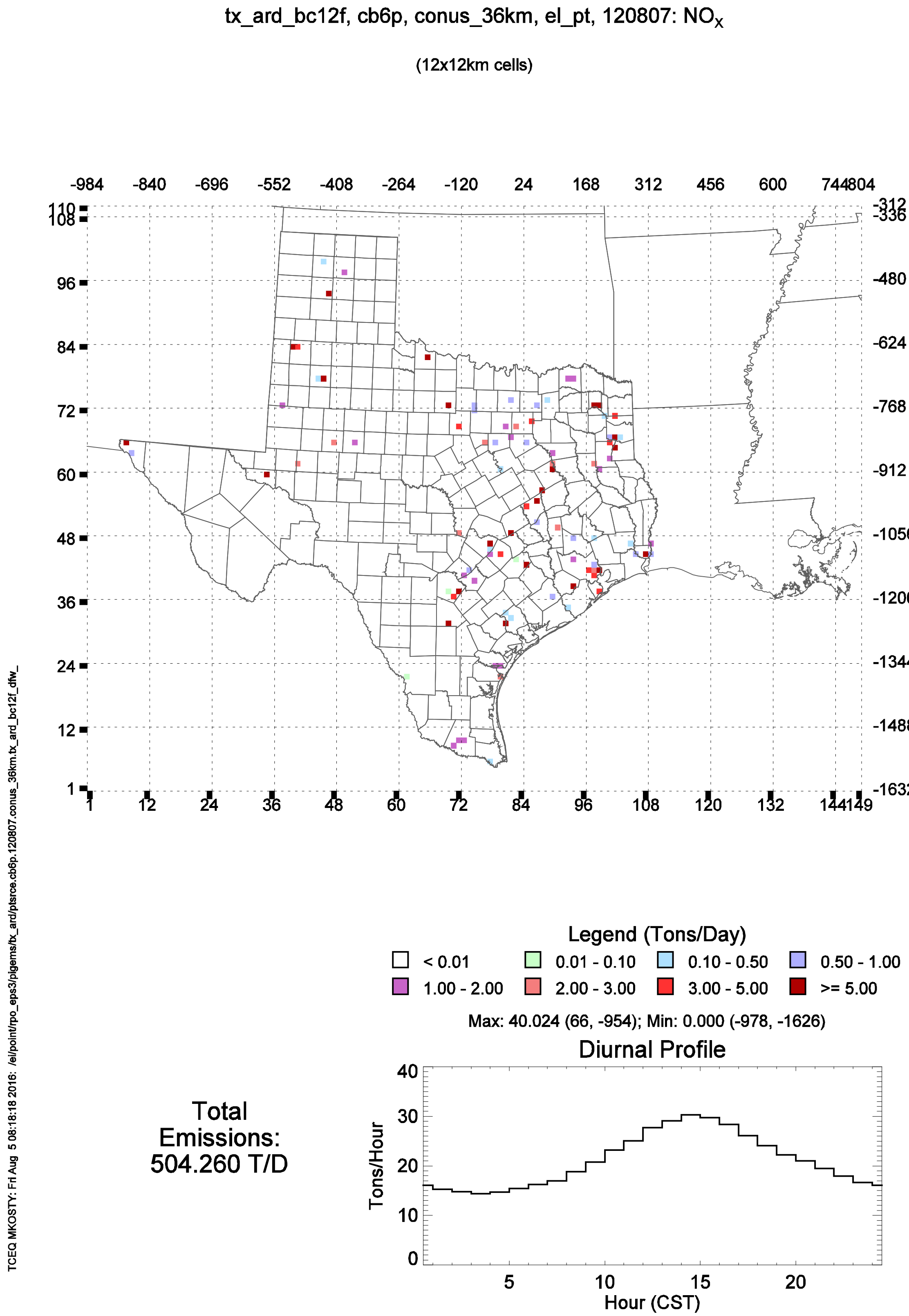



**Figure 2-4: Tile Plot of Texas EGU $NO_X$ Emissions for August 7, 2012**

### 2.1.2. Regional (Outside of Texas) Point Sources

This section discusses the point source modeling emissions development for the following areas outside of Texas within the modeled CAMx domain:

- Continental U.S. (CONUS) outside of Texas;
- Offshore (Gulf of Mexico);
- Mexico; and
- Canada.

#### 2.1.2.1. Regional NEI for Non-EGUs

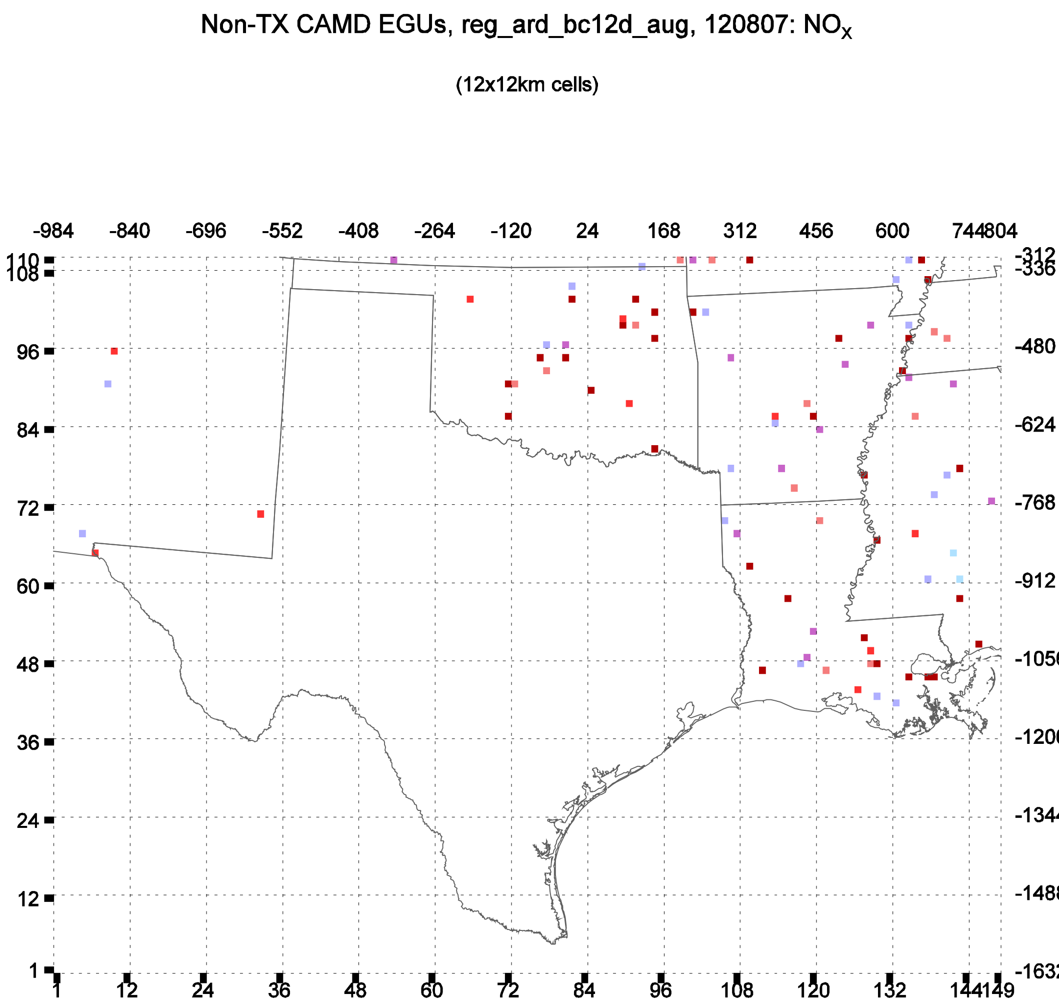
The 2012 EI for states outside of Texas was derived from the EPA's 2011 Modeling Platform. The 2011 Modeling Platform was used because it is the closest in year inventory to the base case, and it was not forecast to 2012. Records with rail and airport Source Classification Codes (SCCs) were removed to avoid duplicating emissions with area source categories. An AFS-formatted file was generated for EPS3 processing. The associated temporal allocation file for SMOKE was converted to create the daily-varying temporal distribution of emissions for each day of the episode. Previous AD SIP revisions used a June day to represent a typical ozone season day.

#### 2.1.2.2. Regional Hourly AMPD Substitution for EGUs

Hourly emissions for EGUs were obtained for 2012 from the EPA's AMPD. The TCEQ replaced the original emission records with hourly records for all of the EGUs in all states outside of Texas by matching the AMPD identifiers, FACILITY ID and UNIT ID. The TCEQ maintains a (ORIS and Unit ID keyed) cross reference that links the 2011-based NEI to the AMPD data.

Location and stack parameters obtained from the NEI are appended to the EGUs to generate an AFS file. All EGUs in the adjacent states of Louisiana, Arkansas, and Oklahoma are the most accurately cross-referenced to assure geographical accuracy. The further away the EGU from Texas, the more tolerance was allowed for geographical location. Corresponding hourly VOC and CO records for EGUs matched with the cross reference were generated using their VOC-to-$NO_X$ and CO-to-$NO_X$ ratios.

AMPD $NO_X$ emissions for the EGUs of the adjacent states for August 7, 2012 are shown in Figure 2-5: *Tile Plot of EGU $NO_X$ Emissions for the Adjacent States for August 7, 2012*. The emissions summary in Figure 2-5 is for the 12 km domain, without Texas. AMPD $NO_X$ emissions for the EGUs of the 36 km CONUS outside of Texas for the same modeled episode day are shown in Figure 2-6: *Tile Plot of EGU $NO_X$ Emissions for the U.S. (outside of Texas) for August 7, 2012.*

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**Emissions Plotted**

| Area | Tons/Day |
|---|---|
| Arkansas | 105.00 |
| Kansas | 0.42 |
| Kentucky | 4.11 |
| Louisiana | 153.02 |
| Mississippi | 56.08 |
| Missouri | 61.84 |
| New Mexico | 7.37 |
| Oklahoma | 256.79 |
| Tennessee | 13.29 |
| Mexico | 0.00 |
| Gulf of Mexico | 0.19 |
| Area SUBTOTAL: | 658.11 |
| MAP TOTAL: | 678.40 |

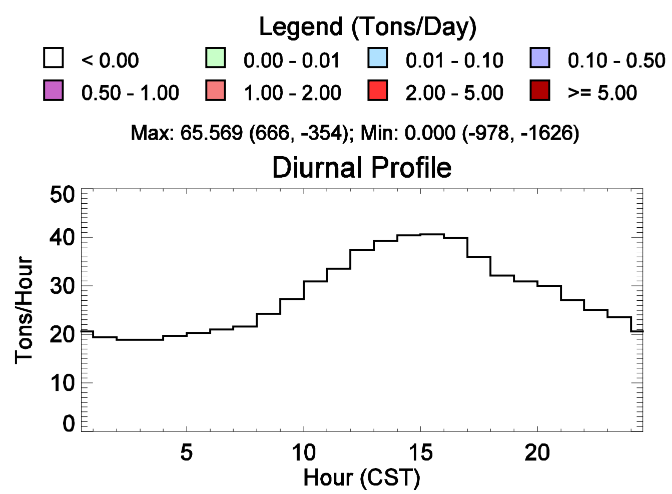


**Figure 2-5: Tile Plot of EGU $NO_X$ Emissions for the Adjacent States for August 7, 2012**

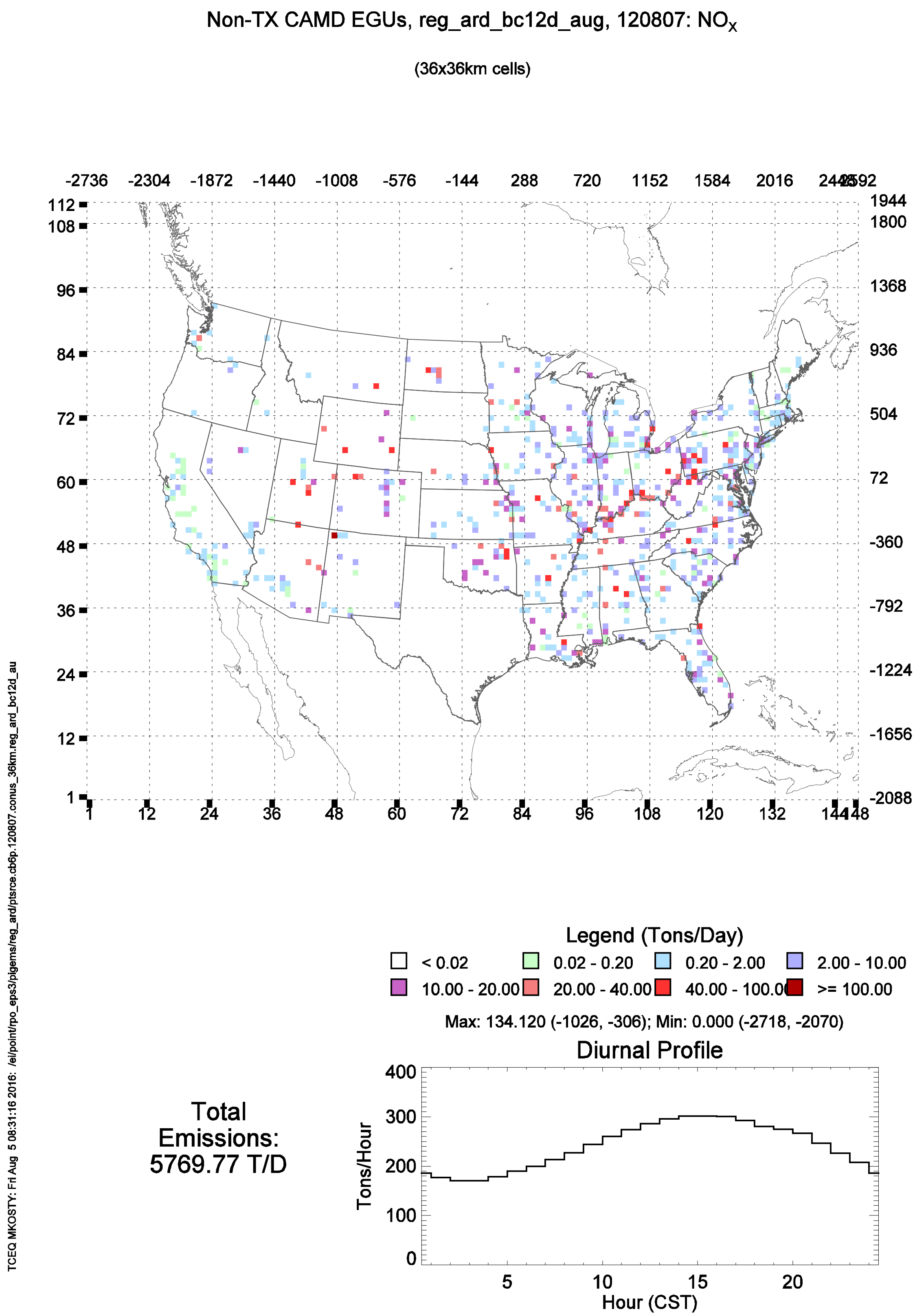


**Figure 2-6: Tile Plot of EGU $NO_X$ Emissions for the U.S. (outside of Texas) for August 7, 2012**

2.1.2.3. Offshore Point Sources

The TCEQ obtained the 2011 Gulf-Wide Emission Inventory, developed by Eastern Research Group (ERG) under contract to the Bureau of Ocean Energy Management. The GWEI has been updated every three years. The use of 2011 data is an update to the 2005 data modeled and documented in previous AD SIP revisions. The report and data are divided into two parts, oil and gas exploration and production platform (point) sources, and non-platform (area) sources. The TCEQ did not forecast the 2011 GWEI to 2012. 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 2011 GWEI, so curves developed for 2008 GWEI were used, as advised in ERG's 2011 documentation. Table 2-2: *GWEI Historical Platform Emissions Summary* summarizes the annual emissions from offshore point sources and shows changes between 2005, 2008 and 2011. The 2011 offshore emissions are illustrated in Figure 2-7: *Tile Plot of Offshore Platform $NO_X$ Emissions for a Representative Day in August 2011*.

**Table 2-2: GWEI Historical Platform Emissions Summary**

| Year | CO (tpy) | $NO_X$ (tpy) | VOC (tpy) |
|---|---|---|---|
| 2005 | 89,813 | 82,581 | 51,241 |
| 2008 | 82,146 | 74,286 | 60,824 |
| 2011 | 70,339 | 84,128 | 54,724 |

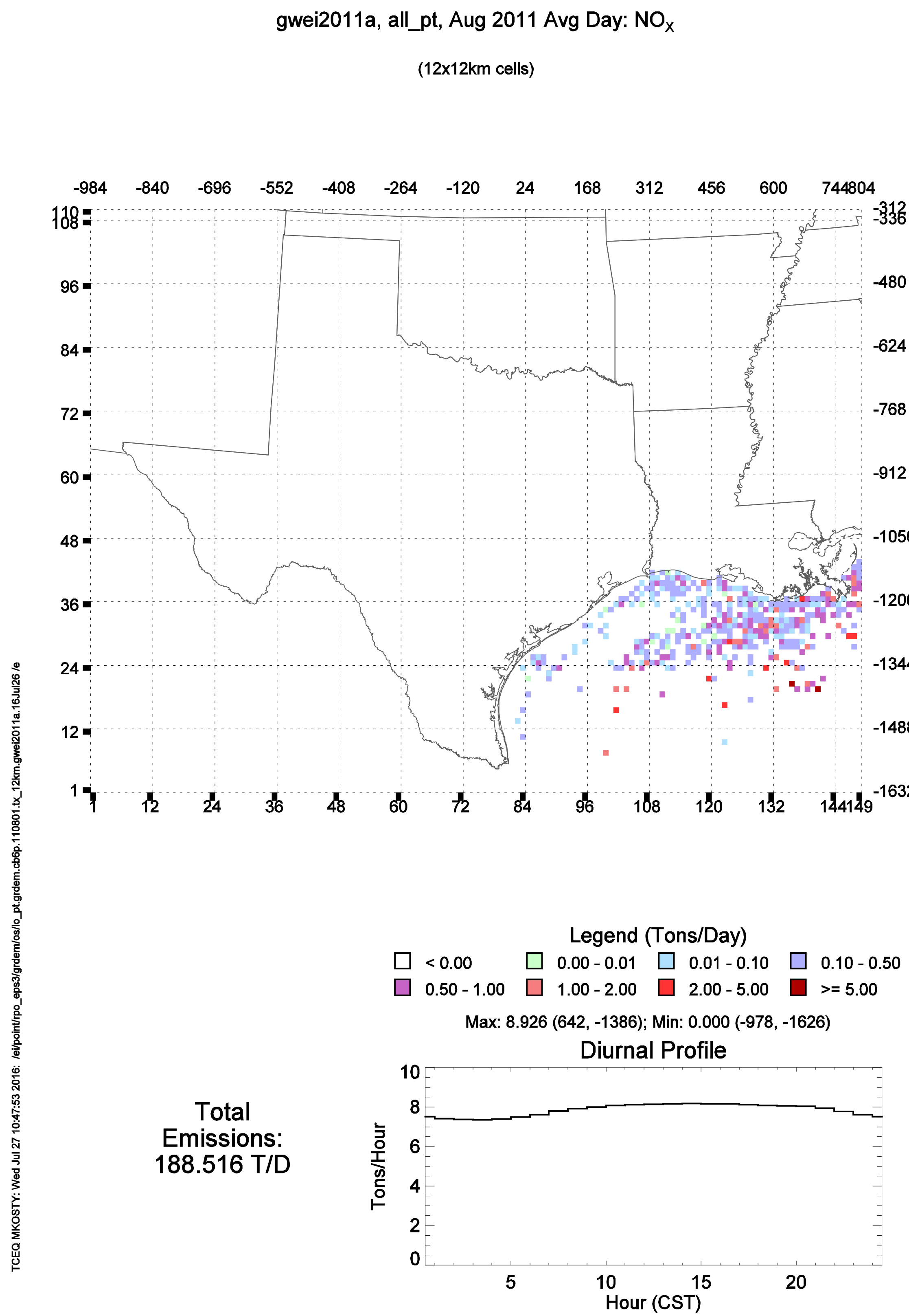


**Figure 2-7: Tile Plot of Offshore Platform $NO_X$ Emissions for a Representative Day in August 2011**

2.1.2.4. Mexican Point Sources

The TCEQ used 2008-based Mexico NEI data from the EPA's 2011 Modeling Platform, which was the current data used by the EPA at the time the TCEQ compiled its modeled emissions. The TCEQ downloaded the FF10 format version of the files from EPA's platform ftp location (ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/) and converted them into AFS format for EPS3 processing. The EPA Modeling Platform includes annual emissions for 2008 and projections to 2018 and 2025. The TCEQ developed average day 2012 emissions by interpolating between the 2008 and 2018 annual emissions and then dividing by 365 days per year. No temporal allocation or speciation data were available, so emissions were distributed evenly across the episode. Figure 2-8: *Tile Plot of Mexico $NO_X$ Emissions for an Interpolated 2012 Day* is presented below.

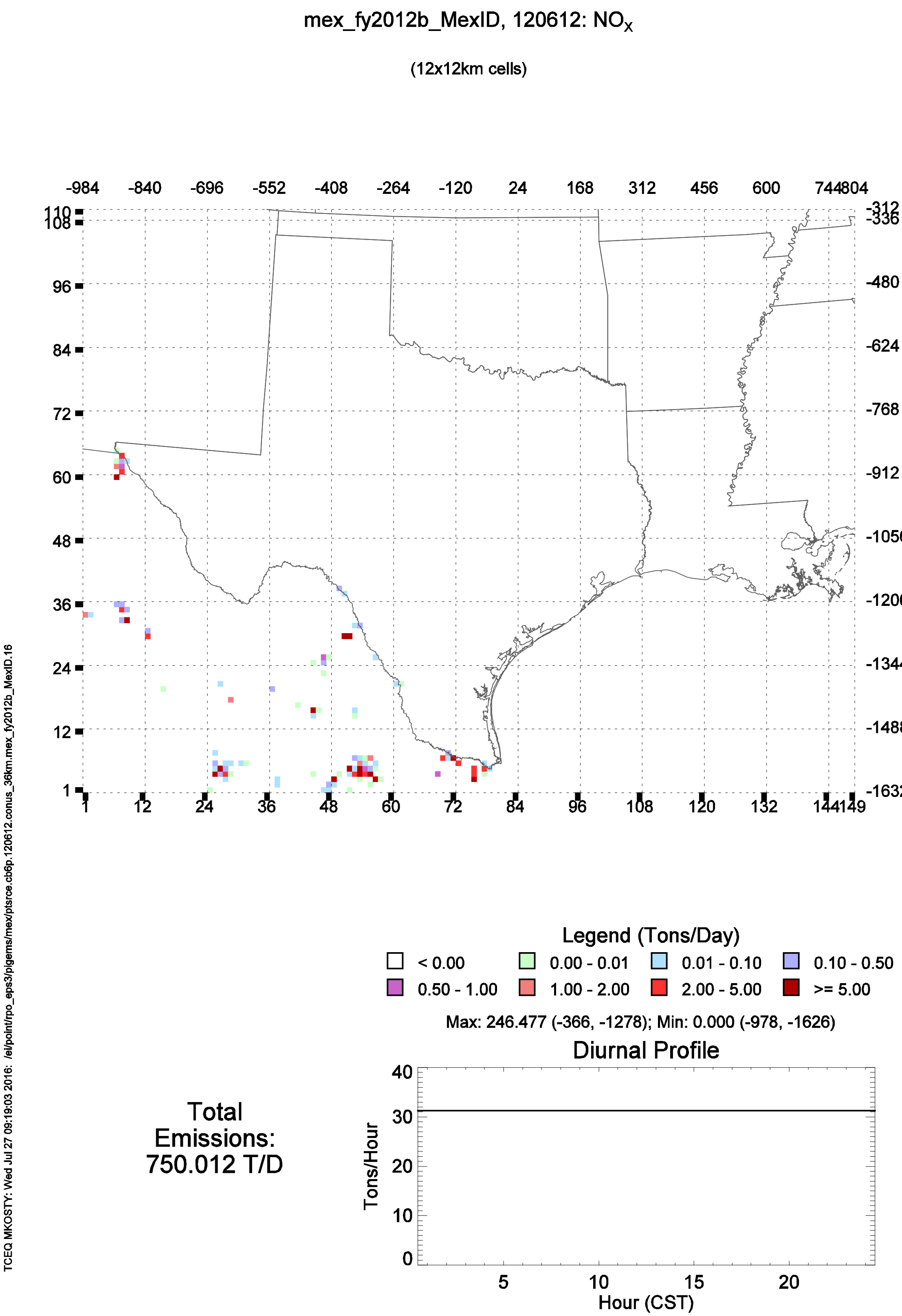


**Figure 2-8: Tile Plot of Mexico $NO_X$ Emissions for an Interpolated 2012 Day**

#### 2.1.2.5. Canadian Point Sources

The Canadian EI in the EPA's 2011 Modeling Platform was 2010 emissions, but already processed through SMOKE and CB05. Since the TCEQ uses the CB6 chemical mechanism, the 2006 point source emissions from the Canadian National Pollutant Release Inventory (NPRI) were used. Environment Canada provided the data, which the TCEQ converted to average day AFS records for further processing with EPS3. No temporal allocation or speciation data were available, so defaults were used. The $NO_X$ emissions for this dataset are illustrated in Figure 2-9: *Tile Plot of Canadian 2006 NPRI* $NO_X$ *Emissions for a Day in 2012*.

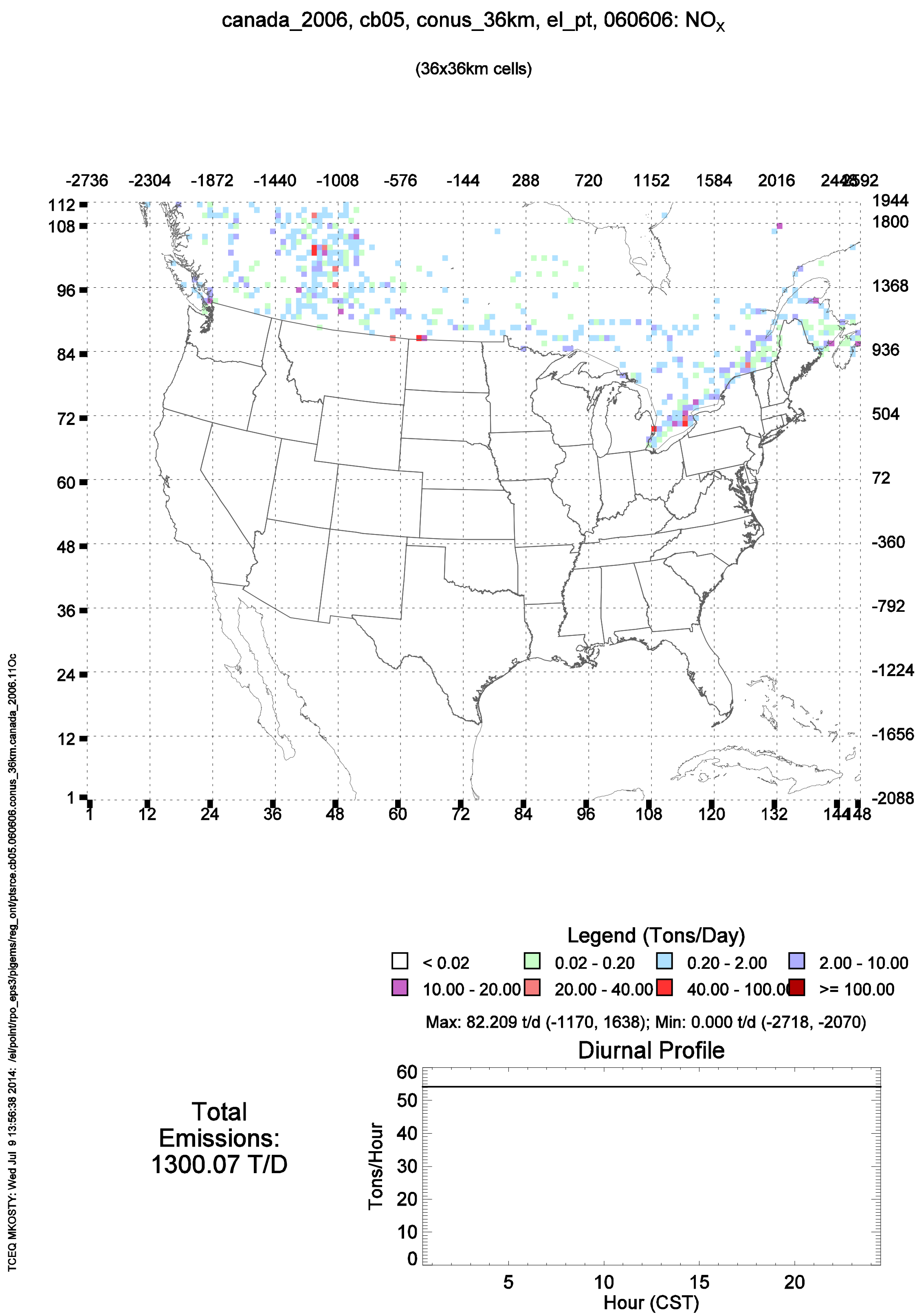


**Figure 2-9: Tile Plot of Canadian 2006 NPRI $NO_X$ Emissions for a Day in 2012**

### 2.1.3. 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 GREASD PiG option in CAMx was used, which is most applicable to large $NO_X$ plumes, for all point sources that met the criteria in Table 2-3: *Summary of PiG Thresholds*.

**Table 2-3: Summary of PiG Thresholds**

| Modeled Area | $NO_X$ Threshold (tpd) |
|---|---|
| Texas | 5.0 |
| Adjacent States (LA, AR, OK) & adjacent Mexican States | 7.5 |
| Next ring of USA and Mexican States (MS, etc.) | 10.0 |
| Next distant ring of States (AL, etc.) | 15.0 |
| Other States, Canada & Offshore | 25.0 |

The $NO_X$ threshold of 5.0 tpd in Texas denotes that any individual stack or colocated group of stacks with 5.0 or more tpd of $NO_X$ emissions on an episode day were tracked as a PiG source. The colocation occurs when multiple stacks are close enough together for their plumes to merge (within 200 meters of each other) and the aggregate $NO_X$ emission rate for the cluster exceeded the threshold value in Table 2-3. A new source was created with the combined $NO_X$ emission rate of the cluster, and this source was flagged for PiG treatment. The stack parameters of the new source became an average of the stack parameters of all of the sources in the cluster. The TCEQ modeled both individual PiGs and combined PiGs within each of the modeled areas of Table 2-3. The EPS3 module, PiGEMS, provides a summary of the PiG treatment. There were 229 PiG sources tracked for the entire domain, 187 of which were colocated and combined as new stacks.

### 2.1.4. Summary of 2012 Base Case Point Sources

The base case point source emission files processed with EPS3 for CAMx are presented in Table 2-4: *Base Case AFS Files Used for the HGB May to September 2012 Episode*. The regional AFS file for the GWEI contains monthly emissions for the year (only June was modeled), the regional AFS file for Canada contains daily emissions that are representative for the entire year, and the regional non-EGU NEI AFS file contains annual emissions. EGU files may be referred to as "ARD" or "AMP", and non-EGU files may contain "OSD" in the file name text. The base case point source files are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/point/basecase. Under the "AFS" subdirectory of this FTP structure is the AFS file format document, "AFS-EPS3-v3.docx", which provides additional details for the expanded fields that the TCEQ provides in its AFS files.

**Table 2-4: Base Case AFS Files Used for the HGB May to September 2012 Episode**

| Area | AFS Point Source Emissions File | Record Type |
|---|---|---|
| Texas | afs.osd_for_2012_amp_based_on_2012v7a.v6 | Daily |
| Texas | afs.amp_01Jan_to_31Dec12_episode_all_pols_RPOlcp.v6 | Hourly |
| Regional | afs.2012_USA_noTX_noEGU_v2.RPOlcp | Annual |
| Regional | afs.amp_USA_Mar2Sep_episode_all_pols_RPOlcp | Hourly |
| Regional | afs.gwei.2011.lcpRPO | Monthly |
| Regional | afs.Mexico_2012_Interpolate_from_EPA2011PlatformV2_MexID.RPOlcp | Daily |
| Regional | afs.canada_2006_all_pols.RPOlcp | Daily |

The TCEQ chose the first Tuesday of August 2012 as a representative day for reporting base case emissions totals. August 7, 2012 was a high ozone day with elevated $NO_X$ concentrations. Table 2-5: *2012 Base Case Emissions Summary for August 7, 2012* summarizes emissions for that day.

**Table 2-5: 2012 Base Case Emissions Summary for August 7, 2012**

| Emissions Source | HGB $NO_X$ (tpd) | HGB VOC (tpd) | Rest of Texas $NO_X$ (tpd) | Rest of Texas VOC (tpd) | Regional $NO_X$ (tpd) | Regional VOC (tpd) |
|---|---|---|---|---|---|---|
| Non-EGUs (OSD) | 69.8 | 130.7 | 417.6 | 354.9 | 3752.1 | 2278.2 |
| EGUs (AMPD) | 46.0 | 4.9 | 458.3 | 23.4 | 5769.8 | 93.8 |

## 2.2 2012 Baseline Point Source Modeling Emissions Development

The 2012 point source emissions used in the base case are specific to individual days and hours for the EGU portion of the EI. For the baseline case, monthly files were created that represent a typical ozone season day in 2012. The following subsections discuss how the baseline emissions differ from the base case.

### 2.2.1. Texas Point Sources

2.2.1.1. Texas Non-EGU Baseline

The non-EGU emissions for the typical 2012 baseline day are the same as the 2012 base case non-EGU emissions, as these are the average OSD emissions extracted from STARS.

Table 2-6: *Texas 2012 Baseline Non-EGU Emissions Summary* shows the modeled ozone precursor 2012 baseline emissions totals for point sources in the HGB eight-county nonattainment area (NAA), the DFW 10-county NAA, and the rest of Texas. The “#points” entries in Table 2-6 are the total number of $NO_X$ or VOC point sources in that area. Emissions were summed within the area to give the area emissions total.

**Table 2-6: Texas 2012 Baseline Non-EGU Emissions Summary**

| Area | $NO_X$ #points | $NO_X$ tpd | VOC #points | VOC tpd |
|---|---|---|---|---|
| HGB | 5422 | 69.8 | 26705 | 130.7 |
| DFW | 2042 | 33.1 | 6331 | 47.7 |
| Rest of TX | 9437 | 384.5 | 27817 | 307.2 |

2.2.1.2. Texas EGU Baseline

To develop an EGU baseline, the TCEQ averaged the AMPD $NO_X$ for each hour of the day for each unit for each of the five months of the 2012 ozone season (May through September). These data records represent the typical day for each month while maintaining the average diurnal profile of the individual units. Corresponding hourly average CO and VOC emissions were calculated from STARS stack-specific emissions by multiplying CO-to-$NO_X$ and VOC-to-$NO_X$ ratios by the hourly $NO_X$ rate for each EGU. The summary of EGU emissions can be found in Table 2-10: *2012 August Average Baseline Point Source Emissions Summary*.

### 2.2.2. Regional (Outside of Texas) Point Sources

2.2.2.1. Regional Non-EGU Baseline

For the states outside of Texas, the TCEQ used the EPA's 2011 Modeling Platform non-EGU file generated for the base case. Table 2-7: *Regional 2012 Baseline Non-EGU Emissions Summary* summarizes the 2012 baseline non-EGU emissions extracted from the NEI for the adjacent states and other states outside Texas.

**Table 2-7: Regional 2012 Baseline Non-EGU Emissions Summary**

| State | $NO_X$ tpd | VOC tpd |
|---|---|---|
| Arkansas | 81.88 | 59.72 |
| Louisiana | 311.19 | 143.70 |
| Oklahoma | 219.84 | 123.64 |
| Other States outside Texas | 3492.05 | 1969.00 |

A typical day for each of the months modeled, derived from temporal profiles from the 2011 EPA Modeling Platform, was used for the baseline.

2.2.2.2. Regional EGU Baseline

The 2012 baseline for the EGUs of the other states was calculated to be the average day of month, with hourly emissions averaged over the month for each EGU. VOC and CO emissions for each hour of the month were calculated as the product of the hourly AMPD $NO_X$ emissions and the 2011 NEI VOC-to-$NO_X$ and CO-to-$NO_X$ emissions ratios. The summary of EGU emissions can be found in Table 2-10.

2.2.2.3. Offshore, Mexico, and Canada

The 2008 Mexican NEI (interpolated to 2012), and the 2006 Canadian baseline point source files are the same as the base case files, and were modeled as an average day. The GWEI was from the same source as the base case, but an average day per month was used in the baseline.

### 2.2.3. Summary of 2012 Baseline Point Sources

A summary of the point source industries by Standard Industrial Classification (SIC) within the eight-county HGB nonattainment area is provided in Table 2-8: *2012 HGB Point Source Baseline Emissions by Industry*. Ten industry types emitted more than 1.0 $NO_X$ tpd in 2012, with 79 other SICs reporting smaller emissions. The Industrial Organic Chemicals, Electric Services (includes the EGUs), and Petroleum Refining SICs reported the vast majority of $NO_X$ and VOC emissions.

**Table 2-8: 2012 HGB Point Source Baseline Emissions by Industry**

| SIC Code | SIC Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|
| **2869** | Industrial Organic Chemicals, Not Elsewhere Classified | 33.88 | 39.46 | 26.10 |
| **4911** | Electric Services (includes the EGUs) | 32.81 | 3.54 | 39.19 |
| **2911** | Petroleum Refining | 22.16 | 31.14 | 16.87 |
| **2813** | Industrial Gases | 2.50 | 0.69 | 3.98 |
| **4931** | Electric and Other Services Combined | 2.39 | 0.41 | 1.91 |
| **1321** | Natural Gas Liquids | 1.78 | 3.38 | 2.09 |
| **1311** | Crude Petroleum and Natural Gas | 1.30 | 9.00 | 2.18 |
| **2819** | Industrial Inorganic Chemicals | 1.08 | 0.86 | 0.68 |
| **2821** | Plastic Materials and Resins | 1.05 | 7.31 | 2.65 |
| **2865** | Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments | 1.03 | 0.48 | 0.31 |
| | Remaining 79 SICs Less Than 1.0 $NO_X$ tpd | 6.27 | 38.31 | 9.49 |
| | HGB Point Source Total (89 SICs) | 106.25 | 134.59 | 105.43 |

The point source emission files that were processed with EPS3 for CAMx for the baseline are presented in Table 2-9: *AFS Files for the 2012 Baseline*. The regional AFS file for the GWEI contains monthly emissions, and the regional AFS file for Canadian emissions contains annual emissions. EGU files may be referred to as “ARD” or “AMP”, and non-EGU files may contain “OSD” in the file name text. The 2012 baseline point source files are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/point/.

**Table 2-9: AFS Files for the 2012 Baseline**

| Area | AFS Point Source Emissions File | Emissions Record Type |
|---|---|---|
| Texas | afs.amp_MAY_2012_average_all_pols_RPOlcp<br>afs.amp_JUN_2012_average_all_pols_RPOlcp<br>afs.amp_JUL_2012_average_all_pols_RPOlcp<br>afs.amp_AUG_2012_average_all_pols_RPOlcp<br>afs.amp_SEP_2012_average_all_pols_RPOlcp | Hourly |
| Texas | afs.osd_for_2012_amp_based_on_2012v7a.v6 | Daily |
| Regional | afs.ard_USA_MAY_2012_average_all_pols_RPOlcp<br>afs.ard_USA_JUN_2012_average_all_pols_RPOlcp<br>afs.ard_USA_JUL_2012_average_all_pols_RPOlcp<br>afs.ard_USA_AUG_2012_average_all_pols_RPOlcp<br>afs.ard_USA_SEP_2012_average_all_pols_RPOlcp | Hourly |
| Regional | afs.2012_USA_noTX_noEGU_v2.RPOlcp | Annual |
| Regional | afs.gwei.2011.lcpRPO | Monthly |
| Regional | afs.Mexico_2012_Interpolate_from_EPA2011PlatformV2_MexID.RPOlcp | Daily |
| Regional | afs.canada_2006_all_pols.RPOlcp | Daily |

Table 2-10: *2012 August Average Baseline Point Source Emissions Summary* summarizes the baseline emissions for the month of August. These tabulated emissions are AFS totals input to EPS3. CAMx input VOC values may differ slightly.

**Table 2-10: 2012 August Average Baseline Point Source Emissions Summary**

| Emission Source | HGB $NO_X$ (tpd) | HGB VOC (tpd) | Rest of Texas $NO_X$ (tpd) | Rest of Texas VOC (tpd) | Regional $NO_X$ (tpd) | Regional VOC (tpd) |
|---|---|---|---|---|---|---|
| Non-EGUs (OSD) | 69.8 | 130.7 | 417.6 | 354.9 | 3752.1 | 2278.2 |
| EGUs (AMPD) | 36.5 | 3.9 | 404.7 | 19.7 | 5328.5 | 56.0 |

## 2.3 2017 Future Year Point Source Modeling Emissions Development

This section describes the development of the 2017 future year point source EI.

Many factors create the foundation for the future case point source EI prior to control strategies and/or sensitivity analyses, including a point source emissions inventory starting point, which is referred to as the projection base, impact of emissions banking and trading programs, economic growth projections, changes in the Texas EGU fleet, existing and anticipated federal, state, and local regulations and emissions reduction measures.

The TCEQ uses the most complete and accurate data available at the time of emissions inventory development. For this proposed AD SIP revision, the 2017 future case EI was developed using the most recent STARS and AMPD data sets available, 2014 and 2015, respectively. These projection base years also become the basis for the SIP emissions used for future emission credit generation. The future case EI provides the basis to determine if attainment has been reached and is the starting point for control strategy testing and/or future year sensitivity analyses, if required. In general, projection base year emissions are grown to the attainment year and existing on-the-books controls (those that will be in place after the baseline year and prior to the future year) are applied.

### 2.3.1. Regulations and the Cap-and-Trade Programs

In some instances, growth of future emissions is limited by regulation. Prior to discussing growth and the development of emission files for specific categories and areas of the state, a description of the various regulations and trading programs is provided here, since they are referenced in several sections below.

In Texas and other covered states, CSAPR became effective January 1, 2015 (taking the place of CAIR), and limits the ozone season (May through September) $NO_X$ emissions from subject EGUs. CSAPR is a federal program administered by the EPA.

In the eight-county HGB NAA, the Mass Emissions Cap-and-Trade program limits annual $NO_X$ emissions for applicable stationary point source equipment. In Harris County, HRVOC Emissions Cap-and-Trade  limits annual HRVOC emissions for certain point sources. Besides MECT, HECT, and CSAPR, there are other regulations and agreements that affect certain $NO_X$ sources in the state, some of which have compliance dates between the projection base years (2015 for Texas EGUs and 2014 for all other Texas point sources) and the attainment year of 2017. For most regulations, the compliance date has already passed and emissions are accurately modeled using the reported projection base year(s) emissions. Additionally, specific for the DFW NAA, the Ellis County cement kilns (near Midlothian) are capped (by site) by a $NO_X$ emissions limit.

#### 2.3.1.1. <u>CSAPR Background</u>

The EPA's CSAPR program requires states to addresses interstate transport related to the 1997 eight-hour ozone standard and the 1997 annual and 2006 24-hour particulate matter of 2.5 microns and less ($PM_{2.5}$) standards in 28 eastern states, including Texas. The program limits annual $NO_X$ and $SO_2$ emissions for affected EGUs in Texas and 20 other states, as well as $NO_X$ emissions during ozone season in 25 states, including Texas. The definition of an EGU for the CSAPR program is approximately the same definition as that for a Federal Clean Air Act Title IV Acid Rain unit, i.e., larger than 25 MW and more than one-third of its generation going to the public grid for sale. CSAPR is a cap-and-trade program, with EPA providing ozone season $NO_X$ and/or annual $NO_X$ and $SO_2$ budgets for each applicable state.

CSAPR provides ozone season $NO_X$ and annual $NO_X$ and SO2 emissions caps[2] for most AMPD EGUs in Texas (and other CSAPR states). CSAPR sources are allocated a specific amount of allowances for each compliance period (ozone season or annual), referred to as allocations. The sum of each state's allocations of all CSAPR sources for each compliance period equals the EPA-prescribed state's budget for that compliance period. At the end of each compliance period, each site with CSAPR sources must have sufficient allowances to cover the total emissions from all its CSAPR sources. Subject sources can purchase or sell allocated allowances, so their annual emissions in any compliance period are not limited to their allocation for that period. The reconciliation of available allowances and emissions is done by the EPA following the completion of the compliance period. Allowances not needed in a compliance period can be

[2] http://www.epa.gov/airtransport/CSAPR/stateinfo.html#states

banked and are available for the site to use in future compliance periods. While the state budget is distributed to each subject source, compliance is determined at the site level.

As CSAPR is a new cap-and-trade program, the TCEQ has no history of how EGUs have complied or will comply with this program; therefore, the EPA's allocations were modeled. 2017 future case EGU emission estimates within Texas were based on the prescribed CSAPR state budgets of 65,560 $NO_X$ tons for the five-month ozone season of May through September. In addition, some sources in CSAPR are in the HGB MECT program. The TCEQ accounts for the cap-and-trade aspects of CSAPR and the overlap of CSAPR and MECT programs by limiting the future emissions of sources subject to these cap-and-trade programs to the most stringent (smallest total cap) program.

#### 2.3.1.2. MECT Background

The MECT program provides $NO_X$ emission limits for applicable sources as specified in 30 TAC §101.351. The MECT program covers most $NO_X$-emitting sources (equipment) in HGB. Sites with these point sources comply with the source category emissions limits specified in 30 TAC Chapter 117 via a cap-and-trade program. The TCEQ allocates a specific amount of allowances to each point source (i.e., piece of equipment) at a site (account, RN) for each compliance year. Similar to the CSAPR program, the MECT program also allows banking and trading of allowances. A key difference between the CSAPR and MECT programs is that in the MECT program, unused allowances can be banked only for one additional compliance year, whereas in CSAPR, unused allowances can be banked indefinitely. To comply with the MECT program, each site in the MECT program should have sufficient allowances to cover the total annual emissions from all its MECT sources. The TCEQQCs the annual reports, submitted by subject sites, to verify that the site has allowances equivalent to the total $NO_X$ emissions from the MECT points at the site. Similar to the CSAPR program, annual allowances are distributed to each subject source, but compliance is determined at the site level. More detail about the MECT program can be found in Appendix B of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision.

Due to time constraints, the MECT cap of 40,176.2 tpy or 110 tpd used in this proposed HGB AD SIP revision is the same as that used for the July 6, 2016 DFW AD SIP Revision. In addition to the allocation portion of the MECT cap, the MECT program allows the use of Discrete ERCs (DERCs) and Mobile DERCs (MDERCs) to be used for MECT compliance. To account for the possible use of DERCs and MDERCs to cover emissions from MECT subject sources, an additional 1240.7 tpy or 3.4 tpd of emissions was added to the MECT cap. Since the development of 2017 emissions for the DFW AD SIP revision, more MECT allowances have been retired reducing the allocation-based portion of the 2017 program cap to 39,984.7 tpy or 109.55 tpd. In previous SIP revisions, MECT sites were modeled at their assigned future year allocations, regardless of their trading history. The fact that some MECT sites sell all or a portion of their allowances each year permanently via "stream trades", gave the TCEQ the impetus to model a more spatially-realistic future case distribution of MECT source emissions, as described below in Section 2.3.1.4 *Modeling the Cap-and-Trade Programs*.

#### 2.3.1.3. HECT Background

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 program is also a cap-and-trade program similar to the MECT program, with compliance being handled by the TCEQ. The HECT cap applies to HRVOC emissions from commonly included sources such as flares, non-tank stacks, and cooling tower emissions. However, unlike the MECT program, the HECT cap is distributed by site (RN, account) via annual allocations. Similar to the MECT cap, the HECT cap of 2,590.3 tpy or 7.1 tpd used in this proposed HGB AD SIP revision is the same as that used in the July 6, 2016 DFW SIP Revision.

HECT allowances were allocated to applicable sites in proportion to the site's level of activity, determined from each site's selection of a twelve-consecutive-month baseline ranging from 2000 through 2004. HECT sites were given the greater of 5.0 tons of HECT allowances or the allocation from the site, determined from using the equation listed in 30 TAC §101.394(a)(1).

2.3.1.4. Modeling the Cap-and-Trade Programs

The TCEQ administers three cap-and-trade programs in Texas: (1) the Emissions Banking and Trading 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, and (3) the HECT program for HRVOC emissions. In addition, Texas EGUs are subject to the federal CSAPR program. The SB7 program, which affects EGUs, is not modeled as it is less stringent than CSAPR. The TCEQ models these cap-and-trade programs by limiting the future emissions of sources subject to these cap-and-trade programs to the appropriate program's total future year cap. If multiple programs cover a set of sources, the most stringent (smallest total cap) program is modeled. The three cap-and-trade programs used to model future year $NO_X$ and HRVOC emissions are summarized in Table 2-11: *Texas Cap-and-Trade Program Emissions Summary*. $SO_2$ is not a modeled precursor for ozone, so it is not included in the CSAPR discussions of this appendix.

**Table 2-11: Texas Cap-and-Trade Program Emissions Summary**

| Program | Pollutant Affected | Geographical Scope of Program | 2017 Program Cap for Texas Sources |
|---|---|---|---|
| CSAPR | $NO_X$ | Texas and 27 eastern states | 65,560 tons for the May-September ozone season |
| MECT | $NO_X$ | HGB Nonattainment Area | 40,176.2 tpy |
| HECT | HRVOC | Harris County | 2,590.3 tpy |

The spatial representation of future year emissions of the sources subject to these cap-and-trade programs is made uncertain due to the trading provisions of these programs. The information currently available to estimate future emissions from sources subject to cap-and-trade programs includes the future year program cap, future year allocation for subject sources, and historical compliance trends for previous compliance periods[3]. While the total future emissions from the sources subject to each program is limited to the 2017 program cap listed in Table 2-11, the TCEQ spatially distributed the 2017 cap to sources expected to be operational in the future using historical trend analysis for the MECT and HECT programs as detailed below. The distributed annual 2017 site emissions (tpy) were converted to future year ozone season day emissions (tpd). The distribution of the 2017 program cap described here is intended to spatially represent future year emissions for modeling purposes only and does not take the place of official allocation of allowances associated with these programs. The official future year allocations can be found at the Emissions Banking and Trading (EBT) program web page (http://www.tceq.texas.gov/airquality/banking/banking.html).

Since CSAPR is a new program and did not have historical trends, the TCEQ used the EPA's tabulated 2017 allocations to project future year emissions. Because this proposed SIP revision addresses ozone, the TCEQ modeled the CSAPR ozone season caps, except for Minnesota,

[3] Details regarding future year allocations for MECT, and HECT can be found in 30 TAC §101.353 and§101.394, respectively. Details regarding CSAPR can be found on EPA's website.

Kansas, and Nebraska, which have only annual caps and were modeled as such. Future year operational $NO_X$ caps were based on the ozone season budget and the latest unit level allocations from the EPA. Since electricity generation is higher during the hottest months, operational profiles based on 2015 measurements were used to allocate higher estimates for ozone season modeling purposes. Assignment of ozone season $NO_X$ emissions to EGUs operational in 2015 resulted in a total less than the 2017 CSAPR unit level allocations, so the remainder, plus the CSAPR new units set-aside was used to assign future year $NO_X$ caps to newly permitted EGUs, with the remainder spread proportionally among all existing EGUs.

For MECT and HECT, the general procedure for the historical trend analysis used to spatially distribute the future year program caps consisted of the following steps[4].

1. For each site, the difference between the total reported site emissions and the site's annual allocation for each of the past compliance periods for a program was calculated. The difference was termed "site cap gap."
2. A positive site cap gap for a compliance year indicated that the site had leftover allowances that it could potentially sell to other sites in the program (a spatial trade) or bank for future use (a temporal trade). A site with a positive cap gap is a potential "Seller" (spatial or temporal). Similarly, a site with a negative site cap gap indicated that the site purchased allowances (spatially or temporally) for compliance purposes and was termed "Buyer." The terms Seller and Buyer are used to refer to the potential to trade and not actual trades. In each compliance year, a site is a Seller or a Buyer in each program based on the site cap gap for that program.
3. If a site was a Seller (had a positive cap gap) 80%[5] of the time, then the site was termed to have a Seller trend. Similarly, if a site was a Buyer (negative cap gap) 80% of the time, then the site was termed to have a Buyer trend. The 80% cut off for a trend translates into a site being a Buyer or a Seller for a certain number of years depending on the total number of completed compliance years for each program.
4. If a site exhibited a trend and the site's behavior for the projection base year followed the trend, then the annual emissions for the projection base year was assigned as future year emissions to the site. This is because if a site exhibited a trend then it can be reasonably expected to have a similar behavior in the future year. Since the annual emissions from the projection base year were representative of the trend behavior, the projection base year emissions are considered to be representative of expected future year emissions. For this proposed HGB AD SIP revision, due to time constraints, the projection base year used for HECT and MECT is 2012, since this was the latest year for which MECT- and HECT-related compliance information was available from the EBT database.
5. Sites below the 80% threshold were termed as "Neither" Buyer nor Seller. For sites that did not have an identifiable trend or sites that had a trend but the behavior in the projection base year did not follow the identified trend, the future year site emissions were represented using future allocations of allowances.
6. To be conservative and to account for possible yearly variations, the assigned caps were proportionally scaled up such that total annual modeled emissions for all sources subject to these programs equal the program's respective 2017 available caps. The available program caps for MECT and HECT are those listed in Table 2-11.

The historical trend analysis was performed individually for each program. For sources subject to both CSAPR and MECT, the 2017 annual site emissions determined using the historical trend

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[4] Data regarding annual emissions and allocations was obtained from the TCEQ's EBT database for MECT and HECT programs.

[5] The 80% cut-off was chosen qualitatively.

analysis for the MECT program was used as it is the more stringent program. Detailed tables with the results of the historical trend analysis for each program are available at: ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/point/cap_trade.

### 2.3.2. Attainment Areas of Texas

The attainment areas of Texas include all of Texas except HGB and DFW. The subsections below address growth and control implementation separately. New units in attainment and nonattainment areas area also addressed.

#### 2.3.2.1. Attainment Area 2017 Growth Projections

Different growth projection techniques were applied to the EGUs, which have AMPD hourly data, and the non-EGUs. The techniques used are similar to EPA projection methods for modeling future cases, except that the TCEQ does not use the Integrated Planning Model (IPM) for EGUs.

##### *2.3.2.1.1. EGUs*

To develop the EGU 2015 projection base, the TCEQ averaged the AMPD $NO_X$ for each hour of the day for each unit for each month of the May through September ozone season, similar to the procedure that generated the 2012 baseline EGUs. The most recent dataset was used because it is newer and contains more of the actual emissions growth from newer units.

The TCEQ generates hourly emissions records for the non-AMPD pollutants ($NH_3$, CO, $PM_{2.5}$, and VOC) for AMPD point sources using 2014 heat input data. From STARS, the TCEQ obtains annual emissions for each pollutant and computes a pollutant-to-heat input ratio from the annual totals. The heat input and emission totals should be from the same year, but a given year's set of ratios can be used for another year if one of the datasets (e.g., STARS) is not available. With a valid set of pollutant-to-heat input ratios, hourly emissions for each pollutant based on the AMPD hourly heat input were calculated.

The complete set of Texas EGUs for future case modeling consists of the 2015 EGUs and the post-2015 new EGUs (e.g., newly-permitted EGUs) discussed in the following section. As with previous AD SIP revisions, the TCEQ assumes that the EGU growth in the state comes from newly-permitted EGUs.

##### *2.3.2.1.2. Newly-Permitted EGUs*

It is most accurate to provide known growth/expansions at the physical locations where they are projected to occur, rather than growing existing emissions in place. Growth in EGUs in Texas is accomplished with the addition of newly-permitted EGUs since the projection base year, all within the constraints described in the controls subsection below, in addition to TCEQ New Source Review permitting requirements. This subsection describes the procedures for developing the newly-permitted EGU EI. It includes the new units in attainment and nonattainment areas.

Texas EGU emissions for 2017 were developed 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).

Information from these sources includes individual units' disposition (i.e., operating status), new units coming online, units to be mothballed, and units to be shut down or retired. The criteria for adding new units are: (1) the units are expected to be operational by the end of 2017,

(2) the owners applied for, and were granted, a TCEQ air permit, and (3) the owners obtained an Interconnection Agreement (IA) from ERCOT (for those units planned within the ERCOT grid). All three of these conditions must be met in order for the unit(s) to be included in the future case modeling. The TCEQ assumed that units with planned retirement dates prior to the 2017 ozone season on EIA Form 860[6] (2013) or ERCOT's Capacity, Demand, and Reserves report would be retired. All data sources were reconciled to ensure all units were accounted for, and that their status as of May 2015 was modeled. Because the most recent EGU emissions data for modeling are from 2015 AMPD, new EGUs are based on additions and changes subsequent to 2015.

ERCOT covers approximately 85% of the power grid in the state. For the three years between December 2014 and December 2017, a comparative analysis was performed to verify that all new units planned by ERCOT are accounted for, and there is ample generation proposed from the newly permitted units to meet the projected demand in electricity. ERCOT projects approximately 2900 megawatts of new non-renewable resources with a reserve margin of approximately 18%. The modeled newly-permitted units meet this megawatt future demand projection.

Newly-permitted EGU emissions 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, and CO. The method of determining the allowable emissions differs based on the type of unit and its primary purpose for being constructed. For example, coal plants may have a 30-day rolling average emission rate, while gas turbines may have a short-term allowable emission rate in pounds per hour (pph) and/or a long term allowable emission rate in tpy. In some cases, a unit may have a combination of the above, in addition to maintenance, startup and shutdown (MSS) emission limits.

When available, the 30-day pph emissions limitation was used. These have most often been available for solid fuel-fired units. This time frame represents a good compromise between the standard short-term allowable, which sometimes includes MSS, and the standard long-term permit allowable.

MSS permitting has become more routine in the last several years. These activities help provide a more realistic operating scenario than the maximum of the short-term or long-term emission rates. This is especially important for those units that have many MSS events during a typical summer, such as the peaking units, which operate only during the peak demand times. MSS limits vary between permits, depending on specific representation in permit applications. Examples of permitted MSS and how they are modeled are described in the Appendix B, Section 2.3.1.1.1 of 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision.

The emission rates calculated represent worst-case for some units, but for most, they represent a typical summer day during the ozone season, corresponding to some of the highest days of electricity demand. Some facilities on the "new" list may have operating data in the 2015 projection base year. If the AMPD reported emissions were not reasonable for a complete year of operation, then these facilities were modeled at their permitted values. The complete list of newly-permitted EGUs added as the EGU growth in Texas sorted by area is provided as Table 2-12: *Newly-Permitted EGUs (post 2015) in Texas as of May 2015*.

[6] http://www.eia.gov/electricity/data/eia860/

**Table 2-12: Newly-Permitted EGUs (post 2015) in Texas as of May 2015**

| Sitename | County | EPN | Permit[7] $NO_X$ (tpd) |
|---|---|---|---|
| Panda Temple Power | BellCTG-10.4538 | | |
| Panda Temple Power | BellCTG-20.4538 | | |
| Panda Temple Power | BellCTG-30.4538 | | |
| Panda Temple Power | BellCTG-40.4538 | | |
| Panda Sherman | GraysonCTG-CC-10.6754 | | |
| Panda Sherman | GraysonCTG-CC-20.6754 | | |
| TC Ferguson Power Plant | LlanoU10.3654 | | |
| TC Ferguson Power Plant | LlanoU20.3654 | | |
| Channel Energy Center | HarrisGTG/HRSG30.8800 | | |
| Woodville Renewable | Tyler10.8900 | | |
| La Paloma Energy Center | CameronU1-STK0.7230 | | |
| La Paloma Energy Center | CameronU2-STK0.7230 | | |
| Guadalupe Generating | GuadalupeCTG-71.0170 | | |
| Guadalupe Generating | GuadalupeCTG-81.0170 | | |
| Montana Power Station | El PasoGT10.1050 | | |
| Montana Power Station | El PasoGT20.1050 | | |
| Montana Power Station | El PasoGT30.1050 | | |
| Montana Power Station | El PasoGT40.1050 | | |
| FGE Texas | MitchellGT10.3090 | | |
| FGE Texas | MitchellGT20.3090 | | |
| PH Robinson | GalvestonPHR10.5990 | | |
| PH Robinson | GalvestonPHR20.5990 | | |
| PH Robinson | GalvestonPHR30.5990 | | |
| PH Robinson | GalvestonPHR40.5990 | | |
| PH Robinson | GalvestonPHR50.5990 | | |
| PH Robinson | Galveston | PHR6 | 0.5990 |
| Goldsmith Peakers | Ector | CT-1 | 0.7522 |
| Goldsmith Peakers | Ector | CT-2 | 0.7522 |
| Pinecrest Energy Center | Angelina | U1 | 0.3810 |
| Pinecrest Energy Center | Angelina | U2 | 0.3810 |
| Red Gate | Hidalgo | ENG01 | 0.7615 |
| Indeck Wharton Energy | Wharton | GT1 | 0.9588 |
| Indeck Wharton Energy | Wharton | GT2 | 0.9588 |

[7] Modeled $NO_X$ as represented in the paragraphs above the table.

| Sitename | County | EPN | Permit[7] $NO_X$ (tpd) |
|---|---|---|---|
| Indeck Wharton Energy | Wharton | GT3 | 0.9588 |

The $NO_X$ emission rates in Table 2-12 reflect the calculated $NO_X$ emissions from permit applications and MAERTs, representing realistic average day emissions, and the $NO_X$ emission rates after incorporating the existing rules that may apply to the EGUs. The TCEQ assumed $NO_X$ controls, offsets, or credit purchases will be used to meet these $NO_X$ emissions rates. VOC and CO rates are modeled at their permitted levels. There were sufficient CSAPR and MECT allowances available for all newly-permitted EGUs to be modeled at the permitted rates in Table 2-12.

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. For some units on the new EGU list, a corresponding SCC did not exist for existing units. In these cases, the default flat profile was assigned.

*2.3.2.1.3. Non-EGUs*

When the EGUs are removed from the point source EI for hourly treatment, the remainder is non-EGUs. The projection base year for non-EGUs in the Texas attainment areas was the most current complete and quality control checked year of STARS emissions, 2014 OSD emissions.

The TCEQ estimated 2014 projection base to 2017 future case growth projections using growth factors developed under contract to TCEQ by ERG. The ERG growth factors[8] are based on county (FIPS) and North American Industry Classification System (NAICS). To manage the growth factors, the TCEQ developed a table that assigned growth factors for all 2014 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/NAICS match, the emissions path was assigned a growth factor equal to the NAICS average for the state. If there was no NAICS 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.

Projection factors were assigned individually to each non-EGU path that does not have a recent rule (or cap) applied to it. No factor was applied to a path that must comply with a rule, since the rule provides an emission rate limit on that path, allowing no growth for that individual piece of equipment. For this AD SIP revision, there were no rules to consider for growth. A summary of the EGU and non-EGU growth in the Texas attainment areas for the August average is provided as Table 2-13: *Summary of Texas Attainment Area August Average Ozone Season Growth Projections to 2017*. In Table 2-13, a Projection Method of 1 indicates ERG growth factors were applied to points that do not have recent existing rule limitations; and a Projection Method of 2 indicates the addition of post-2015 point sources (the newly-permitted EGUs with CSAPR applied to these points).

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[8] Factors and documentation are presented on the TCEQ's webpage at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/point/AFS/ERG_growth_factors/

**Table 2-13: Summary of Texas Attainment Area August Average Ozone Season Growth Projections to 2017**

| EI | Projection Base Data | Projection Base # points | Projection Base $NO_X$ (tpd) | Projection Method | 2017 Future Case #points | 2017 Projected $NO_X$ (tpd) | Projection Base to 2017 Growth |
|---|---|---|---|---|---|---|---|
| Non-EGUs | 2014 STARS | 10233 | 376.2 | 1 | 10212 | 388.00 | 6.5% |
| EGUs | 2015 AMPD | 269 | 369.2 | 2 | 274 | 458.4 | 24.2% |

The 2017 non-EGU $NO_X$ emissions are greater than the total in 2014 due to growth factors applied. The 2017 EGU emissions are also higher than the 2105, because most of the EGUs were operating under their caps in 2015, but in 2017 were modeled at their CSAPR cap values. Additionally, newly-permitted EGUs were added. The increase in the number of EGU points from 2015 to 2017 can be explained by the addition of the newly-permitted EGUs.

#### 2.3.2.2. Texas Attainment Areas 2017 Control Implementation

For this AD SIP revision, the existing TCEQ on-the-books controls for the non-EGUs were accounted for in the 2014/2015 projection base, because the compliance dates were prior to 2013. To develop the future case EGU emissions, the EPA's CSAPR cap-and-trade program was applied.

##### *2.3.2.2.1. EGUs*

The TCEQ modeled the CSAPR source emissions as described in Section 2.3.1.4. Also noted in Section 2.3.2.1.2, the newly-permitted EGUs were modeled at their permitted values using the CSAPR cap that remained after first distributing the cap to the existing EGUs. A summary of the distribution of the CSAPR budget to areas of Texas is provided as Table 2-14: *August Average Distribution of* $NO_X$ *CSAPR Allowances in Texas*.

**Table 2-14: August Average Distribution of $NO_X$ CSAPR Allowances in Texas**

| Area | Emissions Basis | Modeled Allowance for 2017 AMPD Units that were Operating in 2015 (tpd) | Modeled Allowance for Newly-Permitted (post 2015) OSD new EGUs (tpd) |
|---|---|---|---|
| HGB | MECT/CSAPR | 46.5 | 4.5 |
| DFW | CSAPR | 22.5 | 0 |
| Attainment | CSAPR | 445.8 | 12.6 |

The EGU portions of the HGB MECT program also count against the CSAPR budget, as described in sections above. Overall, MECT is more restrictive than CSAPR. The difference between CSAPR and MECT provides a credit that was distributed to point sources that are in CSAPR but not subject to the MECT program.

##### *2.3.2.2.2. Non-EGUs*

An existing program expected to reduce emissions between the 2014 projection base year and 2017 in the attainment areas of the state is the EPA's Petroleum Refinery Initiative. Since the late 1990s, petroleum refineries have been the focus of an EPA enforcement initiative. Since March 2000, the EPA has entered into settlements with 32 petroleum refiners that, collectively, represent 90 percent of U.S. petroleum refining capacity. According to EPA, these settlements, covering 109 refineries in 32 states, including Texas, will result in a reduction of approximately 93,000 tpy of nitrogen oxides ($NO_X$) and 256,000 tpy of sulfur dioxide ($SO_2$) upon full implementation (EPA, 2016).

The TCEQ has not modeled any reductions for these consent decrees, because (1) it is difficult to determine which reductions were already made as of the end of 2014, and which ones were remaining; (2) most of the agreements do not require $NO_X$ reductions; and (3) most of them lack enforceable requirements of quantified reductions. The TCEQ has verified that several refineries (some in HGB and Beaumont-Port Arthur) have modified permits to comply with their consent decrees, but permit reductions do not always result in actual reported emission reductions.

### 2.3.3. Nonattainment Areas (NAAs) of Texas

This section describes the specific growth and control implementation applied to the two ozone NAAs, HGB and DFW. The NAAs were modeled similarly, although HGB is more complex because of the number of TCEQ programs that apply to it. The growth projections to 2017 and any existing controls that will affect the areas between the projection base year(s) and 2017 are described in subsections below. Since emission growth in NAAs is strictly limited by nonattainment New Source Review (NSR) rules and TCEQ control programs, the subsections below address growth and control implementation together.

#### 2.3.3.1. 2017 NAA Growth Projections and Control Implementation

Growth projections were applied to the 2014 and 2015 projection base EIs to obtain the 2017 future case EI. Different techniques were applied to the EGUs (2015 projection base year) and the non-EGUs (2014 projection base year).

##### *2.3.3.1.1. NAA EGUs Projections and Control Implementation*

As with the attainment areas of the state, the projection of nonattainment areas into the future begins with a projection base EI for NAA EGUs that is the typical (average) summer day for each month calculated from AMPD hourly emissions for all days of the May through September 2015 time period. In addition, the CSAPR state budget and program requirements are also considered.

The complete set of 2017 Texas EGUs consists of the existing 2015 AMPD EGUs, the post-2015 newly-permitted EGUs, and any retirement of older/inefficient units. As with previous AD SIP revisions, the TCEQ assumes that the EGU growth in the state comes from newly-permitted EGUs. The Eastern Regional Technical Advisory Committee (ERTAC) EGU projection tool[9] predicts approximately the same amount of new growth for Texas. Similarly, the IPM, which EPA uses for projecting its future case, would add new units when it calculates that new capacity is needed. The TCEQ models the EGU growth (newly-permitted units) in Texas at the locations specified in permit applications; neither the ERTAC model nor IPM can do this.

###### 2.3.3.1.1.1. Existing EGUs in NAAs

All AMPD EGUs in HGB must comply with CSAPR and the more stringent MECT. CSAPR is an ozone season cap, and the TCEQ's modeling episode corresponds to CSAPR's ozone season

[9] A collaborative effort of states, regional planning organizations, and industry. http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation

compliance period. MECT is an annual cap, and the May through September period must be scaled to reflect cap usage in that time span.

Although MECT is an annual cap, account holders do not use these $NO_X$ allowances uniformly across the year. MECT sources use more allowances during the peak electrical demand period of ozone season. To compensate for this seasonal variation for MECT EGUs, the TCEQ computes a set of scaling factors by dividing the annual MECT cap for each account by the sum of its emissions over the 2015 projection base year. The scaling factor is applied to each month of the 2015 projection base year emissions to yield the monthly 2017 future case MECT emissions.

2.3.3.1.1.2. Newly-Permitted EGUs in NAAs

Table 2-12 in Section 2.3.2.1.2, lists the newly-permitted EGUs in each area of the state, which represent the EGU growth in Texas. There are seven newly-permitted units in HGB and no new planned units in DFW. There was enough cap left under MECT and CSAPR in HGB to accommodate the 4.5 tpd $NO_X$ of newly-permitted EGUs (see summary in Section 2.3.3.1.2.3). Care is taken to preclude double counting point sources that are on the new list but have started reporting emissions to the AMPD.

*2.3.3.1.2. NAA Non-EGU Projections and Control Implementation*

As with the attainment areas of the state, the projection into the future begins with a projection base EI for Texas NAA non-EGUs (2014 OSD emissions). Emissions from non-EGUs in the NAAs of the state were projected to 2017 using the lesser of the predicted growth with ERG growth factors or the certified credits (ERCs, DERCS, and MDERCs) available in the TCEQ's Emission Credit and Discrete Emission Credit Registries (EBT Credit Registry) as described in the following paragraphs. HGB $NO_X$ emissions are additionally subject to the MECT program. The ERG growth factors are discussed in Section 2.3.2.1.3.

Major sources of emissions in NAAs cannot grow their emissions of ozone precursors, $NO_X$ and VOC, without offsetting the emissions increases either by purchasing certified credits from the EBT Credit Registry or by making contemporaneous period reductions as needed by the Nonattainment NSR permitting process. The expected future growth for point sources in NAAs is projected with ERG growth factors, in conjunction with how the future emissions may be limited by the amount of certified credits available in the EBT Credit Registry. Historically, ERCs have been preferred for use as offsets in Nonattainment NSR permitting. Therefore, it is assumed that ERCs will be used to cover as much of projected growth as possible, with DERCs being used to cover the remaining projected growth. For the 2017 future case $NO_X$ emissions, there were sufficient credits to allow the growth predicted with ERG factors. The 2017 future case VOC growth, however, was limited to less than the ERG-predicted growth by the available credits.

The procedure for incorporating the certified credits available in the EBT Credit Registry into the future case begins with extracting the certified credits from the EBT Credit Registry, which can be found on EBT's Registry webpage at http://www2.tceq.texas.gov/airperm/index.cfm?fuseaction=ebt_dpa.reg. ERC and DERC totals for each of the NAAs were extracted on March 31, 2016. Table 2-15: *Banked Emissions as of March 31, 2016* summarizes the total tons of emissions associated with the certified ERCs, DERCs, and MDERCs available in TCEQ's EBT Credit Registry as of March 31, 2016. "Modelable Banked" emissions in Table 2-15 refers to the maximum amount of emissions that could be potentially added as growth to the area from certified credits, with the exception of HGB $NO_X$ DERCs and MDERCs, whichcould be used for MECT compliance as noted below.

**Table 2-15: Banked Emissions as of March 31, 2016**

| NAA | $NO_X$ ERCs (tpy) | VOC ERCs (tpy) | $NO_X$ DERCs (tons) | VOC DERCs (tons) | Modelable Banked $NO_X$ (tpd) | Modelable Banked VOC (tpd) |
|---|---|---|---|---|---|---|
| **HGB Registry** | 274.4 | 867.8 | 34380.3 | 1847.7 | | |
| **HGB Discounted Registry** | 211.1 | 667.5 | 25492.0 | 1421.3 | 0.6 ERCs, 69.8 DERCs | 5.7 |
| **HGB DERCs/MDERCs used for MECT Compliance** | | | 1240.7 | | 3.4 | |
| **DFW Registry** | 66.3 | 96.9 | 4124.7 | 8.5 | | |
| **DFW Discounted Registry** | 57.7 | 84.3 | 3586.7 | 7.4 | 0.2 ERCs, 14.6 DERCs | 0.3 |

The available ERC and DERC credits could vary significantly over time. However, given the method by which the TCEQ models growth/projections, small changes in the amount of certified credits available do not affect future case emission projections.

In the HGB NAA, $NO_X$ DERCs/MDERCs can, with certain restrictions, be used for MECT program compliance. 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 amount deducted took into consideration the 10,000 ton annual limit on the use of DERCs for MECT compliance in 30 TAC §101.356, and all the MDERCs in the registry. The resulting HGB $NO_X$ DERCs/MDERCs that could be used for MECT compliance (3.4 tpd) were added to the MECT cap.

The Discounted Registry totals in Table 2-15 incorporate the offset ratios used for the Nonattainment NSR permitting program for each of the NAAs as of March 31, 2016. The HGB area has an offset ratio of 1.3:1. For relevant sources, 13.0 tpy of ERCs would need to be purchased for a 10 tpy proposed increase. Only 10 tons of emissions will be potentially returned to the modeled airshed in the future.

The resulting modelable banked emissions for 2017 and the predicted growth values for 2017 are depicted in Table 2-16: *Comparison of the 2017 Modelable Bank and Predicted Growth*. For the 2017 future case $NO_X$ emissions, there were certified credits to allow the predicted growth. The 2017 future case VOC emissions were limited by the modelable bank.

**Table 2-16: Comparison of the 2017 Modelable Bank and Predicted Growth**

| Area | Pollutant | 2017 Modelable Bank (tpd) | 2017 Predicted Growth (tpd) | 2017 Limiting Attribute |
|---|---|---|---|---|
| HGB | $NO_X$ | 0.6 ERCs 69.8 DERCs | 1.51 | Growth |
| HGB | VOC | 1.8 ERCs 3.9 DERCs | 11.12 | Bank |
| DFW | $NO_X$ | 0.2 ERCs 14.6 DERCs | -0.26 | Growth |

| Area | Pollutant | 2017 Modelable Bank (tpd) | 2017 Predicted Growth (tpd) | 2017 Limiting Attribute |
|---|---|---|---|---|
| DFW | VOC | 0.2 ERCs<br>0.03 DERCs | 0.60 | Bank |

Table 2-17: *Texas Non-EGU "No-Rules" Growth Summary* shows the growth projected by ERG factors in each of the NAAs. The growth was only applied to the sources that were not already limited by recent existing TCEQ rules or constrained by emissions caps. The HGB and DFW modelable banked emissions and growth from the ERG factors were compared on a path-by-path basis, automated with SAS programming. Future case 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. The sum of these for each area is tabulated in Table 2-17. Note that the potential projected DFW $NO_X$ growth was negative.

**Table 2-17: Texas Non-EGU "No-Rules" Growth Summary**

| Area | Projection Index | 2014 STARS $NO_X$ (tpd) | 2017 Projected $NO_X$ (tpd) | Potential $NO_X$ Growth (tpd) | 2014 STARS VOC (tpd) | 2017 Projected VOC (tpd) | Potential VOC Growth (tpd) |
|---|---|---|---|---|---|---|---|
| HGB | ERG factors | 18.99 | 20.50 | 1.51 | 111.97 | 123.09 | 11.11 |
| DFW | ERG factors | 20.45 | 20.19 | -0.26 | 45.25 | 45.85 | 0.60 |
| Attainment | ERG factors | 398.78 | 415.43 | 16.43 | 298.49 | 314.39 | 15.90 |

2.3.3.1.2.1. HGB MECT Non-EGU $NO_X$ Control Implementation

The HGB MECT program also limits the amount of $NO_X$ from all applicable non-EGU sources with a cap. The application of this program and its limits are discussed in Sections 2.3.1.2 and 2.3.1.4 above.

2.3.3.1.2.2. HGB HECT Non-EGU HRVOC Control Implementation

The other cap-and-trade program within HGB that applies to non-EGUs is the HECT program, which only applies in Harris County. The application of this program and its limits are discussed in Sections 2.3.1.3 and 2.3.1.4 above. The HRVOC modeling procedure adopted by the TCEQ does not affect the mass flow rates of non-HRVOC compounds in HECT-qualifying point sources.

2.3.3.1.2.3. 2017 Texas EI Summary

The future case point source EI is composed of three datasets: (1) hourly EGUs averaged for each month based on 2015, projected to the CSAPR or MECT caps, (2) the addition of newly-permitted EGUs, and (3) 2014 non-EGUs projected to MECT caps where applicable. Table 2-18: *Detailed August Average 2017* $NO_X$ *Emissions Summary for Texas* for Texas provides a 2017 modeled $NO_X$ emissions summary.

**Table 2-18: Detailed August Average 2017 $NO_X$ Emissions Summary for Texas**

| Region | Projection | Affected Sources | 2014 STARS $NO_X$ (tpd) | 2015 AMPD $NO_X$ (tpd) | 2017 Modeled $NO_X$ (tpd) |
|---|---|---|---|---|---|
| HGB | MECT cap | Non-EGUs | 50.22 | | 71.89 |
| HGB | MECT cap | Growth under the cap[10] | | | 1.28 |
| HGB | MECT cap | EGUs | | 37.03 | 46.5 |
| HGB | MECT cap | New EGU Growth | | | 4.47 |
| HGB | Growth/bank | non-EGUs | 18.57 | | 20.09 |
| DFW | CSAPR cap | EGUs | | 11.03 | 22.61 |
| DFW | Cap | DFW Cement Kilns[11] | 8.14 | | 14.2 |
| DFW | Growth | non-EGUs | 20.45 | | 20.19 |
| Rest of TX | CSAPR cap | EGUs | | 369.2 | 445.8 |
| Rest of TX | CSAPR cap | New EGU Growth | | | 12.59 |
| Rest of TX | Growth | Non-EGUs | 376.16 | | 388.00 |

### 2.3.4. 2017 Regional (Outside of Texas) Point Sources

Regional emissions include states outside of Texas within the modeling domain, offshore Gulf of Mexico, and the parts of Mexico and Canada within the modeling domain.

2.3.4.1. EGUs

To develop the 2017 future case EGUs for states outside of Texas, the TCEQ used CSAPR for states subject to the CSAPR program and 2015 AMPD data for the rest. The TCEQ used the CSAPR state budgets specified by the EPA's allocations for each state to derive an average ozone season day.

The TCEQ did not estimate EGU growth outside of Texas. Alternatives to the TCEQ's approach that include growth and controls are EGU emission projection tools such as the EPA's IPM or the ERTAC EGU projection tool, as introduced in Section 2.3.3.1.1 above. A comparison was made of the total state emissions predicted by IPM and ERTAC for 2017 to the TCEQ's method, which uses CSAPR caps. Table 2-19: *Comparison of Regional (non-Texas) EGU Projections* shows that using CSAPR caps alone yields higher emissions than the IPM or the ERTAC projection tool.

[10] These are MECT allowances that were assigned to accounts that could not be matched in the 2014 STARS EI which were distributed as growth to existing MECT accounts.

[11] The Midlothian Kiln cap is actually 17.6 tpd NOx; 14.2 tpd was incorrectly modeled because the reconstructed (new) Ash Grove kiln was not identified as new for our processing system. This will be corrected in the adopted SIP version.

**Table 2-19: Comparison of Regional (non-Texas) EGU Projections**

| Source | Ozone Season Average $NO_X$ (tpd) |
|---|---|
| TCEQ-applied CSAPR | 4365 |
| EPA Platform v6.2 (IPM) | 4067 |
| ERTAC v2.5 | 3773 |

Table 2-20: *2017 CSAPR Modeled* $NO_X$ *Emissions for Other States* provides the 2017 modeled $NO_X$ emissions (in ozone season average day) along with CSAPR cap (ozone or annual) emissions for each state outside Texas in the modeling domain. An empty cell indicates CSAPR is not applicable for that state.

**Table 2-20: 2017 CSAPR Modeled NOX Emissions for Other States**

| State | Ozone Season CSAPR $NO_X$ Cap (tons per ozone season) | Annual CSAPR $NO_X$ Cap (tpy) | 2017 May-Sep Average Day Modeled $NO_X$ (tpd) |
|---|---|---|---|
| AL | 30992 | | 202.56 |
| AR | 13959 | | 91.23 |
| AZ | | | 128.18 |
| CA | | | 12.49 |
| CO | | | 104.43 |
| CT | | | 4.18 |
| DC | | | 0.13 |
| DE | | | 4.50 |
| FL | 27371 | | 178.90 |
| GA | 23654 | | 154.60 |
| IA | 15952 | | 104.26 |
| ID | | | 0.99 |
| IL | 19590 | | 128.04 |
| IN | 44951 | | 293.80 |
| KS | | 30729 | 78.33 |
| KY | 31495 | | 205.85 |
| LA | 17825 | | 116.50 |
| MA | | | 8.74 |
| MD | 7064 | | 46.17 |
| ME | | | 0.72 |
| MI | 26507 | | 173.25 |
| MN | | 28977 | 63.07 |
| MO | 19911 | | 130.14 |
| MS | 12231 | | 79.94 |
| MT | | | 46.84 |

| State | Ozone Season CSAPR $NO_X$ Cap (tons per ozone season) | Annual CSAPR $NO_X$ Cap (tpy) | 2017 May-Sep Average Day Modeled $NO_X$ (tpd) |
|---|---|---|---|
| NC | 17414 | | 113.82 |
| ND | | | 122.81 |
| NE | | 28238 | 62.01 |
| NH | | | 2.73 |
| NJ | 3658 | | 23.91 |
| NM | | | 130.31 |
| NV | | | 15.69 |
| NY | 10148 | | 66.33 |
| OH | 38391 | | 250.92 |
| OK | 20869 | | 136.40 |
| OR | | | 11.47 |
| PA | 50647 | | 331.02 |
| RI | | | 1.85 |
| SC | 13687 | | 89.46 |
| SD | | | 5.58 |
| TN | 7887 | | 51.55 |
| UT | | | 129.41 |
| VA | 13776 | | 90.04 |
| VT | | | 0.34 |
| WA | | | 20.17 |
| WI | 13493 | | 88.19 |
| WV | 22217 | | 145.21 |
| WY | | | 118.28 |

#### 2.3.4.2. Non-EGUs

For 2017 non-EGUs for other states, the TCEQ used the EPA's 2018 non-IPM (non-EGU) files from its 2011 Modeling Platform. EPA had not released a 2017 inventory at the time the TCEQ performed this future case modeling. The TCEQ did not backcast the 2018 emissions to 2017. The non-IPM portion of the platform consists of several emissions files including the primary point sources file containing emissions for all states, plus additional files for ethanol and biodiesel plants and cement kilns. After extracting Texas from the list, the TCEQ generated an AFS-formatted file, including all necessary and relevant modeling parameters for EPS3 processing. The associated temporal allocation file was used to create the daily temporal distribution. A June day was selected to represent a typical ozone season day. Summary files provided by the EPA contain individual state totals for non-EGU (non-IPM) emissions. These summaries can be found at the EPA Emissions Inventory website at ftp://ftp.epa.gov/EmisInventory/2011v6/v1platform/reports/2018_emissions/.

Table 2-21: *2017 Regional States Emissions Summary* provides an overall summary of the 2017 emissions for the non-Texas states within the modeling.

**Table 2-21: 2017 Regional States Emissions Summary**

| Model Year | Source Category | $NO_X$ Emissions (tpd) | VOC Emissions (tpd) | CO Emissions (tpd) |
|---|---|---|---|---|
| 2017 CSAPR Future Case | EGU | 4365 | 83 | 1476 |
| 2018 EPA Future Case | non-EGU | 3820 | 2248 | 4883 |

### 2.3.5. Offshore, Mexico, and Canada

The 2017 EI for the Gulf of Mexico offshore is the same as was used in the baseline and base case using the 2011 GWEI. An average day, for each of the months modeled was used. For lack of projection data for this sector of the future case EI, the 2011 GWEI was assumed to represent 2017. The TCEQ used the EPA's 2011 modeling platform for Mexico, based on the 2008 Mexican NEI. The platform provided emissions grown to 2018, which the TCEQ used without backcasting to 2017. The Canadian EI was not updated from the 2006 EI used in the baseline and base case.

### 2.3.6. Summary of Future Case Point Source Data Files

The point source emission files that were processed with EPS3 for CAMx are presented in Table 2-22: *AFS Files for the 2017 Future Case.* The regional AFS file for the GWEI contains monthly emissions for the year, the regional AFS file for Canada contains daily emissions that are representative for the entire year, and the regional non-EGU NEI AFS file contains annual emissions. The 2017 future case point source files are available files is ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/point/ .

**Table 2-22: AFS Files for the 2017 Future Case**

| Area | AFS Point Source Emissions Dataset | Record Type |
|---|---|---|
| Texas | afs.amp_MAY_2017_average_CSAP_RPOlcp | Hourly |
| Texas | afs.amp_JUN_2017_average_CSAP_RPOlcp | Hourly |
| Texas | afs.amp_JUL_2017_average_CSAP_RPOlcp | Hourly |
| Texas | afs.amp_AUG_2017_average_CSAP_RPOlcp | Hourly |
| Texas | afs.amp_SEP_2017_average_CSAP_RPOlcp | Hourly |
| Texas | afs.amp_MAY_2017_average_MECT_RPOlcp | Hourly |
| Texas | afs.amp_JUN_2017_average_MECT_RPOlcp | Hourly |
| Texas | afs.amp_JUL_2017_average_MECT_RPOlcp | Hourly |
| Texas | afs.amp_AUG_2017_average_MECT_RPOlcp | Hourly |
| Texas | afs.amp_SEP_2017_average_MECT_RPOlcp | Hourly |
| Texas | afs.osd_no_controls_grown_to_2017.RPOlcp_v11 | Daily |
| Texas | afs.2017_HECT_cap_n_trade_HarrisCo_2014_basis_all_pts | Daily |
| Texas | afs.osd_hgb_dfw_growth_with_bank_v16 | Daily |
| Texas | afs.osd_CSAP_new_egus_2013_to_2017_all_pols_v2 | Daily |
| Texas | afs.osd_mect_2017_based_on_2014_RPOlcp | Daily |
| Texas | afs.midlokilns_2017_$NO_X$_emissions.RPOlcp | Daily |

| Area | AFS Point Source Emissions Dataset | Record Type |
|---|---|---|
| Regional | afs.amp_USA_MAY_2017_average_all_pols_RPOlcp | Hourly |
| Regional | afs.amp_USA_JUN_2017_average_all_pols_RPOlcp | Hourly |
| Regional | afs.amp_USA_JUL_2017_average_all_pols_RPOlcp | Hourly |
| Regional | afs.amp_USA_AUG_2017_average_all_pols_RPOlcp | Hourly |
| Regional | afs.amp_USA_SEP_2017_average_all_pols_RPOlcp | Hourly |
| Regional | afs.2018_USA_noTX_noEGU.RPOlcp | Annual |
| Regional | afs.gwei.2011.lcpRPO | Monthly |
| Regional | afs.Mexico_2018_from_EPA2011Platform_1999NEI.RPOlcp | Daily |
| Regional | afs.canada_2006_all_pols.RPOlcp | Daily |

Table 2-23: *2017 Future Case Point Source Emissions Summary – August Average* summarizes the future case emissions. The tabulated emissions are AFS totals input to EPS3. CAMx input VOC values may differ slightly due to chemical mechanism conversions. The “Rest of Texas” column includes some points in Texas outside the modeling domain. The “Regional” column includes some points outside the modeling domain. As noted in Section 2.1.1.4.1, VOC emission totals include acetone and ethane.

**Table 2-23: 2017 Future Case Point Source Emissions Summary – August Average**

| Emission Source | HGB $NO_X$ (tpd) | HGB VOC (tpd) | Rest of Texas $NO_X$ (tpd) | Rest of Texas VOC (tpd) | Regional $NO_X$ (tpd) | Regional VOC (tpd) |
|---|---|---|---|---|---|---|
| non-EGUs (OSD) | 97.8 | 135.2 | 408.2 | 354.0 | 3820.4 | 2248.1 |
| EGUs (AMPD) | 46.5 | 2.2 | 480.6 | 8.1 | 4365.3 | 82.5 |

### 2.4 2017 Point Source Control Strategy and/or Sensitivity Analyses

For this AD SIP revision, due to time constraints no sensitivities were performed. Emissions reductions due to the RACT update rule are not included due to the compliance deadline associated with the rule.

## 3. ON-ROAD MOBILE SOURCE MODELING EMISSIONS DEVELOPMENT

### 3.1 On-Road Mobile Source Emissions Inventories for Eight-County HGB

This section provides a brief overview of the development of the eight-county HGB area on-road mobile source emissions inventory files that were input into the photochemical model for the 2012 base case, the 2012 baseline case, and the 2017 future case. The on-road emission inventories were developed with the 2014 version of the Motor Vehicle Emission Simulator (MOVES2014) model.

The on-road emissions inventory datasets were developed under contract by the Texas Transportation Institute (TTI). TTI developed 2012 and 2017 on-road emission estimates using MOVES2014 and vehicle miles traveled (VMT) estimates from the Highway Performance Monitoring System (HPMS) managed by the Texas Department of Transportation (TxDOT). For the eight-county HGB area, link-based on-road emission inventories are under development by

TTI using MOVES2014a emission rates and VMT estimates from the travel demand model (TDM) managed by the Houston-Galveston Area Council (H-GAC). These TDM-based inventories were not available for inclusion with this SIP revision proposal, but are expected to be available for the SIP revision adoption.

MOVES2014 outputs nitrogen oxide (NO), nitrogen dioxide ($NO_2$), and nitrous acid (HONO), which are components of oxides of nitrogen ($NO_X$). The tables in this section report NO, $NO_2$, and $NO_X$ separately. Due to space limitations, HONO is not reported separately, but MOVES2014 calculates it as 0.8% of total $NO_X$ emissions. For both the 2012 base case and the 2017 future case, school and summer season on-road emission inventories were developed for the four day types of weekday (i.e., Monday through Thursday average, Friday, Saturday, and Sunday). For the on-road category, base case and baseline emissions are the same.

Table 3-1: *VMT and Emissions by Day Type for 2012 HGB On-Road Inventory* and Table 3-2: *VMT and Emissions by Day Type for 2017 HGB On-Road Inventory* provide summaries of the total VMT, NO, $NO_2$, $NO_X$, volatile organic compound (VOC), and carbon monoxide (CO) emissions for the eight-county HGB area for each day type for the 2012 base case and 2017 future case, respectively. As shown, Fridays have the highest total VMT of the week, while Saturdays and Sundays have the lowest total daily VMT. While overall VMT increases with future growth, total emissions decrease from 2012 to 2017 because of more stringent emissions standards for newer vehicles entering the fleet, combined with the simultaneous attrition of older, higher-emitting vehicles. Consistent with current federal and state rules, the on-road inventories from TTI include the benefits of:

- reformulated gasoline (RFG) in all eight HGB area counties;
- the inspection and maintenance (I/M) Program in Brazoria, Fort Bend, Galveston, Harris, and Montgomery counties; and
- Texas low emission diesel (TxLED) fuel for all eight HGB area counties.

**Table 3-1: VMT and Emissions by Day Type for 2012 HGB On-Road Inventory**

| Season and Day Type | Vehicle Miles Traveled | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Summer Weekday | 153,416,617 | 145.17 | 15.67 | 162.14 | 73.38 | 836.60 |
| Summer Friday | 165,894,264 | 152.67 | 16.64 | 170.68 | 75.23 | 886.07 |
| Summer Saturday | 134,006,490 | 114.53 | 12.41 | 127.96 | 64.27 | 719.52 |
| Summer Sunday | 111,385,179 | 95.22 | 10.08 | 106.15 | 60.49 | 632.71 |
| School Weekday | 157,780,611 | 148.03 | 16.04 | 165.39 | 74.09 | 853.87 |
| School Friday | 171,998,396 | 156.63 | 17.14 | 175.18 | 76.20 | 909.90 |
| School Saturday | 135,928,033 | 115.48 | 12.54 | 129.05 | 64.54 | 727.18 |
| School Sunday | 113,467,262 | 96.28 | 10.22 | 107.36 | 60.77 | 641.13 |

**Table 3-2: VMT and Emissions by Day Type for 2017 HGB On-Road Inventory**

| Season and Day Type | Vehicle Miles Traveled | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Summer Weekday | 163,443,282 | 74.31 | 10.87 | 85.87 | 49.08 | 653.16 |
| Summer Friday | 176,727,139 | 77.72 | 11.45 | 89.89 | 49.98 | 692.04 |

| Season and Day Type | Vehicle Miles Traveled | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Summer Saturday | 142,757,155 | 58.19 | 8.16 | 66.89 | 43.72 | 563.43 |
| Summer Sunday | 118,654,015 | 48.84 | 6.50 | 55.79 | 41.81 | 496.88 |
| School Weekday | 168,097,071 | 75.68 | 11.11 | 87.50 | 49.44 | 666.70 |
| School Friday | 183,239,215 | 79.62 | 11.79 | 92.15 | 50.47 | 710.82 |
| School Saturday | 144,810,131 | 58.63 | 8.24 | 67.40 | 43.85 | 569.41 |
| School Sunday | 120,877,381 | 49.33 | 6.59 | 56.36 | 41.95 | 503.47 |

Even though all of the day type on-road inventory datasets were used for photochemical model input, only the summer weekday emissions are detailed here. For the 2012 base case and 2017 future case, the summaries of the VMT, NO, $NO_2$, $NO_X$, VOC, and CO emissions for each of the eight counties in the HGB area are shown in Table 3-3: *VMT and Emissions by County for 2012 HGB On-Road Inventory* and Table 3-4: *VMT and Emissions by County for 2017 HGB On-Road Inventory*, respectively.

**Table 3-3: VMT and Emissions by County for 2012 HGB On-Road Inventory**

| HGB Area County | Vehicle Miles Traveled | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 6,112,664 | 6.16 | 0.63 | 6.84 | 3.85 | 39.01 |
| Chambers | 2,808,106 | 6.00 | 0.63 | 6.68 | 1.21 | 15.88 |
| Fort Bend | 10,205,437 | 10.36 | 1.08 | 11.53 | 6.58 | 63.24 |
| Galveston | 5,783,815 | 5.46 | 0.56 | 6.06 | 3.49 | 35.40 |
| Harris | 111,777,645 | 97.84 | 10.67 | 109.39 | 49.64 | 585.94 |
| Liberty | 2,332,648 | 3.51 | 0.37 | 3.91 | 1.42 | 15.45 |
| Montgomery | 12,309,084 | 12.95 | 1.40 | 14.46 | 6.26 | 69.61 |
| Waller | 2,087,218 | 2.90 | 0.33 | 3.26 | 0.94 | 12.07 |
| Total | 153,416,617 | 145.17 | 15.67 | 162.14 | 73.38 | 836.60 |

**Table 3-4: VMT and Emissions by County for 2017 HGB On-Road Inventory**

| HGB Area County | Vehicle Miles Traveled | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 6,667,844 | 3.21 | 0.42 | 3.66 | 2.61 | 30.59 |
| Chambers | 2,932,782 | 3.12 | 0.51 | 3.66 | 0.76 | 11.86 |
| Fort Bend | 10,957,269 | 5.54 | 0.79 | 6.38 | 4.66 | 50.43 |
| Galveston | 6,101,686 | 2.76 | 0.36 | 3.15 | 2.31 | 27.04 |
| Harris | 118,416,697 | 49.30 | 7.19 | 56.94 | 32.79 | 455.76 |
| Liberty | 2,453,850 | 1.83 | 0.27 | 2.12 | 0.96 | 11.72 |
| Montgomery | 13,622,271 | 6.97 | 1.05 | 8.08 | 4.37 | 56.09 |
| Waller | 2,290,883 | 1.57 | 0.28 | 1.87 | 0.63 | 9.67 |
| Total | 163,443,282 | 74.31 | 10.87 | 85.87 | 49.08 | 653.16 |

Summaries for 2012 and 2017 of the VMT, NO, $NO_2$, $NO_X$, VOC, and CO emissions for the gasoline and diesel fuel source use type (SUT) combinations from the MOVES2014 model are presented in Table 3-5: *VMT and Emissions by Vehicle Type for 2012 HGB On-Road Inventory* and Table 3-6: *VMT and Emissions by Vehicle Type for 2017 HGB On-Road Inventory*.

**Table 3-5: VMT and Emissions by Vehicle Type for 2012 HGB On-Road Inventory**

| Fuel and Source Use Type Combination | VMT | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Gasoline - Motorcycle | 111,262 | 0.07 | 0.00 | 0.07 | 0.82 | 1.72 |
| Gasoline - Passenger Car | 110,667,026 | 41.12 | 4.76 | 46.25 | 36.39 | 439.77 |
| Gasoline - Passenger Truck | 22,577,370 | 23.38 | 2.43 | 26.02 | 19.59 | 225.50 |
| Gasoline - Light Commercial Truck | 6,737,918 | 7.73 | 0.81 | 8.61 | 6.35 | 75.59 |
| Gasoline - School Bus | 2,246 | 0.01 | 0.00 | 0.01 | 0.01 | 0.12 |
| Gasoline - Refuse Truck | 29,766 | 0.15 | 0.01 | 0.16 | 0.07 | 1.87 |
| Gasoline - Single Unit Short-Haul Truck | 1,499,049 | 2.87 | 0.21 | 3.10 | 1.26 | 30.80 |
| Gasoline - Single Unit Long-Haul Truck | 257,949 | 0.45 | 0.03 | 0.48 | 0.18 | 4.44 |
| Gasoline - Motor Home | 88,155 | 0.29 | 0.02 | 0.31 | 0.12 | 2.77 |
| Gasoline - Combination Short-Haul Truck | 238,416 | 0.92 | 0.06 | 0.99 | 0.34 | 11.01 |
| Diesel - Passenger Car | 333,119 | 0.14 | 0.01 | 0.15 | 0.16 | 2.89 |
| Diesel - Passenger Truck | 390,553 | 0.85 | 0.09 | 0.95 | 0.30 | 3.47 |
| Diesel - Light Commercial Truck | 917,800 | 2.23 | 0.21 | 2.46 | 0.76 | 7.46 |
| Diesel - Intercity Bus | 204,496 | 2.42 | 0.18 | 2.62 | 0.18 | 0.88 |
| Diesel - Transit Bus | 63,787 | 0.54 | 0.04 | 0.58 | 0.05 | 0.30 |
| Diesel - School Bus | 227,858 | 1.21 | 0.09 | 1.31 | 0.22 | 0.73 |
| Diesel - Refuse Truck | 59,653 | 0.51 | 0.05 | 0.57 | 0.04 | 0.21 |
| Diesel - Single Unit Short-Haul Truck | 2,989,287 | 7.81 | 1.15 | 9.03 | 1.37 | 5.68 |
| Diesel - Single Unit Long-Haul Truck | 501,643 | 1.21 | 0.18 | 1.40 | 0.22 | 0.91 |
| Diesel - Motor Home | 175,074 | 0.84 | 0.07 | 0.92 | 0.17 | 0.48 |
| Diesel - Combination Short-Haul Truck | 2,548,044 | 18.70 | 1.99 | 20.86 | 1.37 | 7.36 |
| Diesel - Combination Long-Haul Truck | 2,796,148 | 31.72 | 3.27 | 35.28 | 3.42 | 12.65 |
| Total | 153,416,617 | 145.17 | 15.67 | 162.14 | 73.38 | 836.60 |

**Table 3-6: VMT and Emissions by Vehicle Type for 2017 HGB On-Road Inventory**

| Fuel and Source Use Type Combination | VMT | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Gasoline - Motorcycle | 118,512 | 0.07 | 0.00 | 0.07 | 0.84 | 1.56 |
| Gasoline - Passenger Car | 117,404,756 | 18.96 | 2.06 | 21.19 | 25.21 | 363.22 |
| Gasoline - Passenger Truck | 25,574,411 | 13.19 | 1.28 | 14.58 | 13.94 | 178.41 |
| Gasoline - Light Commercial Truck | 6,281,766 | 3.61 | 0.35 | 3.99 | 3.70 | 49.79 |
| Gasoline - Transit Bus | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gasoline - School Bus | 3,713 | 0.01 | 0.00 | 0.01 | 0.01 | 0.19 |
| Gasoline - Refuse Truck | 91,572 | 0.40 | 0.03 | 0.43 | 0.19 | 5.08 |
| Gasoline - Single Unit Short-Haul Truck | 1,702,152 | 0.88 | 0.10 | 0.99 | 0.61 | 20.75 |
| Gasoline - Single Unit Long-Haul Truck | 320,829 | 0.15 | 0.02 | 0.17 | 0.10 | 3.33 |
| Gasoline - Motor Home | 72,303 | 0.13 | 0.01 | 0.14 | 0.07 | 1.58 |

| Fuel and Source Use Type Combination | VMT | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|---|
| Gasoline - Combination Short-Haul Truck | 235,678 | 0.28 | 0.03 | 0.30 | 0.14 | 4.61 |
| Diesel - Passenger Car | 827,716 | 0.10 | 0.03 | 0.12 | 0.07 | 2.66 |
| Diesel - Passenger Truck | 442,130 | 0.64 | 0.12 | 0.76 | 0.18 | 2.01 |
| Diesel - Light Commercial Truck | 345,019 | 0.52 | 0.08 | 0.61 | 0.16 | 1.83 |
| Diesel - Intercity Bus | 62,272 | 0.48 | 0.05 | 0.54 | 0.04 | 0.19 |
| Diesel - Transit Bus | 124,068 | 0.63 | 0.07 | 0.70 | 0.06 | 0.40 |
| Diesel - School Bus | 340,732 | 1.23 | 0.12 | 1.37 | 0.22 | 0.85 |
| Diesel - Refuse Truck | 158,784 | 0.71 | 0.11 | 0.83 | 0.05 | 0.34 |
| Diesel - Single Unit Short-Haul Truck | 2,956,135 | 3.46 | 1.00 | 4.50 | 0.49 | 3.05 |
| Diesel - Single Unit Long-Haul Truck | 542,660 | 0.57 | 0.17 | 0.75 | 0.08 | 0.53 |
| Diesel - Motor Home | 124,924 | 0.38 | 0.05 | 0.43 | 0.07 | 0.23 |
| Diesel - Combination Short-Haul Truck | 2,858,024 | 9.98 | 1.88 | 11.96 | 0.66 | 4.16 |
| Diesel - Combination Long-Haul Truck | 2,855,126 | 17.92 | 3.34 | 21.43 | 2.18 | 8.42 |
| Total | 163,443,282 | 74.31 | 10.87 | 85.87 | 49.08 | 653.16 |

The MOVES2014 run specification files used to develop the 2012 inventories, along with detailed reports and summary output data, can be found on the 2012 Texas on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/onroad/tex/mvs14/. The MOVES2014 run specification files used to develop the 2017 inventories, along with detailed reports and summary output data, can be found on the 2017 Texas on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/onroad/tex/mvs14/.

## 3.2 On-Road Mobile Source Emissions Processing

The on-road emissions inventory data provided by TTI were prepared for input into the photochemical model using version 3 of the Emissions Processor System (EPS3). When input into EPS3, the inventory data are in a readable text-based format. However, the emissions data are maintained in a binary format within EPS3. Table 3-7: *EPS3 Modules for Processing On-Road Emissions* summarizes the EPS3 modules that were used to process the eight-county HGB on-road inventories.

**Table 3-7: EPS3 Modules for Processing On-Road Emissions**

| EPS3 Module | Description |
|---|---|
| LBASE | Spatially allocate link-based emissions among grid cells. |
| PREAM | Prepare non-link “roadway type” emissions for further processing. |
| PREPNT | Prepare stationary extended idling emissions for further processing. |
| 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. |
| GRDEM | Sum emissions by grid cell for photochemical model input. |
| MRGUAM | Merge and adjust multiple gridded files for photochemical model input. |

The MOVES2014 model only estimates extended idling emissions for the diesel fuel combination long-haul truck category. Using a combination of SAS and LINUX code, the extended idling emissions were aggregated into an eight-county total and spatially assigned to known truck stop locations. The extended idling emissions were then processed through EPS3 as if they were stationary low-level point sources. The summer weekday extended idling emissions by county are presented below in Table 3-8: *2012 and 2017 HGB Area Long-Haul Truck Extended Idling Emissions*. Greater detail on heavy-duty vehicle idling activity specific to Texas metropolitan areas can be found in a report entitled Heavy-Duty Vehicle Idle Activity and Emissions Characterization Study, which is available at http://www.tceq.texas.gov/airquality/airmod/project/pj_report_mob.html.

**Table 3-8: 2012 and 2017 HGB Area Long-Haul Truck Extended Idling Emissions**

| Calendar Year | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| 2012 | 5.22 | 0.79 | 6.06 | 1.79 | 3.16 |
| 2017 | 4.28 | 1.32 | 5.64 | 1.35 | 3.12 |

### 3.2.1. Texas Low Emission Diesel Fuel Benefits

Based on the EPA memorandum *Texas Low Emission Diesel (LED) Fuel Benefits* (September 27, 2001), a 4.8% $NO_X$ TxLED reduction should be claimed for 2002-and-newer diesel vehicles and a 6.2% $NO_X$ TxLED reduction should be claimed for 2001-and-older diesel vehicles. In order to determine the specific TxLED adjustment factors that should apply to each of the twelve diesel fuel source use types, MOVES2014 model runs were performed to determine $NO_X$ emissions rates by model year. By using these data, the 4.8% and 6.2% TxLED reduction factors were weighted according to the model year specific diesel $NO_X$ emission rates. The TxLED factors FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/txled/ contains more detail on this analysis. The resulting TxLED adjustment factors and benefits for both 2012 and 2017 are summarized in Table 3-9: *2012 HGB On-Road TxLED Benefits by Vehicle Type* and Table 3-10: *2017 HGB On-Road TxLED Benefits by Vehicle Type*, respectively. The TxLED adjustment factors were incorporated by TTI into the on-road inventories by post-processing the MOVES2014 diesel fuel source use type $NO_X$ emission rates.

**Table 3-9: 2012 HGB On-Road TxLED Benefits by Vehicle Type**

| Diesel Fuel Source Use Type | $NO_X$ Reduction | Adjustment Factor | $NO_X$ Benefit (tpd) |
|---|---|---|---|
| Passenger Car | 5.87% | 0.9413 | 0.01 |
| Passenger Truck | 5.34% | 0.9466 | 0.05 |
| Light Commercial Truck | 5.66% | 0.9434 | 0.15 |
| Intercity Bus | 5.84% | 0.9416 | 0.16 |
| Transit Bus | 5.81% | 0.9419 | 0.04 |
| School Bus | 5.80% | 0.9420 | 0.08 |
| Refuse Truck | 5.62% | 0.9438 | 0.03 |
| Single Unit Short-Haul Truck | 5.07% | 0.9493 | 0.48 |
| Single Unit Long-Haul Truck | 5.00% | 0.9500 | 0.07 |
| Motor Home | 5.57% | 0.9443 | 0.05 |
| Combination Short-Haul Truck | 5.48% | 0.9452 | 1.21 |

| Diesel Fuel Source Use Type | $NO_X$ Reduction | Adjustment Factor | $NO_X$ Benefit (tpd) |
|---|---|---|---|
| Combination Long-Haul Truck | 5.55% | 0.9445 | 2.07 |
| Total | | | 4.42 |

**Table 3-10: 2017 HGB On-Road TxLED Benefits by Vehicle Type**

| Diesel Fuel Source Use Type | $NO_X$ Reduction | Adjustment Factor | $NO_X$ Benefit (tpd) |
|---|---|---|---|
| Passenger Car | 5.17% | 0.9483 | 0.01 |
| Passenger Truck | 5.08% | 0.9492 | 0.04 |
| Light Commercial Truck | 5.35% | 0.9465 | 0.03 |
| Intercity Bus | 5.69% | 0.9431 | 0.03 |
| Transit Bus | 5.66% | 0.9434 | 0.04 |
| School Bus | 5.67% | 0.9433 | 0.08 |
| Refuse Truck | 5.38% | 0.9462 | 0.05 |
| Single Unit Short-Haul Truck | 4.89% | 0.9511 | 0.23 |
| Single Unit Long-Haul Truck | 4.90% | 0.9510 | 0.04 |
| Motor Home | 5.38% | 0.9462 | 0.02 |
| Combination Short-Haul Truck | 5.19% | 0.9481 | 0.65 |
| Combination Long-Haul Truck | 5.26% | 0.9474 | 1.19 |
| Total | | | 2.42 |

## 3.3 On-Road Mobile Eight-County HGB Photochemical Modeling Input

The summer weekday on-road emissions by county that were input into the photochemical model are summarized below in Table 3-11: *2012 HGB Area Summer Weekday On-Road Emissions by County* and Table 3-12: *2017 HGB Area Summer Weekday On-Road Emissions by County*. These on-road inventory summaries are a combination of running exhaust, evaporative, off-network, and extended idling emissions. Differences by individual counties between these figures and those referenced above in Table 3-3 and Table 3-4 are due to the spatial reallocation of extended idling emissions presented above in Table 3-8. However, the eight-county total on-road emission estimates do not differ.

**Table 3-11: 2012 HGB Area Summer Weekday On-Road Emissions by County**

| HGB Area County | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Brazoria | 6.16 | 0.63 | 6.85 | 3.85 | 39.01 |
| Chambers | 6.00 | 0.63 | 6.69 | 1.21 | 15.88 |
| Fort Bend | 10.32 | 1.08 | 11.49 | 6.56 | 63.22 |
| Galveston | 5.47 | 0.56 | 6.08 | 3.49 | 35.41 |
| Harris | 97.73 | 10.66 | 109.25 | 49.61 | 585.88 |
| Liberty | 3.52 | 0.37 | 3.92 | 1.42 | 15.46 |
| Montgomery | 13.02 | 1.41 | 14.54 | 6.28 | 69.65 |
| Waller | 2.95 | 0.34 | 3.32 | 0.96 | 12.10 |

| HGB Area County | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Total | 145.17 | 15.67 | 162.14 | 73.38 | 836.61 |

**Table 3-12: 2017 HGB Area Summer Weekday On-Road Emissions by County**

| HGB Area County | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Brazoria | 3.22 | 0.42 | 3.67 | 2.61 | 30.59 |
| Chambers | 3.12 | 0.51 | 3.65 | 0.76 | 11.86 |
| Fort Bend | 5.51 | 0.78 | 6.34 | 4.65 | 50.40 |
| Galveston | 2.77 | 0.36 | 3.16 | 2.32 | 27.05 |
| Harris | 49.23 | 7.17 | 56.85 | 32.77 | 455.71 |
| Liberty | 1.84 | 0.27 | 2.13 | 0.96 | 11.73 |
| Montgomery | 7.00 | 1.07 | 8.13 | 4.38 | 56.12 |
| Waller | 1.62 | 0.29 | 1.93 | 0.64 | 9.71 |
| Total | 74.31 | 10.87 | 85.87 | 49.08 | 653.17 |

The total eight-county HGB on-road emissions input to the photochemical model by day type are summarized in Table 3-13: *2012 HGB Area On-Road Emissions by Season and Day Type* and Table 3-14: *2017 HGB Area On-Road Emissions by Season and Day Type*. Slight differences by day type between these figures and those presented in Table 3-1 and Table 3-2 are due to the on-road emission inventories being developed in Central Daylight Time (CDT), but processed for photochemical model input in Central Standard Time (CST). For example, the 11 PM – 12 AM CST emissions on a Friday evening are based on 12-1 AM CDT emissions from a Saturday.

**Table 3-13: 2012 HGB Area On-Road Emissions by Season and Day Type**

| Season and Day Type | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Summer Weekday | 145.17 | 15.67 | 162.14 | 73.38 | 836.61 |
| Summer Friday | 153.04 | 16.67 | 171.08 | 75.46 | 890.63 |
| Summer Saturday | 114.48 | 12.40 | 127.90 | 64.27 | 720.22 |
| Summer Sunday | 94.75 | 10.04 | 105.64 | 60.22 | 626.65 |
| School Weekday | 148.03 | 16.03 | 165.39 | 74.08 | 853.87 |
| School Friday | 156.99 | 17.17 | 175.56 | 76.42 | 914.47 |
| School Saturday | 115.50 | 12.54 | 129.07 | 64.55 | 728.29 |
| School Sunday | 95.73 | 10.17 | 106.76 | 60.50 | 634.54 |

**Table 3-14: 2017 HGB Area On-Road Emissions by Season and Day Type**

| Season and Day Type | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Summer Weekday | 74.31 | 10.87 | 85.87 | 49.08 | 653.17 |
| Summer Friday | 77.81 | 11.41 | 89.94 | 50.12 | 695.69 |
| Summer Saturday | 58.13 | 8.14 | 66.80 | 43.71 | 563.99 |

| Season and Day Type | NO (tpd) | $NO_2$ (tpd) | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) |
|---|---|---|---|---|---|
| Summer Sunday | 48.75 | 6.54 | 55.74 | 41.67 | 492.02 |
| School Weekday | 75.68 | 11.11 | 87.49 | 49.44 | 666.70 |
| School Friday | 79.68 | 11.74 | 92.16 | 50.60 | 714.47 |
| School Saturday | 58.59 | 8.22 | 67.35 | 43.85 | 570.30 |
| School Sunday | 49.21 | 6.63 | 56.29 | 41.81 | 498.22 |

The EPS3 message files for 2012 HGB along with the gridded photochemical model input files are available on the HGB 2012 on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/onroad/hgb/. The EPS3 message files for 2017 HGB along with the gridded photochemical model input files are available on the HGB 2017 on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/onroad/hgb/.

### 3.4 Attainment Demonstration Motor Vehicle Emissions Budget

By definition, the future case on-road $NO_X$ and VOC emission estimates input into the final attainment demonstration photochemical modeling run should establish the motor vehicle emissions budget (MVEB). The 2017 summer weekday on-road emissions are the most representative season and day type for this purpose, and are presented below in Table 3-15: *Attainment Demonstration MVEB for the Eight-County HGB Area*. As shown, these 2017 figures match those provided by TTI as summarized above in Table 3-2, Table 3-4, and Table 3-6. No emission reduction credits were taken for local transportation control measures (TCMs) or voluntary mobile source emission reduction program (VMEP) strategies.

**Table 3-15: Attainment Demonstration MVEB for the Eight-County HGB Area**

| Eight-County HGB Area On-Road Emissions | $NO_X$ (tpd) | VOC (tpd) |
|---|---|---|
| **2017 On-Road Inventory From TTI (Table 3-2)**<br>Includes RFG, Low RVP, I/M, and TxLED | 85.87 | 45.08 |

As stated in Section 3.1, the 2017 emission estimates were developed by TTI using MOVES2014 and the TxDOT HPMS data sets as the basis for VMT estimates. For the adopted version of this SIP revision, it is likely that the 2017 emission estimates will be replaced with an on-road inventory based on MOVES2014a emission rates and VMT estimates from the local TDM managed by H-GAC.

The following pages contain graphical plots of the spatial and temporal distribution of 2012 and 2017 on-road summer weekday $NO_X$ and VOC emissions for the HGB area. The plots show that the morning rush hour peak is appropriately allocated to 6-7 AM CST, which is 7-8 AM CDT. These plots are respectively entitled Figure 3-1: *2012 Summer Weekday HGB On-Road NOX Emissions Distribution*, Figure 3-2: *2012 Summer Weekday HGB On-Road VOC Emissions Distribution*, Figure 3-3: *2017 Summer Weekday HGB On-Road NOX Emissions Distribution*, and Figure 3-4: *2017 Summer Weekday HGB On-Road VOC Emissions Distribution*.

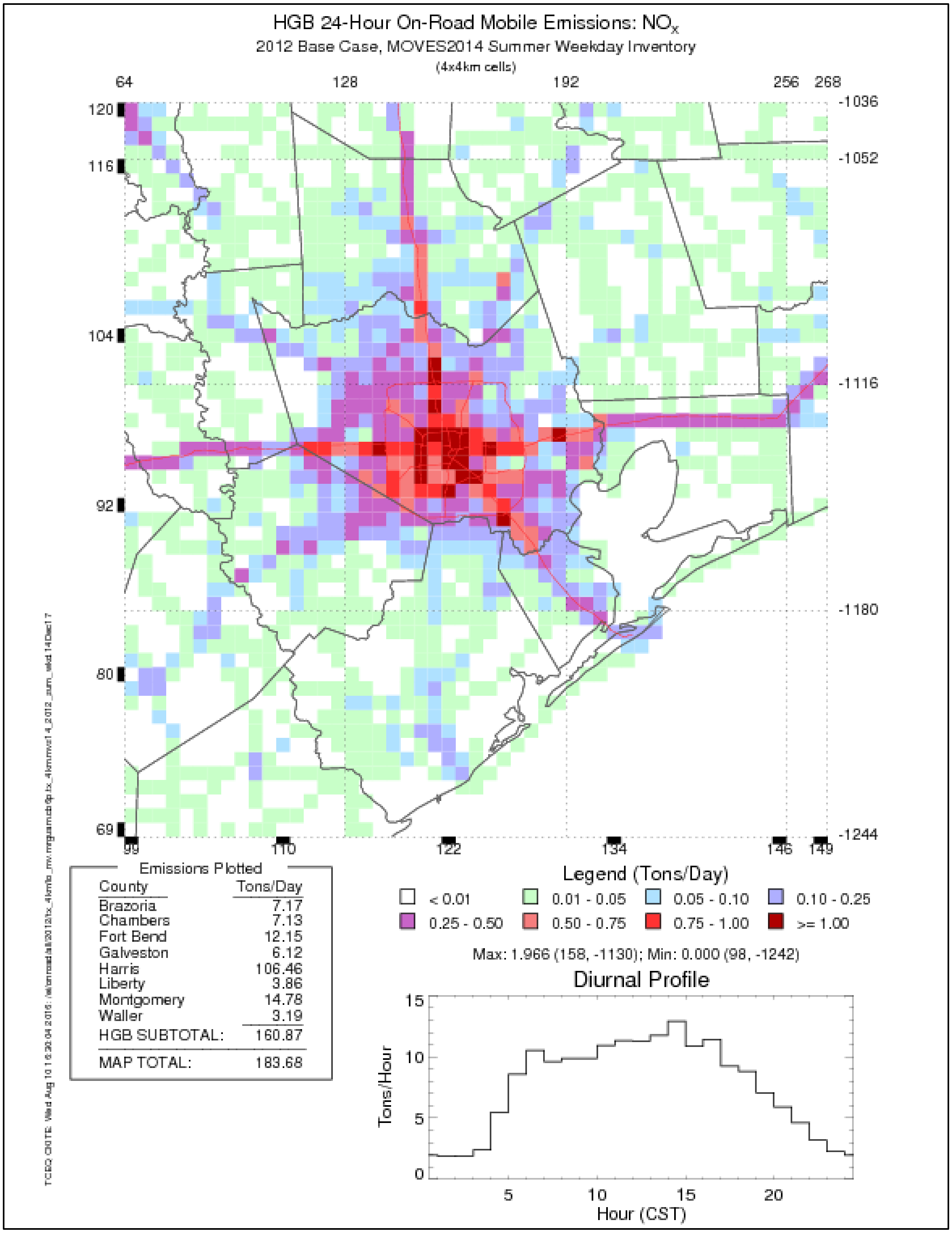


**Figure 3-1: 2012 Summer Weekday HGB On-Road $NO_X$ Emissions Distribution**

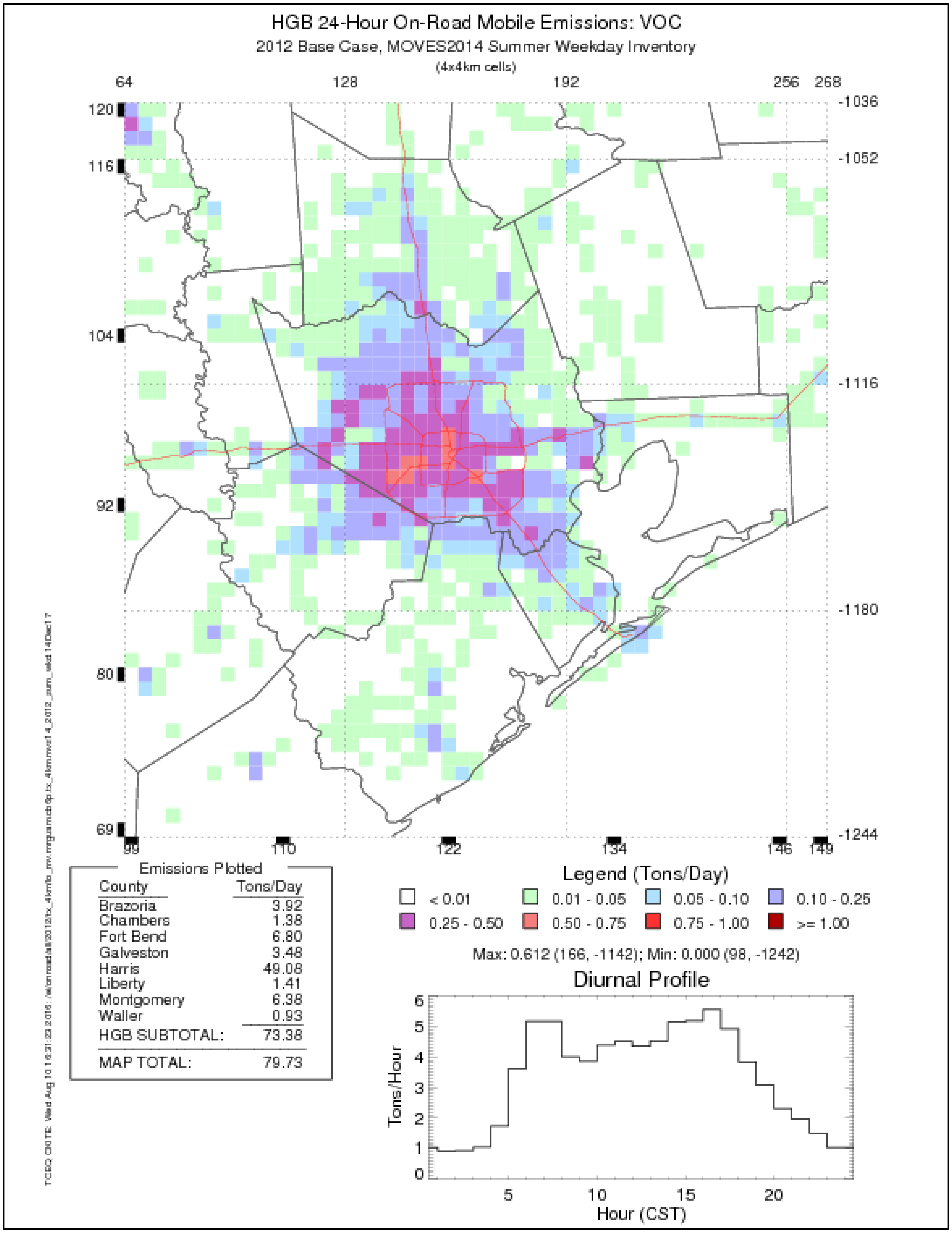


**Figure 3-2: 2012 Summer Weekday HGB On-Road VOC Emissions Distribution**

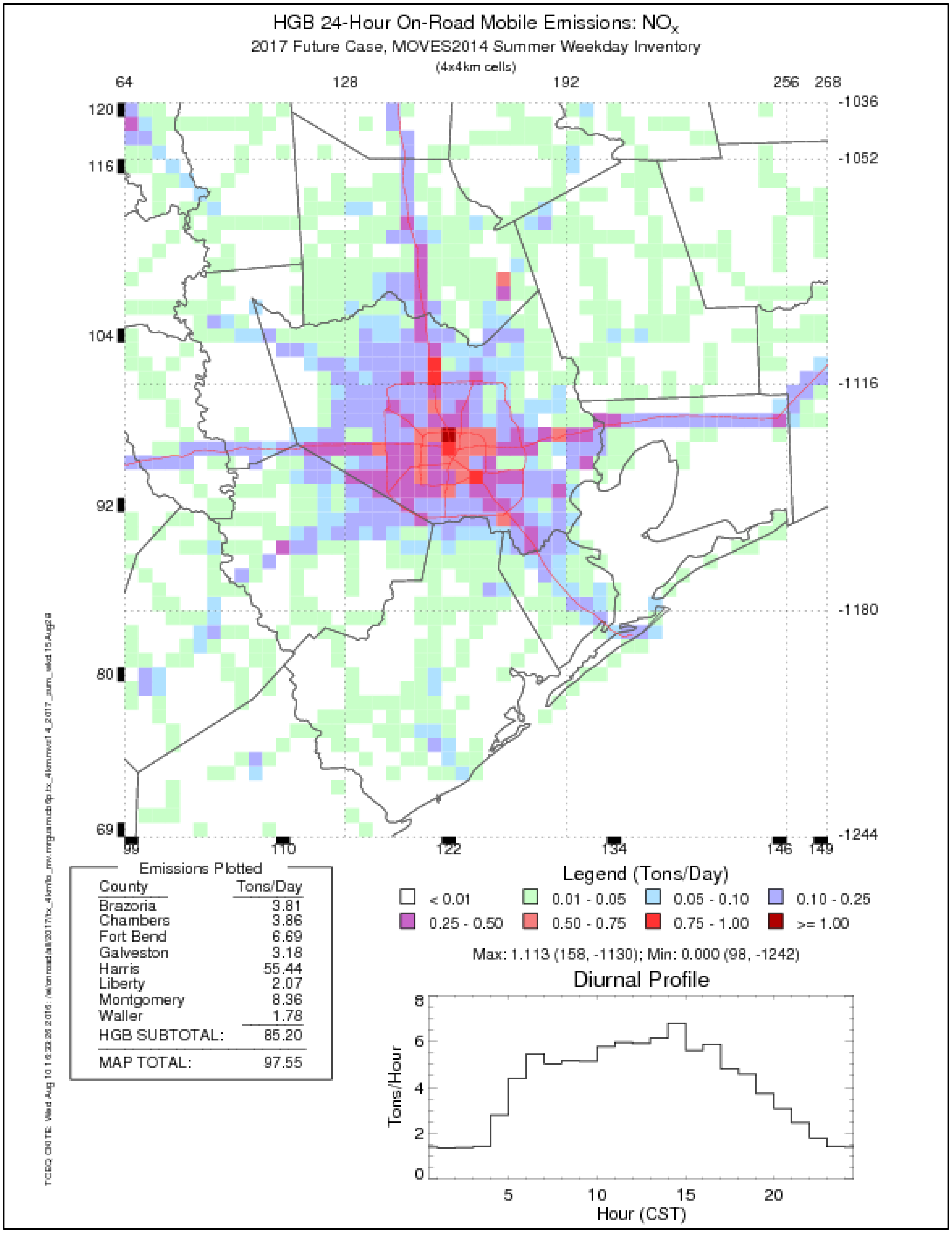


**Figure 3-3: 2017 Summer Weekday HGB On-Road $NO_X$ Emissions Distribution**

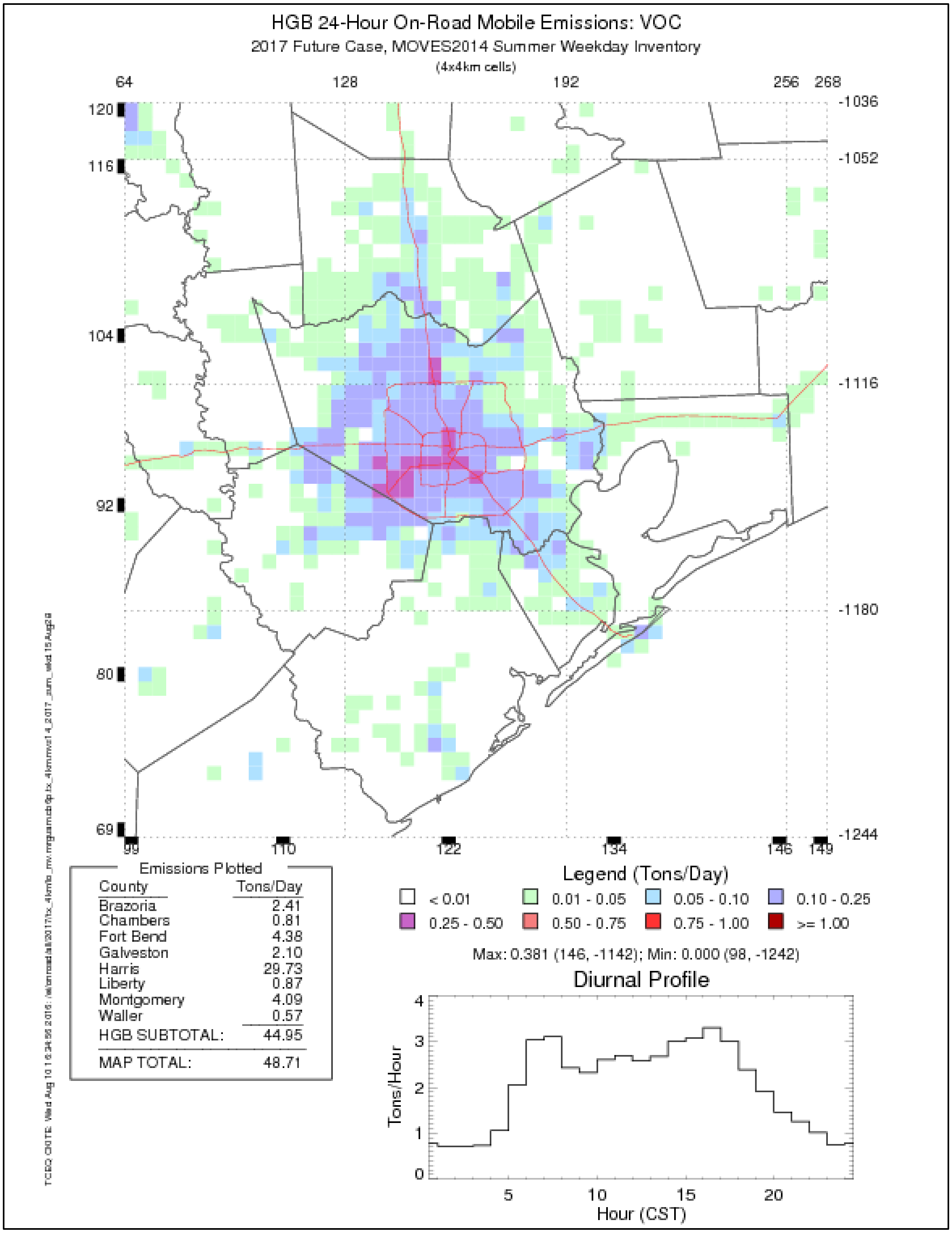


**Figure 3-4: 2017 Summer Weekday HGB On-Road VOC Emissions Distribution**

### 3.5 On-Road Mobile Source Emissions Inventories for Non-HGB Areas

For the Texas counties outside of the HGB area, on-road emissions were developed by TTI using HPMS data as the basis for VMT estimates. Both school and summer season emission estimates were developed for the four day types of weekday, Friday, Saturday, and Sunday. Hourly emission rates from MOVES2014 were coupled with county-level VMT estimates by roadway type for 2012 and 2017. More detail on the development of these HPMS-based on-road datasets can be found on the Texas 2012 on-road FTP site and Texas 2017 on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/onroad/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/onroad/tex/, respectively.

On-road emission estimates for non-Texas states within the photochemical modeling domain were developed for both 2012 and 2017 using MOVES2014 model default runs, which are available on EPA's MOVES web page at https://www3.epa.gov/otaq/models/moves/. For 2012 and 2017, default on-road emissions were estimated for the July weekday option available with MOVES2014. These summer weekday emission totals were then adjusted with EPS3 to obtain inputs for the other season and day type combinations. More detail on the development of the MOVES2014 on-road datasets can be found on the U.S. 2012 on-road FTP site and the U.S. 2017 on-road FTP site at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/onroad/usa/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/onroad/usa/, respectively.

More detail on this analysis is documented in *Using the MOVES Model in Inventory Mode to Develop Regional On-Road Emission Inputs for Air Quality Modeling Applications*, which was presented at a June 2011 EPA workshop and is available at https://www3.epa.gov/otaq/models/moves/conference2011/inventory-regional-moves-2011.pdf. A summary of the different on-road emission estimation approaches by geographic area for this HGB SIP revision is provided in Table 3-16: *On-Road Inventory Development Methodologies by Geographic Area*.

**Table 3-16: On-Road Inventory Development Methodologies by Geographic Area**

| On-Road Inventory Development Parameter | HGB Area | Non-HGB Texas Counties | Non-Texas States and Counties |
|---|---|---|---|
| VMT Source | HPMS | HPMS | MOVES2014 Defaults |
| VMT Resolution | 19 Roadway Types | 19 Roadway Types | 12 Roadway Types |
| Season Types | School and Summer | School and Summer | School and Summer |
| Day Types | Weekday, Friday, Saturday, and Sunday | Weekday, Friday, Saturday, and Sunday | Weekday, Friday, Saturday, and Sunday |
| Hourly Variation in VMT? | Yes | Yes | Yes |
| Roadway Speed Distribution | Varies by Hour and Roadway Type | Varies by Hour and Roadway Type | MOVES2014 Defaults |
| Spatial Resolution | Very Good | Very Good | Good |
| Temporal Resolution | Very Good | Very Good | Good |
| MOVES Fuel and Source Use Types | Gasoline and Diesel 13 Source Use Types | Gasoline and Diesel 13 Source Use Types | Gasoline and Diesel 13 Source Use Types |

# 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) multiplied by emission factors for specific operations and types of equipment from an Eastern Research Group (ERG) study, *Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions*. This report is available on the TCEQ Air Quality Research and Contracts Reports: Emissions Inventory web page at http://www.tceq.texas.gov/airquality/airmod/project/pj_report_ei.html. Activity data from the RRC specific to 2012 and 2014 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 figures 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 contains a summary of how each calculation is performed. The 2012 oil and gas production emission estimates for the eight-county HGB area are summarized in Table 4-1: *2012 HGB Area Oil and Gas Production Emissions by Equipment Type*. Emission estimates for nitrogen oxides ($NO_X$), volatile organic compounds (VOC), carbon monoxide (CO), sulfur dioxide ($SO_2$), and particulate matter with a mean diameter of 2.5 microns ($PM_{2.5}$) are provided.

**Table 4-1: 2012 HGB Area Oil and Gas Production Emissions by Equipment Type**

| Oil and Gas Production Equipment | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Artificial Lift | 0.99 | 0.01 | 1.54 | 0.00 | 0.01 |
| Heater Treater | 0.40 | 0.04 | 0.58 | 0.00 | 0.05 |
| Hydraulic Fracturing Engines | 0.34 | 0.02 | 0.07 | 0.00 | 0.01 |
| Natural Gas Fired Four-Cycle Rich-Burn Compressor Engines from 50 to 499 Horsepower (HP) w/NSCR | 0.21 | 0.01 | 0.23 | 0.00 | 0.02 |
| Gas Well Heaters | 0.05 | 0.01 | 0.11 | 0.00 | 0.01 |
| Natural Gas Fired Four-Cycle Rich-Burn Compressor Engines less than 50 HP | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| Natural Gas Fired Four-Cycle Lean-Burn Compressor Engines above 500 HP | 0.02 | 0.02 | 0.13 | 0.00 | 0.00 |
| Natural Gas Fired Two-Cycle Lean-Burn Compressor Engines less than 50 HP | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 |
| Total: All Processes | 0.02 | 0.04 | 0.08 | 0.13 | 0.00 |
| Natural Gas Fired Two-Cycle Lean-Burn Compressor Engines from 50 To 499 HP | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| Gas Well Dehydrators | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Storage Tanks: Condensate | 0.00 | 25.20 | 0.00 | 0.00 | 0.00 |
| Storage Tanks: Crude Oil | 0.00 | 21.99 | 0.00 | 0.00 | 0.00 |
| Produced Water | 0.00 | 4.79 | 0.00 | 0.00 | 0.00 |
| Wellhead | 0.00 | 3.58 | 0.00 | 0.00 | 0.00 |
| Tank Truck/Railcar Loading: Crude Oil | 0.00 | 2.32 | 0.00 | 0.00 | 0.00 |

| Oil and Gas Production Equipment | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Oil Well Completion: All Processes | 0.00 | 1.92 | 0.00 | 0.00 | 0.00 |
| Gas Well Pneumatic Devices | 0.00 | 1.29 | 0.00 | 0.00 | 0.00 |
| Oil Well Pneumatic Devices | 0.00 | 1.22 | 0.00 | 0.00 | 0.00 |
| Tank Truck/Railcar Loading: Condensate | 0.00 | 0.85 | 0.00 | 0.00 | 0.00 |
| Gas Well Pneumatic Pumps | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 |
| Mud Degassing | 0.00 | 0.52 | 0.00 | 0.00 | 0.00 |
| Fugitives: Other | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 |
| Oil Well Pneumatic Pumps | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 |
| Fugitives: Valves | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 |
| Gas Well Venting | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 |
| Fugitives: Other | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 |
| Fugitives: Pumps | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 |
| Fugitives: Connectors | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 |
| Gas Well Completion: All Processes | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 |
| Mud Degassing | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 |
| Fugitives: Flanges | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| Fugitives: Connectors | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| Fugitives: Open Ended Lines | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Fugitives: Open Ended Lines | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Fugitives: Pumps | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Fugitives: Flanges | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| **Oil and Gas Production Total** | 2.09 | 66.60 | 2.78 | 0.14 | 0.11 |

2017 future year emission estimates for oil and gas production were projected using 2014 RRC data, which is the latest full year available when this projection was done. Since upstream oil and gas production for the HGB area has been relatively stable over time, the 2014 production emissions were held constant and used as 2017 inputs. In accordance with the recently promulgated OOOO regulations for “green completions” issued by the U.S. EPA, $NO_X$ and CO emissions associated with gas well completions for 2017 were reduced to zero. This reduced the total 2017 production emissions by 0.01 $NO_X$ tpd and 0.01 CO tpd to 1.89 $NO_X$ tpd and 0.37 CO tpd. The 2017 oil and gas production emission estimates for the eight-county HGB area are summarized in Table 4-2: *2017 HGB Area Oil and Gas Production Emissions by Equipment Type*.

**Table 4-2: 2017 HGB Area Oil and Gas Production Emissions by Equipment Type**

| Oil and Gas Production Equipment | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Artificial Lift | 0.99 | 0.01 | 0.00 | 0.00 | 0.01 |
| Heater Treater | 0.40 | 0.04 | 0.00 | 0.00 | 0.05 |
| Hydraulic Fracturing Engines | 0.20 | 0.01 | 0.00 | 0.00 | 0.01 |
| Natural Gas Fired Four-Cycle Rich Burn Compressor Engines from 50 to 499 HP w/NSCR | 0.16 | 0.01 | 0.17 | 0.00 | 0.01 |
| Gas Well Heaters | 0.06 | 0.01 | 0.00 | 0.00 | 0.01 |

| Oil and Gas Production Equipment | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Natural Gas Fired Four-Cycle Rich-Burn Compressor Engines less than 50 HP | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total: All Processes | 0.01 | 0.04 | 0.07 | 0.12 | 0.00 |
| Natural Gas Fired Four-Cycle Lean-Burn Compressor Engines Above 500 HP | 0.01 | 0.01 | 0.07 | 0.00 | 0.00 |
| Natural Gas Fired Two-Cycle Lean-Burn Compressor Engines less than 50 HP | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| Storage Tanks: Crude Oil | 0.00 | 14.62 | 0.02 | 0.00 | 0.00 |
| Natural Gas Fired Two-Cycle Lean-Burn Compressor Engines from 50 to 499 HP | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 |
| Storage Tanks: Condensate | 0.00 | 17.63 | 0.01 | 0.00 | 0.00 |
| Tank Truck/Railcar Loading: Crude Oil | 0.00 | 1.16 | 0.00 | 0.00 | 0.00 |
| Tank Truck/Railcar Loading: Condensate | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 |
| Gas Well Dehydrators | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Produced Water | 0.00 | 3.78 | 0.00 | 0.00 | 0.00 |
| Wellhead | 0.00 | 3.57 | 0.00 | 0.00 | 0.00 |
| Oil Well Completion: All Processes | 0.00 | 2.40 | 0.00 | 0.00 | 0.00 |
| Oil Well Pneumatic Devices | 0.00 | 0.95 | 0.00 | 0.00 | 0.00 |
| Gas Well Pneumatic Devices | 0.00 | 0.82 | 0.00 | 0.00 | 0.00 |
| Mud Degassing | 0.00 | 0.82 | 0.00 | 0.00 | 0.00 |
| Gas Well Pneumatic Pumps | 0.00 | 0.54 | 0.00 | 0.00 | 0.00 |
| Fugitives: Other | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 |
| Oil Well Pneumatic Pumps | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 |
| Fugitives: Valves | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 |
| Gas Well Venting | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 |
| Fugitives: Other | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 |
| Fugitives: Pumps | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 |
| Fugitives: Connectors | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 |
| Mud Degassing | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 |
| Gas Well Completion: All Processes | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| Fugitives: Flanges | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| Fugitives: Connectors | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| Fugitives: Open Ended Lines | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Fugitives: Open Ended Lines | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Fugitives: Pumps | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Fugitives: Flanges | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| **Oil and Gas Production Total** | 1.89 | 48.73 | 0.37 | 0.13 | 0.10 |

Daily average drilling rig emission estimates for 2012 and 2017 are summarized in Table 4-3: *2012 and 2017 HGB Area Drilling Rig Emission Estimates*. The 2012 estimates were based on the ERG study, *2014 Statewide Drilling Rig Emissions Inventory with Updated Trends*

*Inventories*, which is available on the TCEQ Air Quality Research and Contracts Reports: Emissions Inventory web page.

**Table 4-3: 2012 and 2017 HGB Area Drilling Rig Emission Estimates**

| Calendar Year for Drilling Rig Activity | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| 2012 Drilling Rig Emissions | 0.81 | 0.06 | 0.26 | 0.00 | 0.04 |
| 2017 Drilling Rig Emissions | 0.57 | 0.07 | 0.25 | 0.00 | 0.03 |

The 2017 drilling rig emission estimates were obtained by applying 2017 emission factors to the 2015 drilling activity summarized in Table 4-4: *2015 HGB Area Oil and Gas Drilling Activity*. Different emission rates apply based on average well depth and whether conventional "vertical only" drilling is being done versus horizontal drilling commonly associated with fracturing. Since drilling rig equipment is subject to federal non-road emission standards, average emission rates decline over time due to fleet turnover. Drilling rig emission rates for each year from 2012-2040 are summarized in Chapter 6: Emissions Factor Development of the *2014 Statewide Drilling Rig Emissions Inventory with Updated Trends Inventory* ERG study.

**Table 4-4: 2015 HGB Area Oil and Gas Drilling Activity**

| Type and Depth of 2015 Drilling Levels | 2015 Thousands of Feet Drilled |
|---|---|
| Vertical/Horizontal Drilling | 335 |
| Vertical Drilling less than 7,000 Feet | 514 |
| Vertical Drilling greater than 7,000 Feet | 232 |

The production and drilling rig emission estimates presented above were prepared for photochemical model input using EPS3. Spatial allocation of these emission estimates was based on the latest available activity data from the RRC. For example, 2014 natural gas production data for each operational well were used to develop a weighted surrogate for allocating 2017 natural gas production emissions. A similar approach was used to develop separate weighted surrogates for emissions associated with crude oil and condensate production. 2017 drilling rig emissions were allocated to locations where 2015 wells were drilled. Even though it is unlikely that 2017 drilling will occur in the exact same locations as 2015, low-level emissions are evenly distributed within 4 kilometer (km) grid cells for photochemical model input. Since 2017 production and drilling is likely to be concentrated near currently operational wells, this spatial allocation approach is reasonable. 2012 production and drilling rig emissions were allocated based on available RRC data specific to that year.

For the non-HGB areas of Texas, the steps described above are similar for the development and EPS3 processing of emissions associated with drilling rigs and production of natural gas, crude oil, and condensate. For projecting to 2017, the latest available RRC activity data from 2014 were obtained for every Texas county. The ERG *Forecasting Oil and Gas Activities* study provided different emission projection factors for the Barnett, Eagle Ford, and Haynesville Shale formations. The EPS3 processing streams for emissions from oil and gas activities are divided into seven separate streams for:

- the eight-county HGB area;
- the 10-county DFW area;

- the eight Barnett Shale counties of Cooke, Erath, Hill, Hood, Jack, Montague, Palo Pinto, and Somervell not included within the 10-county DFW area;
- the 10 counties comprising the Texas portion of the Haynesville Shale;
- the 26 counties within the Eagle Ford Shale in South Texas;
- the 45 counties within the Permian Basin in West Texas; and
- the remaining 147 Texas counties.

The complete EPS3 processing streams for the oil and gas activities are available for both 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/oil_gas/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/oil_gas/tex/, respectively.

The following pages contain graphical plots of the 2012 and 2017 oil and gas production and drilling $NO_X$ and VOC emissions for the HGB area. These plots are titled Figure 4-1: *2012 HGB Oil and Gas Production NOX Emissions Distribution*, Figure 4-2: *2012 HGB Oil and Gas Production VOC Emissions Distribution*, Figure 4-3: *2017 HGB Oil and Gas Production NOX Emissions Distribution*, and Figure 4-4: *2017 HGB Oil and Gas Production VOC Emissions Distribution*. Spatial allocation of drilling rig emission estimates for 2012 and 2017, respectively, are provided in Figure 4-5: 2012 HGB Drilling Rig $NO_X$ Emissions Distribution and Figure 4-6: 2017 HGB Drilling Rig $NO_X$ Emissions Distribution. Since diesel-powered drilling rig equipment emits low levels of VOC, only $NO_X$ plots are provided.

For the non-Texas U.S. areas of the modeling domain, oil and gas emission estimates from the EPA NEI were used. The 2011 oil and gas NEI was projected to 2012 and 2017 to develop the non-Texas inputs based on growth factors from the U.S. Energy Information Administration (EIA). The oil and gas emission estimates from the NEI datasets were processed through EPS3 in a manner similar to that described above for the oil and gas emissions within Texas. The non-Texas EPS3 processing streams for oil and gas emissions for 2012 and 2017 are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/oil_gas/usa/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/oil_gas/usa/, respectively.

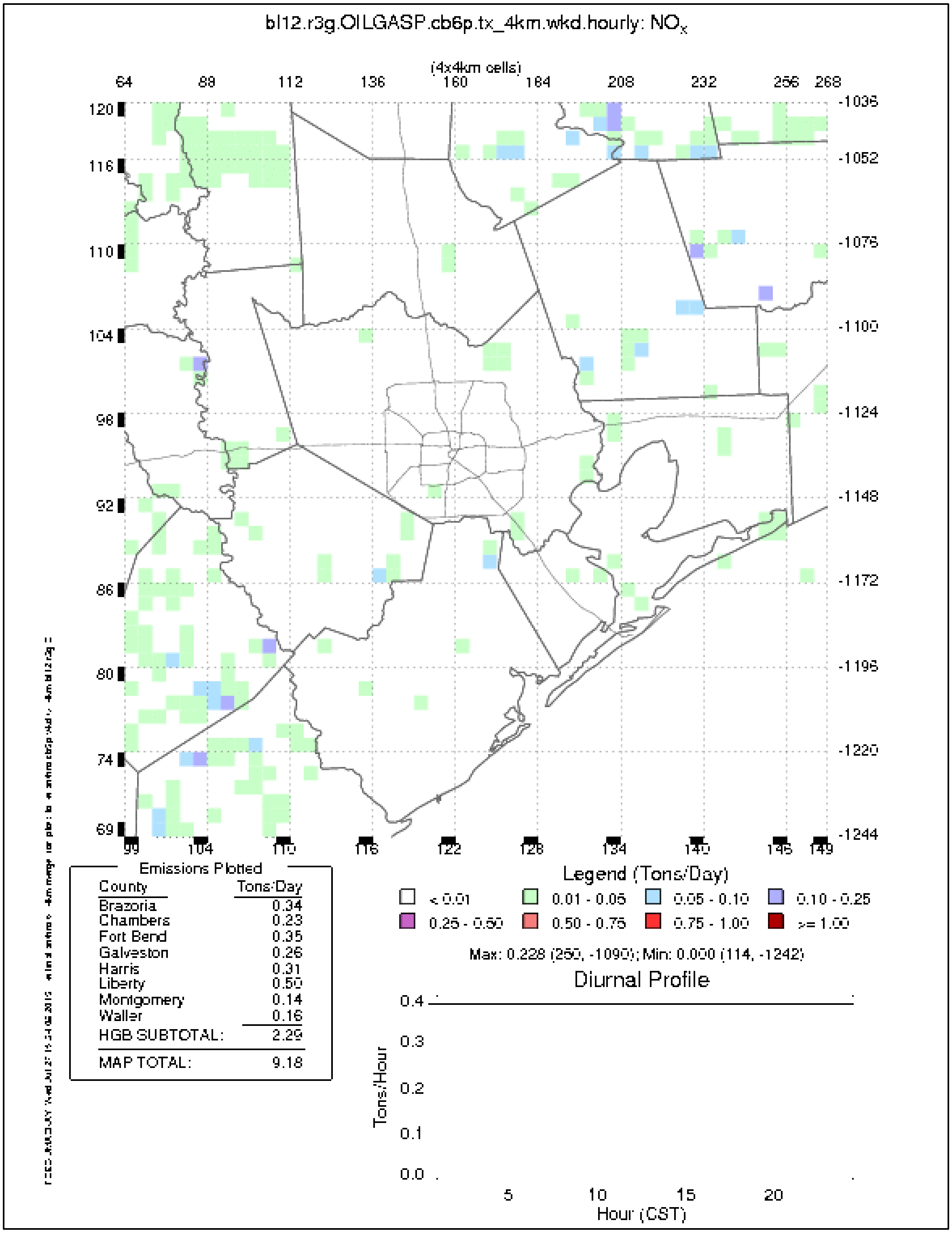


**Figure 4-1: 2012 HGB Oil and Gas Production $NO_X$ Emissions Distribution**

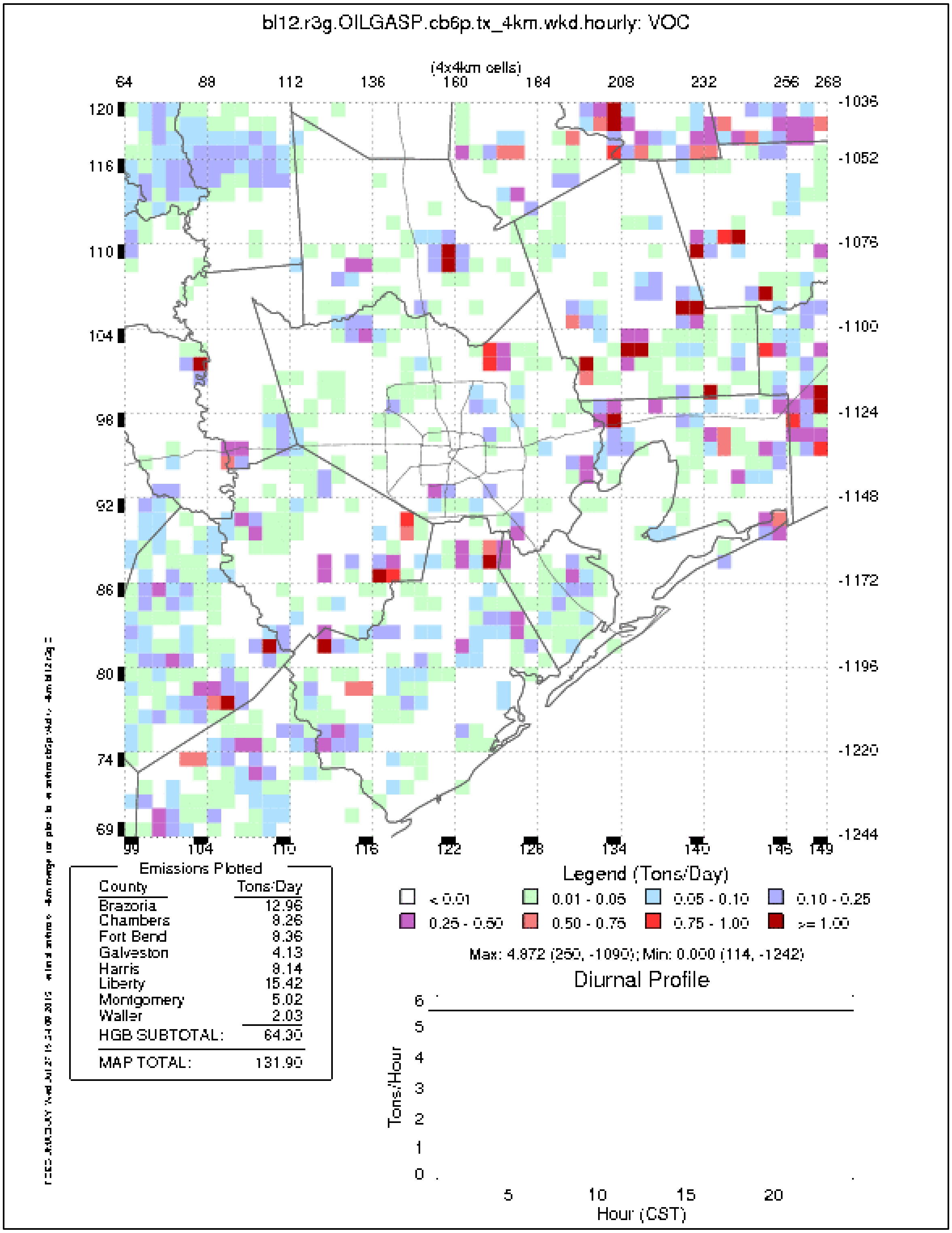


**Figure 4-2: 2012 HGB Oil and Gas Production VOC Emissions Distribution**

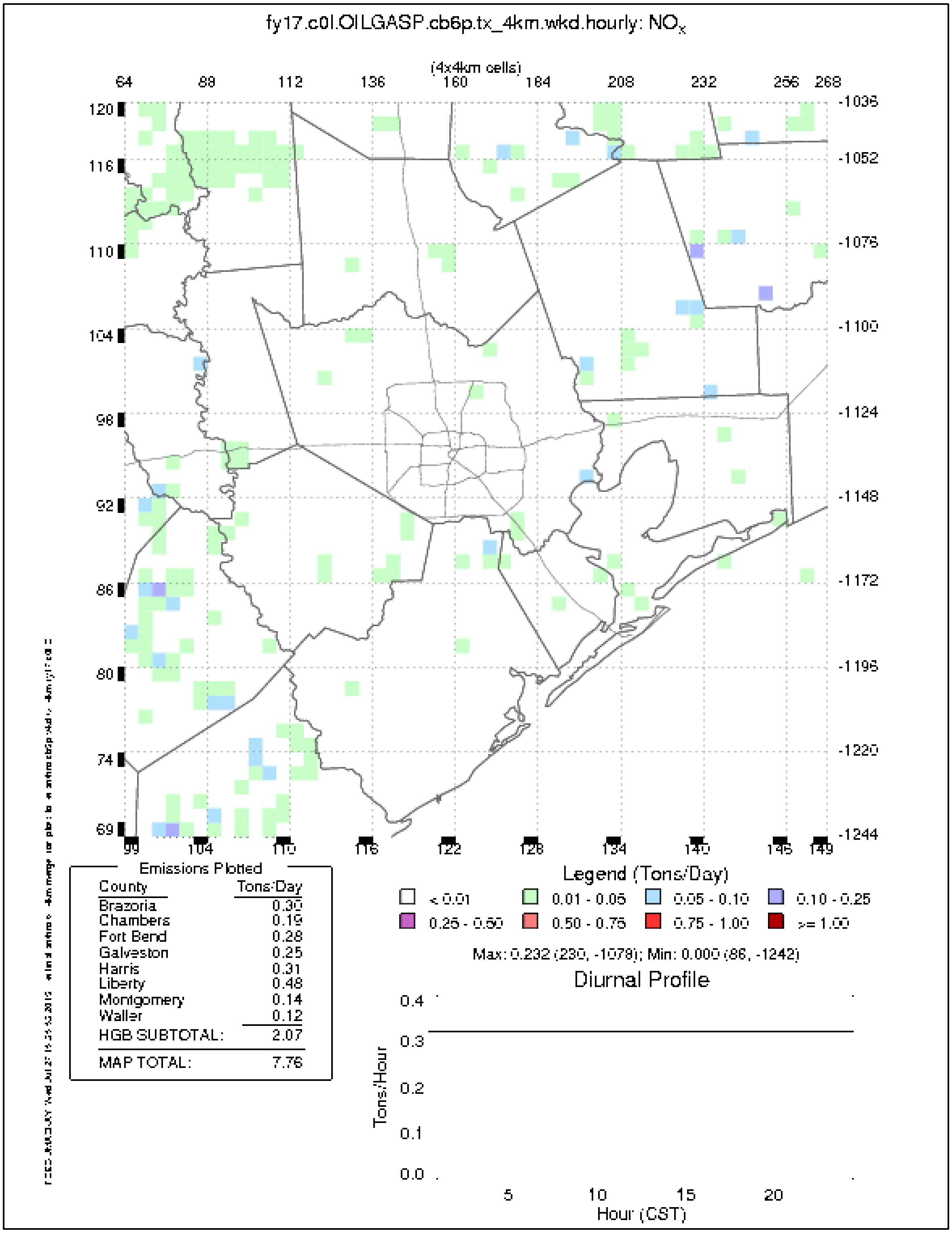


**Figure 4-3: 2017 HGB Oil and Gas Production $NO_X$ Emissions Distribution**

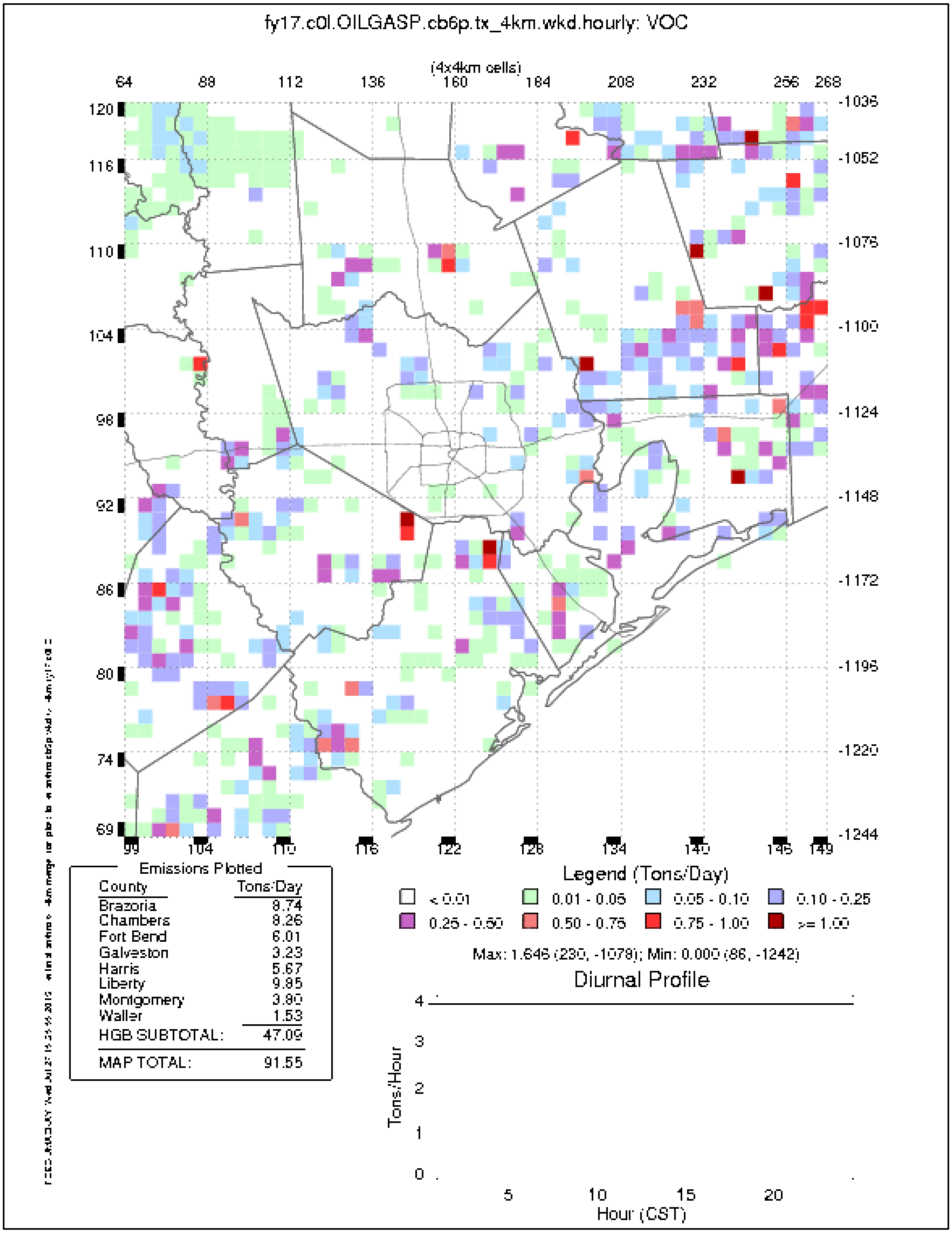


**Figure 4-4: 2017 HGB Oil and Gas Production VOC Emissions Distribution**

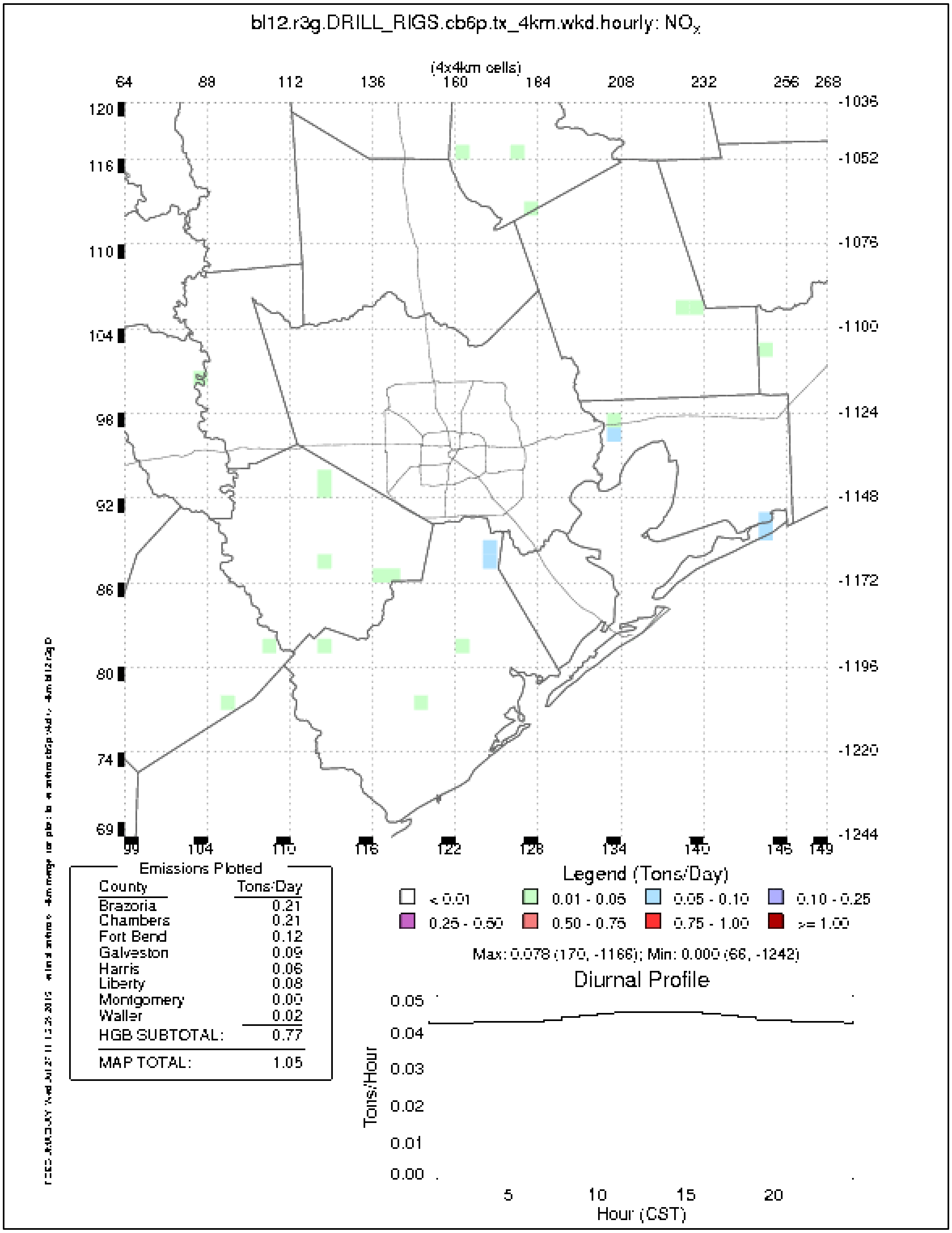


**Figure 4-5: 2012 HGB Drilling Rig $NO_X$ Emissions Distribution**

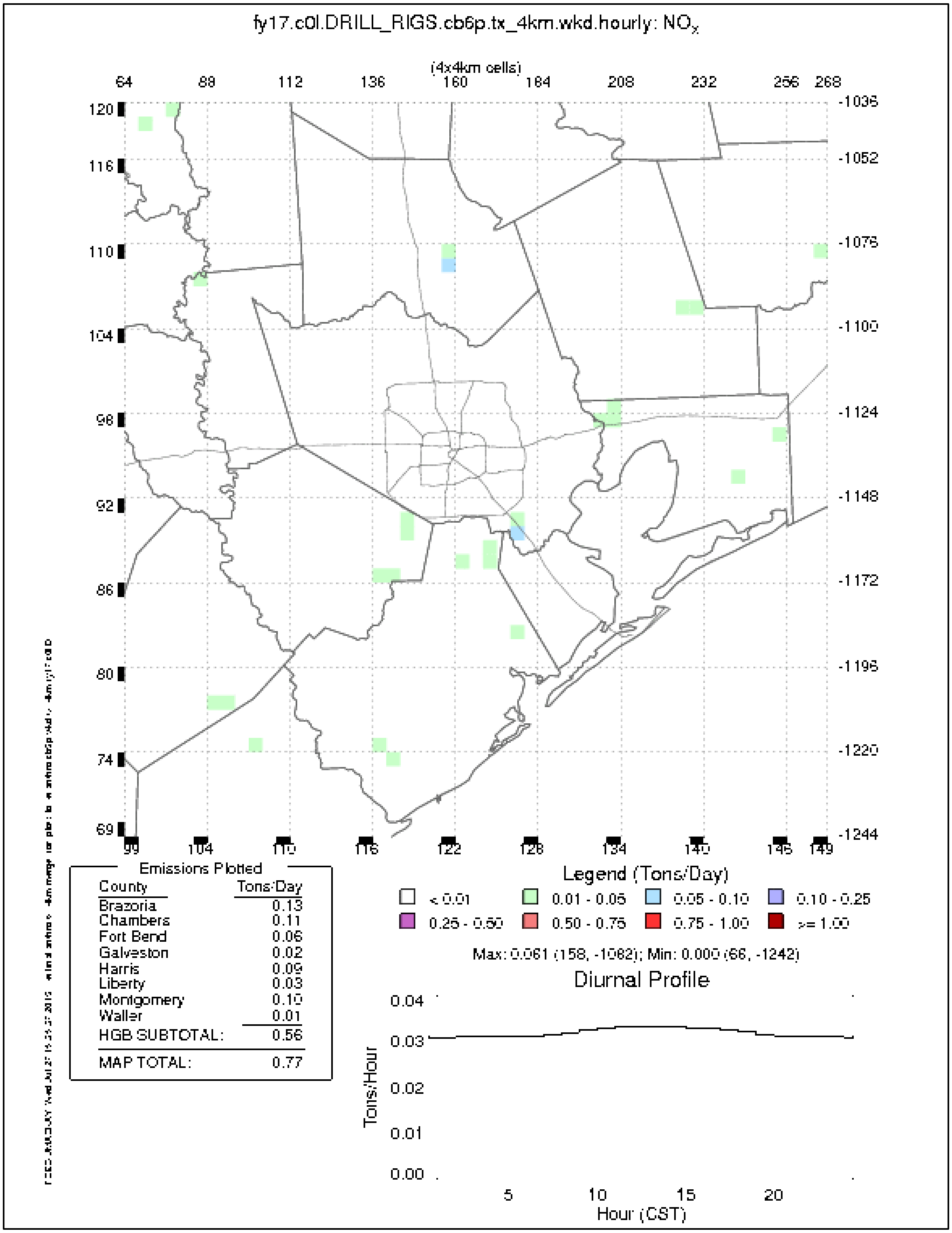


**Figure 4-6: 2017 HGB Drilling Rig $NO_X$ Emissions Distribution**

## 4.2 Airports

Airport emission estimates for 2012 and 2017 were based on a July 2015 ERG study, *Aircraft Emissions Inventory for Texas Statewide 2014 AERR Inventory and 2008 to 2014 Trend Analysis Years*. At the time that the ERG work was performed, the latest version of the Emissions and Dispersion Modeling System (EDMS) from the Federal Aviation Administration (FAA) was used. For past years, historical flight activity for each airport is input to the EDMS model. Future year flight activity are based on Terminal Area Forecast (TAF) datasets available from FAA. In addition to estimating emissions from aircraft activity, the EDMS model outputs estimates for auxiliary power units (APUs) and ground support equipment (GSE) at major airports. 2012 summaries of aircraft, APU, and GSE emission estimates for George Bush Intercontinental, Houston Hobby, and the smaller regional airports throughout HGB are presented in Table 4-5: *2012 George Bush Intercontinental Airport Emissions by Source Type*, Table 4-6: *2012 Houston Hobby Airport Emissions by Source Type*, and Table 4-7: *2012 HGB Area Regional Airport Emissions by Source Type*, respectively. The EDMS model estimates emissions associated with parking garage activity and routine construction at major airports, but these are already included in the comprehensive TCEQ on-road and non-road construction emission inventories. 2012 emission totals for George Bush Intercontinental, Houston Hobby, and the smaller regional airports are presented in Table 4-8: *2012 HGB Area Major and Regional Airport Emissions*.

**Table 4-5: 2012 George Bush Intercontinental Airport Emissions by Source Type**

| George Bush Intercontinental Airport Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 4.36 | 1.17 | 7.01 | 0.58 | 0.08 |
| Auxiliary Power Units | 0.13 | 0.01 | 0.17 | 0.02 | 0.02 |
| Ground Support Equipment | 0.19 | 0.06 | 1.40 | 0.00 | 0.01 |
| George Bush Intercontinental Airport Total | 4.69 | 1.24 | 8.58 | 0.61 | 0.11 |

**Table 4-6: 2012 Houston Hobby Airport Emissions by Source Type**

| Houston Hobby Airport Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 1.39 | 0.39 | 1.85 | 0.16 | 0.02 |
| Auxiliary Power Units | 0.03 | 0.00 | 0.06 | 0.00 | 0.01 |
| Ground Support Equipment | 0.06 | 0.02 | 0.54 | 0.00 | 0.00 |
| Houston Hobby Airport Total | 1.48 | 0.41 | 2.44 | 0.17 | 0.03 |

**Table 4-7: 2012 HGB Area Regional Airport Emissions by Source Type**

| Regional Airports Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 0.22 | 0.46 | 8.70 | 0.05 | 0.14 |
| Auxiliary Power Units | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| Ground Support Equipment | 0.05 | 0.01 | 0.22 | 0.00 | 0.00 |
| Regional Airports Total | 0.27 | 0.47 | 8.93 | 0.05 | 0.14 |

**Table 4-8: 2012 HGB Area Major and Regional Airport Emissions**

| HGB Area Airport or Airport Group | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| George Bush Intercontinental | 4.69 | 1.24 | 8.58 | 0.61 | 0.11 |
| Houston Hobby | 1.48 | 0.41 | 2.44 | 0.17 | 0.03 |
| Regional Airports | 0.27 | 0.47 | 8.93 | 0.05 | 0.14 |
| HGB Area Airport Total | 6.44 | 2.11 | 19.95 | 0.82 | 0.28 |

2017 summaries of aircraft, APU, and GSE emission estimates for HGB are shown in Table 4-9: *2017 George Bush Intercontinental Airport Emissions by Source Type*, Table 4-10: *2017 Houston Hobby Airport Emissions by Source Type*, and Table 4-11: *2017 HGB Area Regional Airport Emissions by Source Type*, respectively. 2017 emission totals for George Bush Intercontinental, Houston Hobby, and the smaller regional airports are presented in Table 4-12: *2017 HGB Area Major and Regional Airport Emissions*.

**Table 4-9: 2017 George Bush Intercontinental Airport Emissions by Source Type**

| George Bush Intercontinental Airport Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 4.59 | 1.23 | 7.38 | 0.61 | 0.08 |
| Auxiliary Power Units | 0.14 | 0.02 | 0.18 | 0.02 | 0.02 |
| Ground Support Equipment | 0.20 | 0.06 | 1.47 | 0.01 | 0.01 |
| George Bush Intercontinental Airport Total | 4.93 | 1.30 | 9.04 | 0.64 | 0.12 |

**Table 4-10: 2017 Houston Hobby Airport Emissions by Source Type**

| Houston Hobby Airport Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 1.54 | 0.43 | 2.04 | 0.18 | 0.03 |
| Auxiliary Power Units | 0.03 | 0.00 | 0.06 | 0.01 | 0.01 |
| Ground Support Equipment | 0.06 | 0.02 | 0.60 | 0.00 | 0.00 |
| Houston Hobby Airport Total | 1.63 | 0.45 | 2.70 | 0.19 | 0.03 |

**Table 4-11: 2017 HGB Area Regional Airport Emissions by Source Type**

| Regional Airports Source Category | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Aircraft Operation | 0.23 | 0.48 | 9.35 | 0.05 | 0.15 |
| Auxiliary Power Units | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| Ground Support Equipment | 0.05 | 0.01 | 0.22 | 0.00 | 0.00 |
| Regional Airports Total | 0.28 | 0.49 | 9.58 | 0.05 | 0.15 |

**Table 4-12: 2017 HGB Area Major and Regional Airport Emissions**

| HGB Area Airport or Airport Group | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| George Bush Intercontinental | 4.93 | 1.30 | 9.04 | 0.64 | 0.12 |
| Houston Hobby | 1.63 | 0.45 | 2.70 | 0.19 | 0.03 |

| HGB Area Airport or Airport Group | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Regional Airports | 0.28 | 0.49 | 9.58 | 0.05 | 0.15 |
| HGB Area Airport Total | 6.85 | 2.24 | 21.32 | 0.88 | 0.30 |

The airport emissions were prepared for photochemical modeling input using EPS3. The emissions were allocated to grid cells using spatial surrogates based on the respective areal extent of each airport. The EPS3 processing for Texas airport emissions was separated into streams for:

- the eight-county HGB area;
- the 10-county DFW area; and
- the remaining 236 Texas counties.

The complete EPS3 processing streams for the airports are available for 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/offroad/airport/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/offroad/airport/tex/, respectively. The following pages contain graphical plots of the 2012 and 2017 airport $NO_X$ emissions for the HGB area. These plots are respectively titled Figure 4-7: *2012 HGB Airport NOX Emissions Distribution* and Figure 4-8: *2017 HGB Airport NOX Emissions Distribution*. Since airports are not significant contributors of VOC emissions, only $NO_X$ plots are provided.

For the non-Texas U.S. areas of the modeling domain, airport emission estimates from the EPA 2011 NEI were projected to 2012 and 2017. The airport emission estimates from the NEI datasets were processed through EPS3 in a manner similar to that described above for the airport emissions within Texas. The EPS3 airport processing streams for the non-Texas areas for 2012 and 2017 are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/offroad/airport/usa/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/offroad/airport/usa/, respectively.

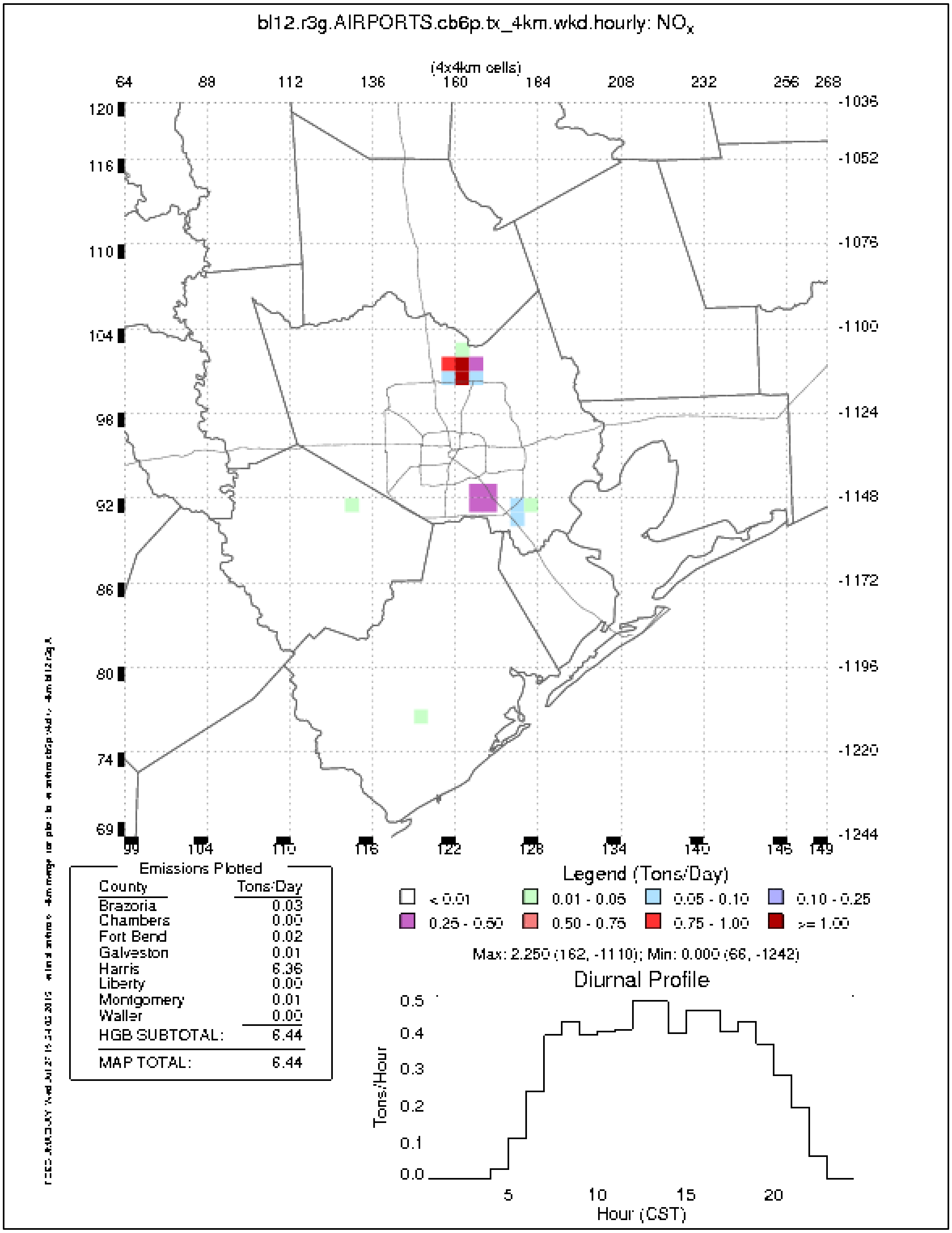


**Figure 4-7: 2012 HGB Airport $NO_X$ Emissions Distribution**

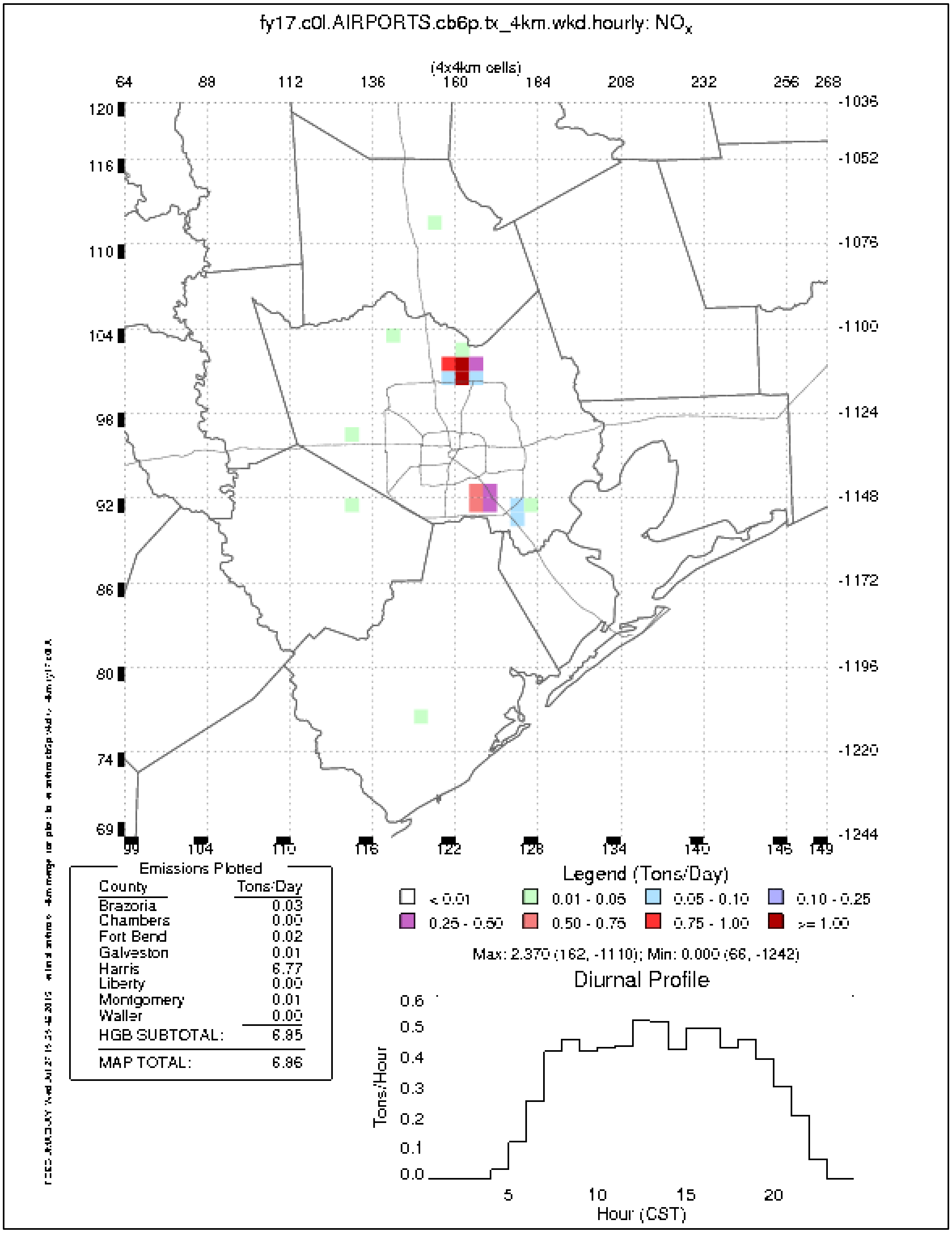


**Figure 4-8: 2017 HGB Airport $NO_X$ Emissions Distribution**

## 4.3 Locomotives

Locomotive emission estimates for 2012 and 2017 were based on an August 2015 ERG study, *2014 Texas Statewide Locomotive Emissions Inventory and 2008 through 2040 Trend Inventories*. The locomotive emissions data output from TexAER were prepared for photochemical modeling using EPS3. Table 4-13: *EPS3 Modules for Processing Locomotive Emissions* summarizes the steps that were taken to process the 2012 and 2017 locomotive inventories.

**Table 4-13: EPS3 Modules for Processing Locomotive Emissions**

| EPS3 Module | Description |
|---|---|
| LBASE | Assign line-haul emissions to known railway segments (not for switchers). |
| PREAM | Convert text-based input files to binary format for further processing. |
| SPCEMS | Chemically speciate VOC emissions into olefins, paraffins, etc. |
| TMPRL | Apply profiles to temporally allocate daily emission totals. |
| CNTLEM | Apply temperature/humidity $NO_X$ correction. |
| GRDEM | Spatially allocate switcher emissions with surrogates. |

The 24-hour locomotive emission totals estimated in the trends study do not account for the effects of hourly variation in temperature and humidity on $NO_X$ emissions. Greater detail on the development of correction equations to account for these effects can be found in Appendices *F.4: Humidity and Temperature Correction Factors for $NO_X$ Emissions from Diesel Engines* and *F.5: Humidity and Temperature Correction Factors for $NO_X$ Emissions from Spark Ignited Engines* of the December 2004 HGB SIP revision. During EPS3 processing, the CNTLEM module is also used to apply an hourly temperature/humidity $NO_X$ correction and the impacts on the 2012 and 2017 locomotive HGB inventories are presented in Table 4-14: *Temperature/Humidity NOX Correction for Locomotive Emissions.*

**Table 4-14: Temperature/Humidity $NO_X$ Correction for Locomotive Emissions**

| Locomotive Source Classification Description | 2012 $NO_X$ Change (tpd) | 2017 $NO_X$ Change (tpd) |
|---|---|---|
| Line-Haul Locomotives – Class I | -1.49 | -1.22 |
| Line-Haul Locomotives – Classes II and III | -0.04 | -0.04 |
| Rail-Yard Switcher Locomotives | -0.38 | -0.36 |
| HGB Area Total | -1.90 | -1.62 |

Locomotive activity levels do not vary much by day type, so there are negligible differences in weekday versus weekend emissions for this source category. The line-haul emissions were spatially allocated to individual railway segments based on gross ton miles (GTM) activity data. The switcher emissions were allocated to known rail yards within the HGB area. Table 4-15: *2012 HGB Locomotive Emissions* and Table 4-16: *2017 HGB Locomotive Emissions* present the 2012 and 2017 HGB area locomotive emission inputs for the photochemical model for each episode day in these respective years.

**Table 4-15: 2012 HGB Locomotive Emissions**

| Locomotive Source Classification Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Line-Haul Locomotives – Class I | 11.97 | 0.74 | 2.65 | 0.01 | 0.01 | 0.40 |
| Line-Haul Locomotives – Classes II and III | 0.29 | 0.02 | 0.03 | 0.00 | 0.00 | 0.01 |
| Rail-Yard Switcher Locomotives | 3.09 | 0.23 | 0.45 | 0.00 | 0.00 | 0.08 |
| HGB Area Total | 15.34 | 0.99 | 3.14 | 0.01 | 0.01 | 0.48 |

**Table 4-16: 2017 HGB Locomotive Emissions**

| Locomotive Source Classification Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Line-Haul Locomotives – Class I | 9.79 | 0.50 | 2.74 | 0.01 | 0.01 | 0.29 |
| Line-Haul Locomotives – Classes II and III | 0.30 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 |
| Rail-Yard Switcher Locomotives | 2.99 | 0.22 | 0.48 | 0.00 | 0.00 | 0.08 |
| HGB Area Total | 13.08 | 0.73 | 3.26 | 0.01 | 0.01 | 0.37 |

For the non-HGB areas of Texas, the steps described above are similar for the development and EPS3 processing of locomotive emission estimates for 2012 and 2017. The EPS3 processing for Texas locomotive emissions is divided into streams for:

- the eight-county HGB area;
- the 10-county DFW area; and
- the remaining 236 Texas counties.

The EPS3 processing streams for locomotives are available for both 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/offroad/locomotive/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/offroad/locomotive/tex/, respectively. The following pages contain graphical plots of the 2012 and 2017 locomotive $NO_X$ emissions for the HGB area. These plots are respectively titled Figure 4-9: *2012 HGB Locomotive NOX Emissions Distribution* and Figure 4-10: *2017 HGB Locomotive NOX Emissions Distribution*. Since the diesel engines that power locomotives are not significant contributors of VOC emissions, only $NO_X$ plots are provided here.

For the non-Texas U.S. areas of the modeling domain, locomotive emission estimates from the EPA 2011 NEI were projected to 2012 and 2017. The locomotive emission estimates from the NEI datasets were processed through EPS3 in a manner similar to that described above for the locomotive emissions within Texas. The EPS3 locomotive processing streams for the non-Texas areas for 2012 and 2017 are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/offroad/locomotive/usa/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/offroad/locomotive/usa/, respectively.

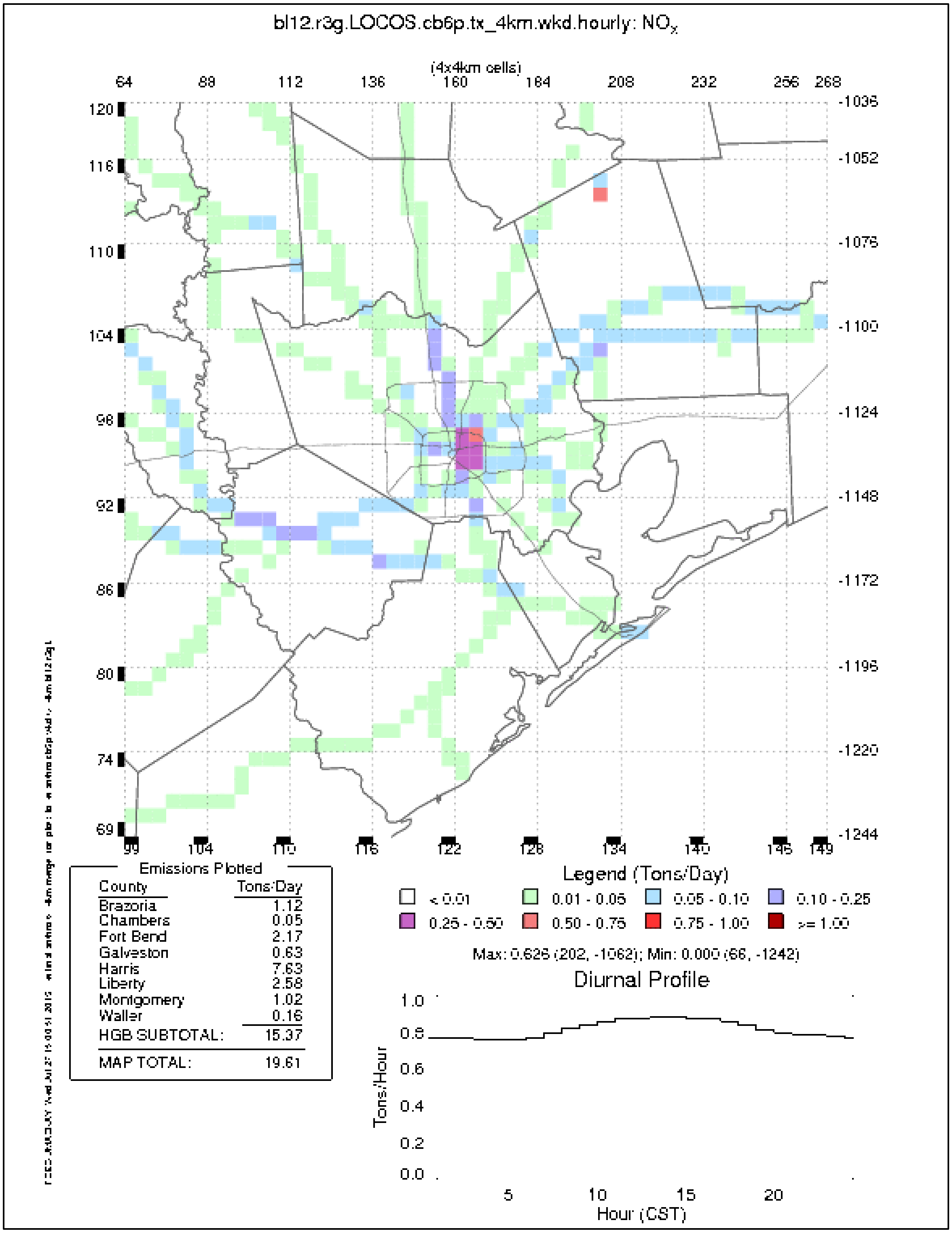


**Figure 4-9: 2012 HGB Locomotive $NO_X$ Emissions Distribution**

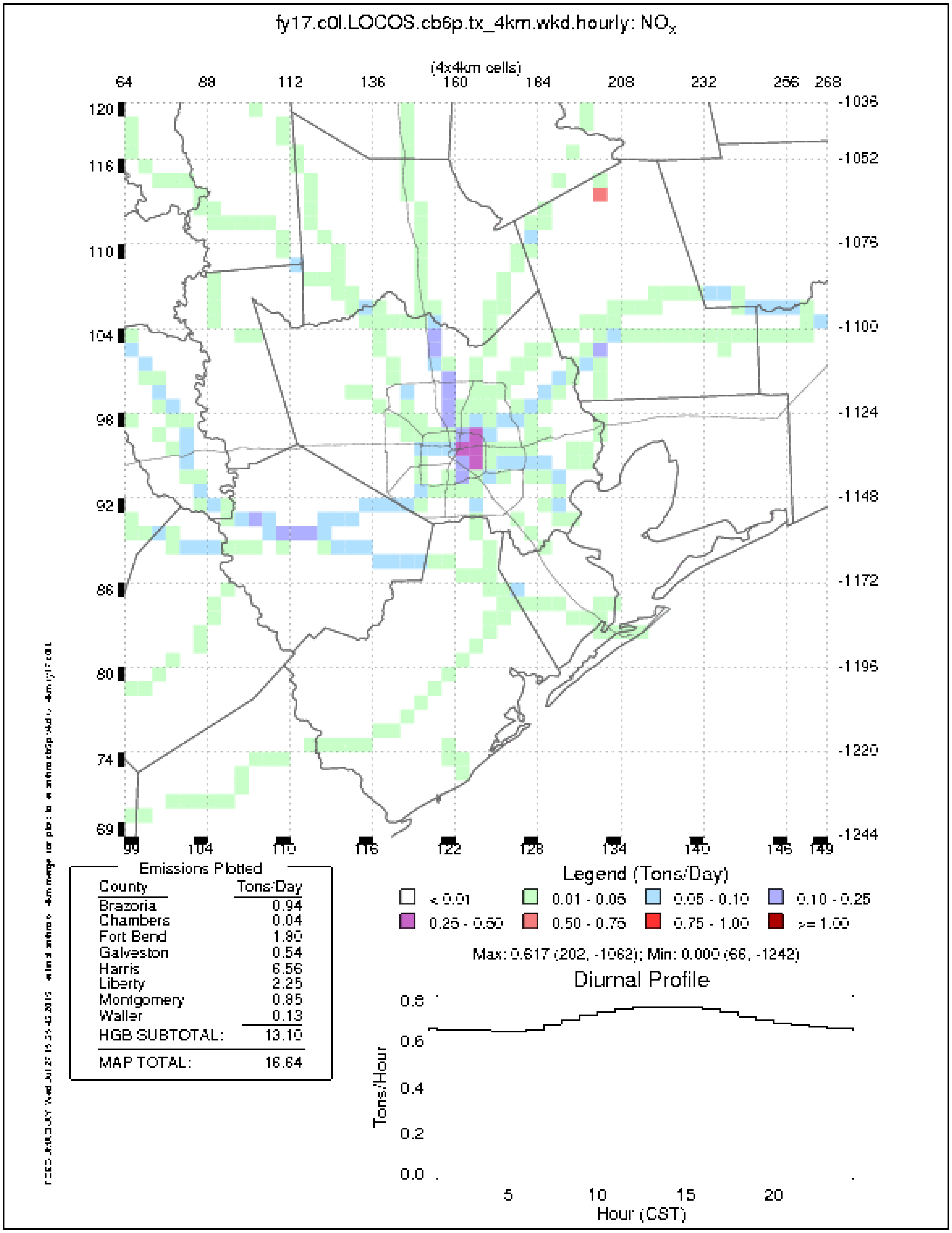


**Figure 4-10: 2017 HGB Locomotive $NO_X$ Emissions Distribution**

## 4.4 Non-Road/TexN

Non-road emissions for 2012 and 2017 for the eight-county HGB area were estimated with a customized version of EPA's NONROAD model called Texas NONROAD (TexN). For each county specified in a TexN scenario, 25 separate runs of the NONROAD model are performed for the non-road categories outlined in Table 4-17: *Texas NONROAD Model Subsector Categories*. Runs 1 through 25 (excluding 24) are for specific diesel construction equipment (DCE) categories, while the numeric code of '0' is for all non-DCE categories.

**Table 4-17: Texas NONROAD Model Subsector Categories**

| Numeric Code | NONROAD Model Subsector Description (Diesel Construction Equipment for 1-24) |
|---|---|
| 0 | Other - Non-Diesel Construction Equipment |
| 1 | DCE - Agricultural Activities |
| 2 | DCE - Boring and Drilling Equipment |
| 3 | DCE - Brick and Stone Operations |
| 4 | DCE - City and County Road Construction |
| 5 | DCE - Commercial Construction |
| 6 | DCE - Concrete Operations |
| 7 | DCE - County-Owned Construction Equipment |
| 8 | DCE – Cranes |
| 9 | DCE - Heavy Highway Construction |
| 10 | DCE - Landfill Operations |
| 11 | DCE - Landscaping Activities |
| 12 | DCE - Manufacturing Operations |
| 13 | DCE - Municipal-Owned Construction Equipment |
| 14 | DCE - Transportation/Sales/Services |
| 15 | DCE - Residential Construction |
| 16 | DCE - Rough Terrain Forklifts |
| 17 | DCE - Scrap/Recycling Operations |
| 18 | DCE - Skid Steer Loaders |
| 19 | DCE - Special Trades Construction |
| 20 | DCE - Trenchers |
| 21 | DCE - TxDOT Construction Equipment |
| 22 | DCE - Utility Construction |
| 23 | DCE - Mining and Quarry Operation |
| 25 | DCE - Off-Road Tractors, Miscellaneous, and Equipment Under 25 Horsepower |

2012 and 2017 summer weekday scenarios were run with the TexN model for the eight counties in the HGB area. 25 DCE subcategories for the eight counties resulted in 200 NONROAD model runs for each calendar year. The results of this work are available on the HGB non-road emissions FTP site for 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/nonroad/tex/texn/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/nonroad/tex/texn/, respectively. The $NO_X$, VOC, CO, $SO_2$, and $PM_{2.5}$ emissions by county along with associated non-road equipment population figures are presented for 2012 and 2017, respectively, in Table 4-18:

*2012 HGB Area Non-Road Emissions Inventory by County* and Table 4-19: *2017 HGB Area Non-Road Emissions Inventory by County*.

**Table 4-18: 2012 HGB Area Non-Road Emissions Inventory by County**

| HGB Area County | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 111,661 | 3.57 | 2.68 | 24.31 | 0.01 | 0.31 |
| Chambers | 23,724 | 0.83 | 0.87 | 4.99 | 0.00 | 0.07 |
| Fort Bend | 128,539 | 4.32 | 2.13 | 31.57 | 0.01 | 0.39 |
| Galveston | 146,352 | 2.44 | 2.99 | 22.62 | 0.01 | 0.22 |
| Harris | 1,441,923 | 39.84 | 26.85 | 391.72 | 0.12 | 3.20 |
| Liberty | 28,141 | 1.27 | 0.51 | 5.30 | 0.00 | 0.11 |
| Montgomery | 155,189 | 3.38 | 3.72 | 33.94 | 0.01 | 0.35 |
| Waller | 15,783 | 0.94 | 0.38 | 3.98 | 0.00 | 0.09 |
| HGB Total | 2,051,311 | 56.58 | 40.13 | 518.44 | 0.17 | 4.74 |

**Table 4-19: 2017 HGB Area Non-Road Emissions Inventory by County**

| HGB Area County | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 121,443 | 2.46 | 1.93 | 21.74 | 0.01 | 0.22 |
| Chambers | 25,317 | 0.50 | 0.59 | 4.14 | 0.00 | 0.04 |
| Fort Bend | 142,867 | 3.30 | 1.71 | 29.67 | 0.01 | 0.31 |
| Galveston | 157,924 | 1.65 | 2.18 | 21.14 | 0.00 | 0.16 |
| Harris | 1,582,771 | 27.63 | 19.66 | 358.38 | 0.08 | 2.52 |
| Liberty | 30,885 | 0.78 | 0.40 | 4.71 | 0.00 | 0.07 |
| Montgomery | 167,931 | 2.31 | 2.83 | 32.30 | 0.01 | 0.26 |
| Waller | 17,285 | 0.59 | 0.30 | 3.69 | 0.00 | 0.05 |
| HGB Total | 2,246,423 | 39.23 | 29.59 | 475.77 | 0.10 | 3.64 |

Even with overall growth in the non-road equipment population from roughly 2.1 million in 2012 to 2.2 million in 2017, total emissions decrease due to the more stringent emissions standards for new equipment purchases, combined with the simultaneous attrition of older, higher-emitting pieces of non-road equipment. The eight-county HGB non-road emissions inventory includes 195 different types of equipment referenced by source classification code (SCC). The eight-county HGB aggregate equipment categories for 2012 and 2017, respectively, are summarized in Table 4-20: *2012 HGB Area Non-Road Emissions Inventory by Equipment Group* and Table 4-21: *2017 HGB Area Non-Road Emissions Inventory by Equipment Group*.

**Table 4-20: 2012 HGB Area Non-Road Emissions Inventory by Equipment Group**

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Agricultural Equipment | 7,148 | 4.59 | 0.43 | 4.04 | 0.01 | 0.37 |
| Commercial Equipment | 222,561 | 6.83 | 8.74 | 216.38 | 0.02 | 0.61 |
| Construction and Mining Equipment | 80,948 | 26.85 | 4.55 | 47.68 | 0.08 | 2.46 |
| Industrial Equipment | 35,048 | 16.00 | 3.79 | 74.75 | 0.04 | 0.49 |

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Lawn and Garden Equipment | 1,506,654 | 1.32 | 10.41 | 130.46 | 0.01 | 0.56 |
| Logging Equipment | 1,870 | 0.15 | 0.12 | 1.25 | 0.00 | 0.02 |
| Pleasure Craft | 124,084 | 0.66 | 7.58 | 23.09 | 0.00 | 0.08 |
| Railroad Equipment | 109 | 0.07 | 0.01 | 0.05 | 0.00 | 0.01 |
| Recreational Equipment | 72,888 | 0.13 | 4.51 | 20.74 | 0.00 | 0.12 |
| HGB Total | 2,051,311 | 56.58 | 40.13 | 518.44 | 0.17 | 4.74 |

**Table 4-21: 2017 HGB Area Non-Road Emissions Inventory by Equipment Group**

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Agricultural Equipment | 7,823 | 2.71 | 0.32 | 2.62 | 0.00 | 0.19 |
| Commercial Equipment | 250,623 | 5.58 | 6.75 | 223.16 | 0.02 | 0.52 |
| Construction and Mining Equipment | 101,651 | 20.68 | 4.10 | 42.57 | 0.03 | 1.87 |
| Industrial Equipment | 38,463 | 8.33 | 1.60 | 37.37 | 0.04 | 0.31 |
| Lawn and Garden Equipment | 1,637,943 | 1.04 | 8.29 | 127.05 | 0.01 | 0.60 |
| Logging Equipment | 2,107 | 0.06 | 0.13 | 1.26 | 0.00 | 0.02 |
| Pleasure Craft | 128,585 | 0.65 | 4.99 | 20.50 | 0.00 | 0.05 |
| Railroad Equipment | 123 | 0.05 | 0.01 | 0.04 | 0.00 | 0.01 |
| Recreational Equipment | 79,105 | 0.13 | 3.41 | 21.19 | 0.00 | 0.09 |
| HGB Total | 2,246,423 | 39.23 | 29.59 | 475.77 | 0.10 | 3.64 |

The eight-county HGB non-road emissions are summarized by fuel type for 2012 and 2017, respectively, in Table 4-22: *2012 HGB Area Non-Road Emissions Inventory by Fuel Type* and Table 4-23: *2017 HGB Area Non-Road Emissions Inventory by Fuel Type*.

**Table 4-22: 2012 HGB Area Non-Road Emissions Inventory by Fuel Type**

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Two-Stroke Gasoline | 669,181 | 0.38 | 15.94 | 45.96 | 0.00 | 0.91 |
| Four-Stroke Gasoline | 1,246,452 | 2.76 | 16.54 | 377.35 | 0.02 | 0.18 |
| Diesel | 103,978 | 40.63 | 4.05 | 22.39 | 0.11 | 3.49 |
| Compressed Natural Gas (CNG) | 1,681 | 0.40 | 0.21 | 2.26 | 0.00 | 0.01 |
| Liquefied Petroleum Gas (LPG) | 30,019 | 12.41 | 3.39 | 70.48 | 0.03 | 0.15 |
| HGB Total | 2,051,311 | 56.58 | 40.13 | 518.44 | 0.17 | 4.74 |

**Table 4-23: 2017 HGB Area Non-Road Emissions Inventory by Fuel Type**

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Two-Stroke Gasoline | 722,354 | 0.45 | 12.85 | 47.14 | 0.00 | 0.89 |
| Four-Stroke Gasoline | 1,358,107 | 1.99 | 11.77 | 374.62 | 0.02 | 0.18 |
| Diesel | 130,329 | 30.57 | 3.47 | 16.14 | 0.04 | 2.39 |
| Compressed Natural Gas (CNG) | 1,871 | 0.27 | 0.10 | 1.28 | 0.00 | 0.01 |

| Equipment Category | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Liquefied Petroleum Gas (LPG) | 33,762 | 5.96 | 1.41 | 36.59 | 0.03 | 0.17 |
| HGB Total | 2,246,423 | 39.23 | 29.59 | 475.77 | 0.10 | 3.64 |

The eight-county HGB non-road emissions for 2012 and 2017, respectively, are summarized by the 25 DCE subcategory codes from Table 4-17 in Table 4-24: *2012 HGB Area Non-Road Emissions Inventory by Diesel Subcategory* and Table 4-25: *2017 HGB Area Non-Road Emissions Inventory by Diesel Subcategory*.

**Table 4-24: 2012 HGB Area Non-Road Emissions Inventory by Diesel Subcategory**

| Non-Road DCE Subsector | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Non-Diesel Equipment | 1,995,226 | 30.03 | 37.47 | 503.64 | 0.10 | 2.44 |
| Agricultural Activities | 781 | 0.68 | 0.07 | 0.43 | 0.00 | 0.07 |
| Boring and Drilling Equipment | 283 | 0.21 | 0.02 | 0.07 | 0.00 | 0.01 |
| Brick and Stone Operations | 83 | 0.15 | 0.01 | 0.07 | 0.00 | 0.01 |
| City and County Road Construction | 751 | 0.20 | 0.02 | 0.08 | 0.00 | 0.01 |
| Commercial Construction | 16,756 | 2.93 | 0.26 | 1.30 | 0.01 | 0.18 |
| Concrete Operations | 81 | 0.12 | 0.01 | 0.06 | 0.00 | 0.01 |
| County-Owned Construction | 284 | 0.15 | 0.01 | 0.07 | 0.00 | 0.01 |
| Cranes | 2,815 | 4.84 | 0.33 | 1.24 | 0.02 | 0.24 |
| Heavy Highway Construction | 646 | 0.60 | 0.05 | 0.27 | 0.00 | 0.05 |
| Landfill Operations | 137 | 0.49 | 0.04 | 0.20 | 0.00 | 0.04 |
| Landscaping Activities | 1,245 | 0.45 | 0.08 | 0.40 | 0.00 | 0.06 |
| Manufacturing Operations | 152 | 0.20 | 0.02 | 0.10 | 0.00 | 0.02 |
| Municipal-Owned Construction | 1,203 | 0.49 | 0.07 | 0.38 | 0.00 | 0.06 |
| Transportation/Sales/Services | 1,656 | 1.99 | 0.18 | 1.12 | 0.01 | 0.18 |
| Residential Construction | 2,085 | 2.33 | 0.18 | 0.95 | 0.01 | 0.17 |
| Rough Terrain Forklifts | 3,315 | 2.21 | 0.19 | 1.53 | 0.01 | 0.22 |
| Scrap/Recycling Operations | 168 | 0.26 | 0.02 | 0.11 | 0.00 | 0.02 |
| Skid Steer Loaders | 10,600 | 2.59 | 0.63 | 3.21 | 0.01 | 0.51 |
| Special Trades Construction | 84 | 0.03 | 0.00 | 0.02 | 0.00 | 0.00 |
| Trenchers | 5,261 | 3.00 | 0.23 | 1.89 | 0.01 | 0.25 |
| TxDOT Construction Equipment | 190 | 0.06 | 0.01 | 0.03 | 0.00 | 0.00 |
| Utility Construction | 2,659 | 0.76 | 0.06 | 0.32 | 0.00 | 0.05 |
| Mining and Quarry Operations | 78 | 0.19 | 0.02 | 0.07 | 0.00 | 0.01 |
| Miscellaneous Equipment | 4,772 | 1.61 | 0.17 | 0.87 | 0.00 | 0.12 |
| HGB Total | 2,051,311 | 56.58 | 40.13 | 518.44 | 0.17 | 4.74 |

**Table 4-25: 2017 HGB Area Non-Road Emissions Inventory by Diesel Subcategory**

| Non-Road DCE Subsector | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Non-Diesel Equipment | 2,170,003 | 18.75 | 27.17 | 464.23 | 0.07 | 1.94 |

| Non-Road DCE Subsector | Equipment Population | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Agricultural Activities | 729 | 0.33 | 0.04 | 0.20 | 0.00 | 0.03 |
| Boring and Drilling Equipment | 384 | 0.20 | 0.02 | 0.06 | 0.00 | 0.01 |
| Brick and Stone Operations | 108 | 0.08 | 0.01 | 0.04 | 0.00 | 0.01 |
| City and County Road Construction | 808 | 0.15 | 0.01 | 0.05 | 0.00 | 0.01 |
| Commercial Construction | 23,772 | 3.01 | 0.27 | 1.28 | 0.00 | 0.17 |
| Concrete Operations | 109 | 0.07 | 0.01 | 0.04 | 0.00 | 0.01 |
| County-Owned Construction | 307 | 0.11 | 0.01 | 0.05 | 0.00 | 0.01 |
| Cranes | 3,362 | 2.64 | 0.30 | 0.68 | 0.01 | 0.12 |
| Heavy Highway Construction | 901 | 0.44 | 0.05 | 0.20 | 0.00 | 0.03 |
| Landfill Operations | 148 | 0.15 | 0.03 | 0.05 | 0.00 | 0.01 |
| Landscaping Activities | 1,350 | 0.34 | 0.05 | 0.28 | 0.00 | 0.04 |
| Manufacturing Operations | 205 | 0.13 | 0.02 | 0.06 | 0.00 | 0.01 |
| Municipal-Owned Construction | 1,302 | 0.37 | 0.04 | 0.25 | 0.00 | 0.03 |
| Transportation/Sales/Services | 2,268 | 1.32 | 0.17 | 0.74 | 0.00 | 0.11 |
| Residential Construction | 2,701 | 1.59 | 0.16 | 0.66 | 0.00 | 0.12 |
| Rough Terrain Forklifts | 4,480 | 1.52 | 0.15 | 1.04 | 0.00 | 0.15 |
| Scrap/Recycling Operations | 188 | 0.09 | 0.02 | 0.03 | 0.00 | 0.00 |
| Skid Steer Loaders | 16,771 | 3.20 | 0.65 | 3.62 | 0.00 | 0.55 |
| Special Trades Construction | 131 | 0.03 | 0.00 | 0.02 | 0.00 | 0.00 |
| Trenchers | 7,141 | 2.62 | 0.19 | 1.17 | 0.00 | 0.14 |
| TxDOT Construction Equipment | 190 | 0.04 | 0.00 | 0.02 | 0.00 | 0.00 |
| Utility Construction | 3,740 | 0.77 | 0.06 | 0.30 | 0.00 | 0.04 |
| Mining and Quarry Operations | 47 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 |
| Miscellaneous Equipment | 5,280 | 1.26 | 0.14 | 0.67 | 0.00 | 0.09 |
| HGB Total | 2,246,423 | 39.23 | 29.59 | 475.77 | 0.10 | 3.64 |

The non-road emissions data output from TexN were prepared for photochemical modeling using EPS3. Table 4-26: *EPS3 Modules for Processing Non-Road Emissions* summarizes the steps that were taken to process the 2012 and 2017 non-road inventories.

**Table 4-26: EPS3 Modules for Processing Non-Road Emissions**

| EPS3 Module | Description |
|---|---|
| PREAM | Convert text-based input files to binary format for further processing. |
| CNTLEM | Apply adjustments for temperature/humidity $NO_X$ correction and TxLED. |
| TMPRL | Apply profiles to temporally allocate daily emission totals. |
| SPCEMS | Chemically speciate VOC emissions into olefins, paraffins, etc. |
| GRDEM | Spatially allocate emissions with surrogates and prepare model inputs. |
| MRGUAM | Merge and adjust multiple gridded files for photochemical model input. |

When running a summer weekday scenario, the NONROAD model reports 24-hour emission totals and does not account for the effects of hourly variation in temperature and humidity on

$NO_X$ emissions. Greater detail on the development of correction equations to account for these effects can be found in Appendices F.4 and F.5 of the December 2004 HGB SIP revision. During EPS3 processing, the CNTLEM module is used to apply an hourly temperature/humidity $NO_X$ correction and the impacts on the 2012 and 2017 non-road HGB inventories are presented in Table 4-27: *Temperature/Humidity NOX Correction for Non-Road Emissions*.

**Table 4-27: Temperature/Humidity $NO_X$ Correction for Non-Road Emissions**

| **Calendar Year** | **Temperature/Humidity $NO_X$ Correction** (tpd) |
|---|---|
| 2012 | 3.88 |
| 2017 | 2.92 |

The 2012 and 2017 non-road $NO_X$ emission totals presented above in Table 4-18 through Table 4-25 exclude the benefits of Texas Low Emission Diesel (TxLED) fuel. Instead, TxLED benefits were accounted for by applying a $NO_X$ reduction to the diesel non-road equipment categories through use of the EPS3 CNTLEM module. The specific adjustment factors vary by horsepower range and certification standard, as summarized in Table 4-28: *Non-Road TxLED Adjustments by Horsepower and Standard*. More detail on development of the post-processing adjustments can be found in the September 27, 2001 EPA memorandum, *Texas Low Emission Diesel (LED) Fuel Benefits*.

**Table 4-28: Non-Road TxLED Adjustments by Horsepower and Standard**

| **Non-Road Diesel Equipment Standard/Category** | **TxLED $NO_X$ Reduction Factor** |
|---|---|
| Under 50 Horsepower | 0.0% |
| Base, Tier 0, Tier 1, and Tier 2 | 6.2% |
| Tier 3 and Tier 4 | 4.8% |

The 2012 and 2017 non-road TxLED benefits for the eight-county HGB area are presented in Table 4-29: *2012 and 2017 HGB Area Non-Road TxLED Benefits*.

**Table 4-29: 2012 and 2017 HGB Area Non-Road TxLED Benefits**

| **Calendar Year** | **TxLED $NO_X$ Reduction** (tpd) |
|---|---|
| 2012 | 1.91 |
| 2017 | 1.34 |

The activity level for different non-road equipment varies between weekday and weekend day types. For example, commercial construction equipment is more commonly used on weekdays than weekends. Conversely, recreational boats are more commonly used on weekends than on weekdays. The EPS3 TMPRL module is used to adjust the average weekday emissions by equipment type for creating Saturday and Sunday day types. Within each day type, TMPRL also allocates daily totals to each hour. After the CNTLEM and TMPRL adjustments are made, the EPS3 GRDEM module is used to spatially allocate the non-road emissions with surrogates that vary based on SCC. The files output from GRDEM are in the binary gridded format required by the photochemical model. The 2012 and 2017 non-road emissions output from GRDEM by day type for the eight-county HGB area are respectively summarized in Table 4-30: *2012 HGB Area*

*Non-Road Emissions Inventory by Day Type* and Table 4-31: *2017 HGB Area Non-Road Emissions Inventory by Day Type.*

**Table 4-30: 2012 HGB Area Non-Road Emissions Inventory by Day Type**

| 2012 Day Type | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Monday – Friday Average Weekday | 50.78 | 40.11 | 518.13 | 0.17 | 4.25 |
| Saturday | 37.69 | 77.62 | 678.12 | 0.14 | 3.19 |
| Sunday | 28.07 | 71.67 | 590.95 | 0.11 | 2.51 |

**Table 4-31: 2017 HGB Area Non-Road Emissions Inventory by Day Type**

| 2017 Day Type | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|
| Monday – Friday Average Weekday | 34.97 | 29.57 | 475.47 | 0.10 | 3.16 |
| Saturday | 26.60 | 53.93 | 633.37 | 0.09 | 2.34 |
| Sunday | 20.40 | 50.01 | 561.19 | 0.07 | 1.85 |

Comparing Table 4-30 and Table 4-31 with Table 4-18 through Table 4-25 indicates that the weekday VOC, CO, and $SO_2$ totals remain unchanged, while the weekday $NO_X$ totals are reduced by the temperature/humidity and TxLED adjustments presented in Table 4-27 and Table 4-29. The $PM_{2.5}$ totals are also slightly lower in Table 4-30 and Table 4-31 because they include only organic carbon, elemental carbon, and sulfate ($SO_4$). The $PM_{2.5}$ emissions from gasoline, compressed natural gas (CNG), and liquefied petroleum gas (LPG) equipment were allocated to these $PM_{2.5}$ categories based on profiles from the EPA SPECIATE Database. The amount allocated to these categories for diesel engines varies based on whether exhaust after-treatment is needed to meet applicable standards. To obtain these diesel $PM_{2.5}$ factors, the MOVES2014 model was run in default mode to obtain contributions by model year group for 2006-and-older and 2010-and newer diesel vehicles. The former group did not need after-treatment while the latter group does, and the 2007 through 2009 model years were not included in the analysis because they are transition years for the tighter standards. These $PM_{2.5}$ allocation methods are summarized in Table 4-32: *Speciation of Non-Road PM2.5 Emissions.*

**Table 4-32: Speciation of Non-Road $PM_{2.5}$ Emissions**

| Non-Road Fuel Type and/or Standard | $PM_{2.5}$ Allocation Approach |
|---|---|
| Gasoline | SPECIATE profile 92113 for non-road gasoline exhaust |
| CNG and LPG | SPECIATE profile 92112 for natural gas combustion |
| Diesel – Base and Tiers 0-3 | MOVES2014 default runs for 2006-and-older without after-treatment |
| Diesel – Tier 4 | MOVES2014 default for 2010-and-newer with after-treatment |

For the non-HGB areas of Texas, the steps described above are similar for the TexN development and EPS3 processing of non-road emission estimates for 2012 and 2017. The EPS3 processing for Texas non-road emissions is divided into streams for:

- the eight-county HGB area;
- the 10-county DFW area;
- the remaining 92 of all 110 eastern Texas counties subject to TxLED; and

- the 144 counties of western Texas not subject to TxLED.

The non-road EPS3 processing streams for non-road sources are available for both 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/nonroad/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/nonroad/tex/, respectively. The following pages contain graphical plots of the 2012 and 2017 summer weekday non-road $NO_X$ and VOC emissions for the HGB area. These plots are respectively titled Figure 4-11: *2012 Summer Weekday HGB Non-Road NOX Emissions Distribution*, Figure 4-12: *2012 Summer Weekday HGB Non-Road VOC Emissions Distribution*, Figure 4-13: *2017 Summer Weekday HGB Non-Road NOX Emissions Distribution*, and Figure 4-14: *2017 Summer Weekday HGB Non-Road VOC Emissions Distribution*.

For the non-Texas U.S. areas of the modeling domain, the EPA National Mobile Inventory Model (NMIM) was run for 2012 and 2017 to obtain non-road emission estimates for each county. The NMIM output was processed through EPS3 in a manner similar to that described above for non-road emissions within Texas.

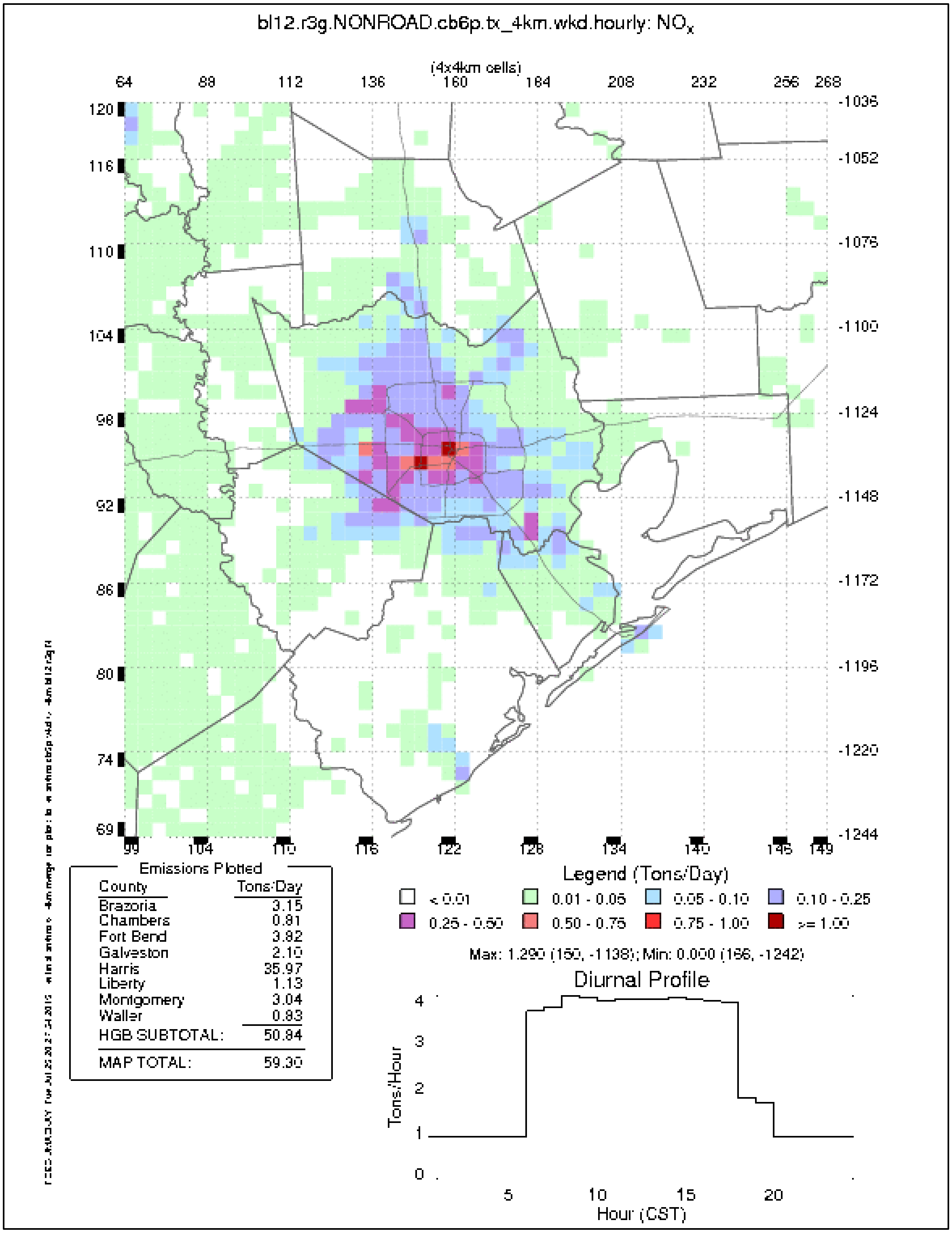


**Figure 4-11: 2012 Summer Weekday HGB Non-Road $NO_X$ Emissions Distribution**

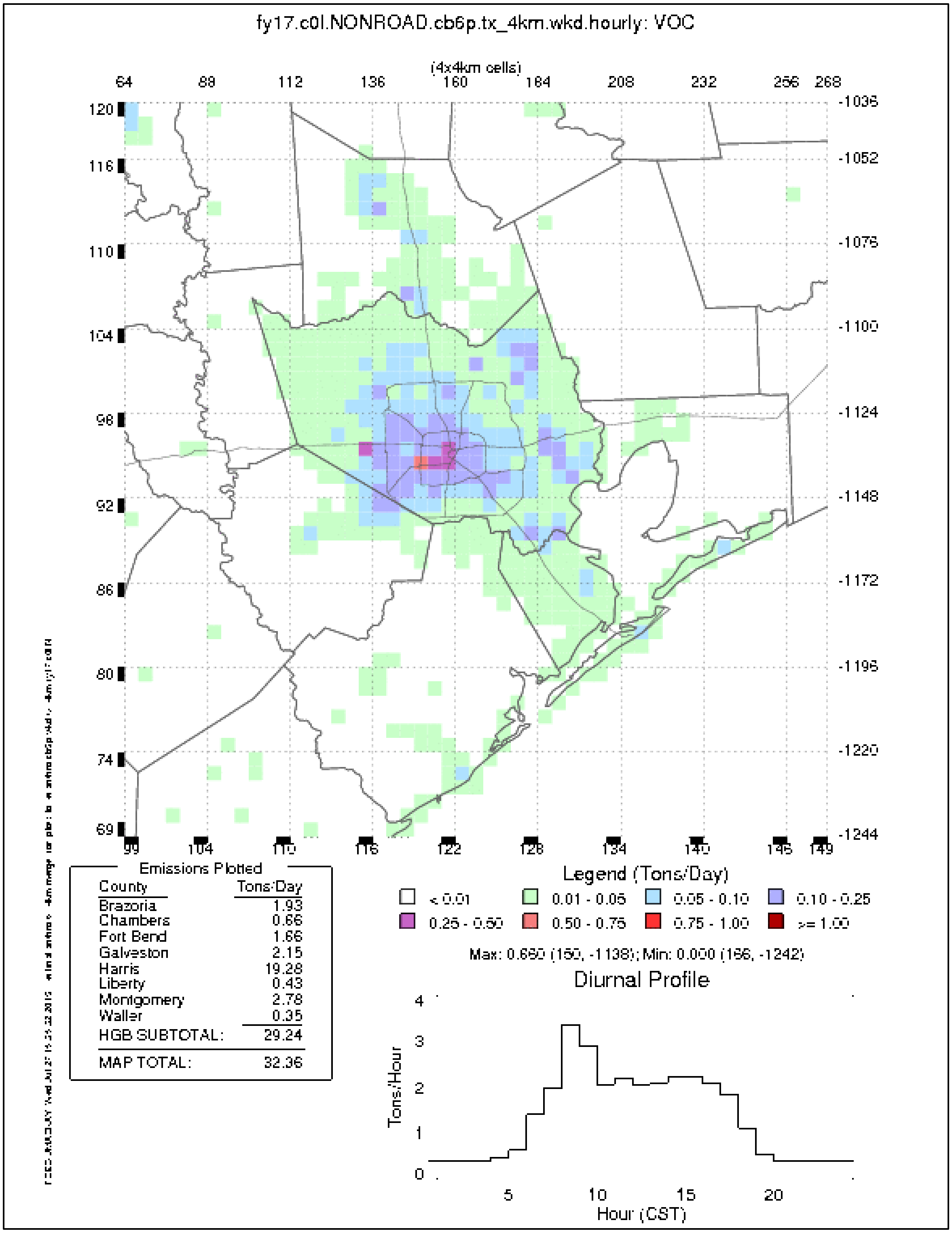


**Figure 4-12: 2012 Summer Weekday HGB Non-Road VOC Emissions Distribution**

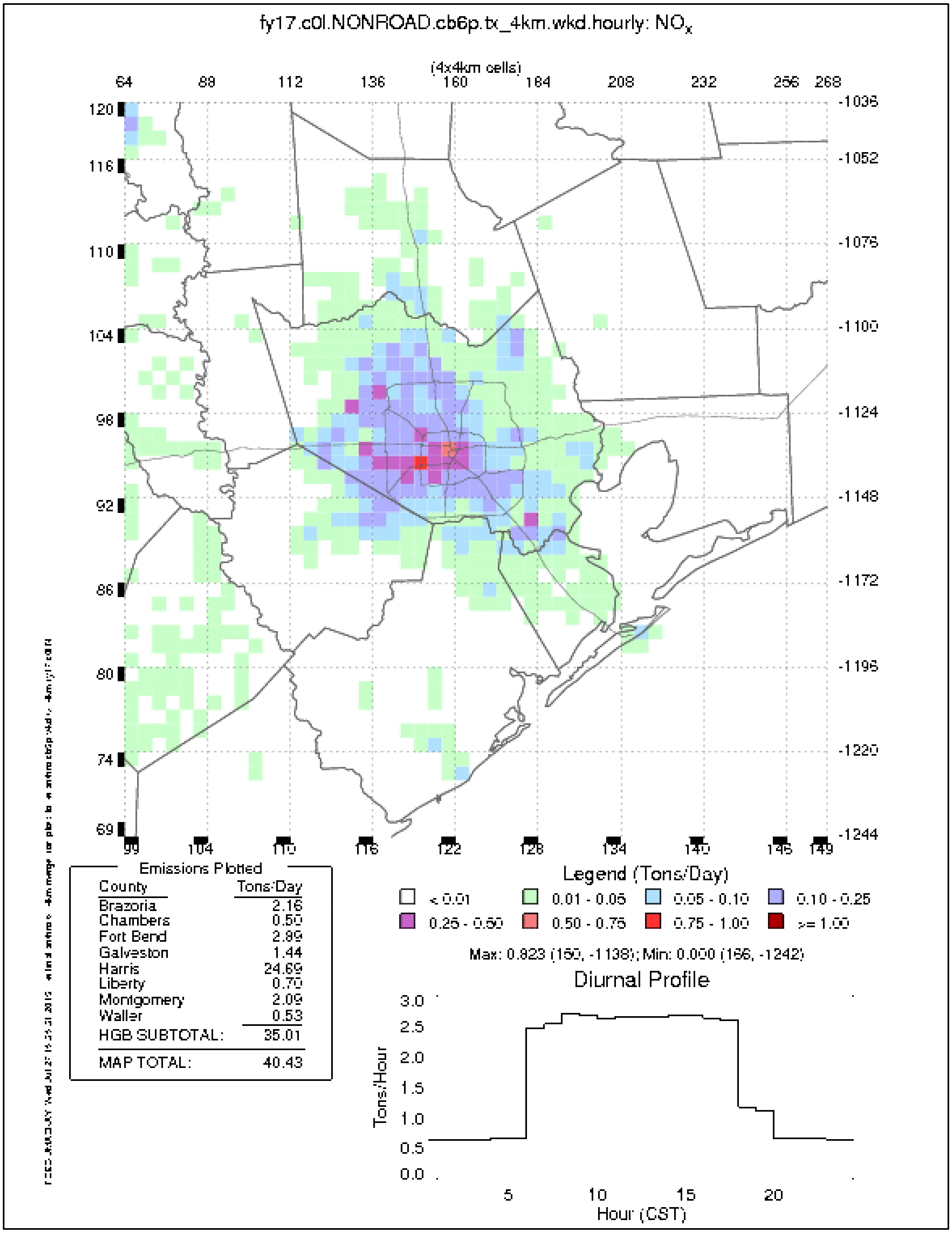


**Figure 4-13: 2017 Summer Weekday HGB Non-Road $NO_X$ Emissions Distribution**

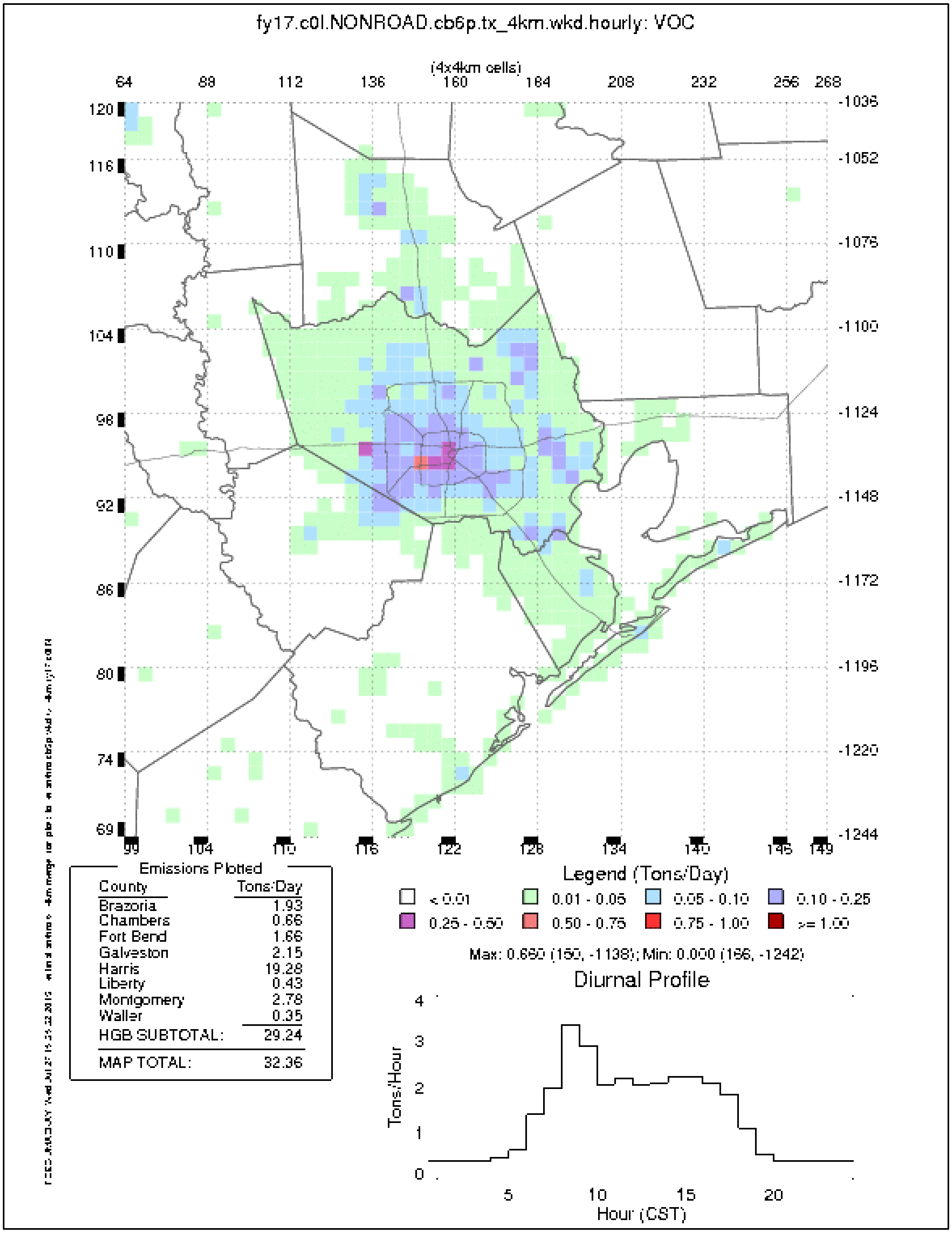


**Figure 4-14: 2017 Summer Weekday HGB Non-Road VOC Emissions Distribution**

## 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 commonly used 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. Area source modeling estimates were based primarily on data from the 2011 and 2014 periodic emissions inventories, which are available via TexAER at http://www.tceq.state.tx.us/airquality/areasource/TexAER.html.

The $NO_X$, VOC, CO, $SO_2$, $NH_3$, and $PM_{2.5}$ area source emissions by county from TexAER for 2011 and 2014, respectively, are presented below in Table 4-33: *2011 HGB Area Source Emissions Inventory by County* and Table 4-34: *2014 HGB Area Source Emissions Inventory by County*.

**Table 4-33: 2011 HGB Area Source Emissions Inventory by County**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 1.60 | 18.46 | 23.22 | 0.04 | 6.28 | 13.68 |
| Chambers | 0.14 | 1.92 | 0.88 | 0.04 | 1.54 | 3.25 |
| Fort Bend | 1.42 | 15.76 | 2.90 | 0.28 | 3.92 | 10.30 |
| Galveston | 0.88 | 9.81 | 1.93 | 0.13 | 0.88 | 4.34 |
| Harris | 15.92 | 167.93 | 23.74 | 3.61 | 13.08 | 34.75 |
| Liberty | 0.29 | 4.03 | 3.13 | 0.03 | 3.52 | 5.64 |
| Montgomery | 2.20 | 16.62 | 31.08 | 0.26 | 3.10 | 21.41 |
| Waller | 0.23 | 1.64 | 2.44 | 0.05 | 3.09 | 2.48 |
| HGB Total | 22.68 | 236.17 | 89.34 | 4.45 | 35.40 | 95.84 |

**Table 4-34: 2014 HGB Area Source Emissions Inventory by County**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 1.57 | 18.39 | 19.90 | 0.50 | 5.41 | 12.72 |
| Chambers | 0.16 | 1.98 | 1.54 | 0.08 | 1.32 | 3.06 |
| Fort Bend | 1.50 | 15.23 | 3.71 | 0.49 | 3.01 | 9.48 |
| Galveston | 0.89 | 9.84 | 2.31 | 0.24 | 1.76 | 3.83 |
| Harris | 16.36 | 157.61 | 22.05 | 6.54 | 11.79 | 34.29 |
| Liberty | 0.32 | 3.89 | 4.51 | 0.07 | 2.20 | 7.43 |
| Montgomery | 2.22 | 17.28 | 33.53 | 0.44 | 1.76 | 19.49 |
| Waller | 0.22 | 1.54 | 1.32 | 0.11 | 2.22 | 4.03 |

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| HGB Total | 23.24 | 225.75 | 88.89 | 8.48 | 29.47 | 94.34 |

The 2011 and 2014 area source emissions data from TexAER were prepared for photochemical modeling using EPS3. Table 4-35: *EPS3 Modules for Processing Area Source Emission Inventories* summarizes the steps that were taken to prepare the 2012 and 2017 area source emission inventories.

**Table 4-35: EPS3 Modules for Processing Area Source Emission Inventories**

| EPS3 Module | Description |
|---|---|
| PREAM | Convert text-based input files to binary format for further processing. |
| CNTLEM | Project 2011 emissions to 2012, and 2014 emissions to 2017. |
| SPCEMS | Chemically speciate VOC emissions into olefins, paraffins, etc. |
| TMPRL | Apply profiles to temporally allocate daily emission totals. |
| GRDEM | Spatially allocate emissions with surrogates and prepare model inputs. |
| MRGUAM | Merge and adjust multiple gridded files for photochemical model input. |

As shown, the EPS3 CNTLEM module was used to project 2011 HGB area source emission estimates from TexAER to 2012, and to project the 2014 HGB area source emission estimates to 2017. In both cases, a study done under contract by ERG was conducted to develop growth factors from 2005 through 2030 based on data available from Moody's Analytics and the U.S. EIA. More detail on this analysis is available within TexAER. The adjusted $NO_X$, VOC, CO, $SO_2$, $NH_3$, and $PM_{2.5}$ area source emissions for 2012 and 2017, respectively, by county are presented below in Table 4-36: *2012 HGB Area Source Emissions Inventories by County* and Table 4-37: *2017 HGB Area Source Emission Inventories by County*.

**Table 4-36: 2012 HGB Area Source Emissions Inventories by County**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 1.93 | 20.81 | 30.97 | 0.05 | 6.28 | 14.40 |
| Chambers | 0.16 | 2.10 | 1.06 | 0.05 | 1.54 | 3.29 |
| Fort Bend | 1.56 | 18.84 | 3.03 | 0.34 | 3.93 | 10.35 |
| Galveston | 0.96 | 11.73 | 2.01 | 0.16 | 0.88 | 4.36 |
| Harris | 17.89 | 199.61 | 25.23 | 4.32 | 13.13 | 35.08 |
| Liberty | 0.34 | 4.80 | 3.97 | 0.04 | 3.52 | 5.76 |
| Montgomery | 2.68 | 20.43 | 42.28 | 0.31 | 3.10 | 22.49 |
| Waller | 0.27 | 1.91 | 2.90 | 0.07 | 3.09 | 2.54 |
| HGB Total | 25.79 | 280.22 | 111.45 | 5.33 | 35.47 | 98.26 |

**Table 4-37: 2017 HGB Area Source Emission Inventories by County**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Brazoria | 1.88 | 20.73 | 26.56 | 0.57 | 5.41 | 13.35 |

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Chambers | 0.18 | 2.21 | 1.78 | 0.09 | 1.32 | 3.10 |
| Fort Bend | 1.67 | 18.03 | 3.96 | 0.56 | 3.02 | 9.58 |
| Galveston | 0.97 | 11.78 | 2.43 | 0.28 | 1.77 | 3.87 |
| Harris | 18.44 | 187.82 | 24.10 | 7.50 | 11.85 | 34.82 |
| Liberty | 0.38 | 4.64 | 5.69 | 0.08 | 2.20 | 7.58 |
| Montgomery | 2.80 | 21.72 | 47.95 | 0.51 | 1.76 | 20.79 |
| Waller | 0.26 | 1.81 | 1.53 | 0.13 | 2.22 | 4.08 |
| HGB Total | 26.58 | 268.74 | 113.99 | 9.72 | 29.55 | 97.17 |

The eight-county HGB area source emissions inventory includes 174 different types of SCCs. The eight-county HGB aggregate SCC categories for the area source emissions are summarized for 2012 and 2017, respectively, in Table 4-38: *2012 HGB Area Source Emission Inventories by Aggregate Category* and Table 4-39: *2017 HGB Area Source Emission Inventories by Aggregate Category*.

**Table 4-38: 2012 HGB Area Source Emission Inventories by Aggregate Category**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Agricultural Production | 0.07 | 0.38 | 2.42 | 0.00 | 24.09 | 3.69 |
| Catastrophic/Accidental Releases | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chemical Transport | 0.00 | 3.53 | 0.00 | 0.00 | 0.00 | 0.00 |
| Commercial/Institutional | 6.56 | 86.19 | 3.97 | 0.18 | 0.04 | 0.13 |
| Construction | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.99 |
| Degreasing | 0.00 | 10.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dry Cleaning | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fabricated Metals | 0.00 | 0.95 | 0.00 | 0.00 | 0.00 | 0.00 |
| Food and Kindred Products | 0.00 | 1.27 | 1.71 | 0.00 | 0.00 | 4.61 |
| Graphic Arts | 0.00 | 15.29 | 0.00 | 0.00 | 0.00 | 0.00 |
| Incineration, Burning, and Combustion | 2.44 | 5.48 | 75.81 | 0.07 | 0.00 | 7.62 |
| Industrial | 9.82 | 7.99 | 6.75 | 4.99 | 0.37 | 0.29 |
| Landfills | 0.00 | 3.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| Petroleum Refining, Storage, and Transport | 0.00 | 76.75 | 0.03 | 0.00 | 0.00 | 0.00 |
| Residential | 6.90 | 3.32 | 20.76 | 0.09 | 0.18 | 2.91 |
| Roads - Paved and Unpaved | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 58.04 |
| Rubber/Plastics | 0.00 | 2.48 | 0.00 | 0.00 | 0.00 | 0.00 |
| Secondary Metal Production | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Surface Coating | 0.00 | 61.41 | 0.00 | 0.00 | 0.00 | 0.00 |
| Underground Storage Tanks | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| Waste Animal Emissions | 0.00 | 0.00 | 0.00 | 0.00 | 10.72 | 0.00 |
| Wastewater Treatment | 0.00 | 0.32 | 0.00 | 0.00 | 0.06 | 0.00 |
| HGB Total | 25.79 | 280.22 | 111.45 | 5.33 | 35.47 | 98.26 |

**Table 4-39: 2017 HGB Area Source Emission Inventories by Aggregate Category**

| HGB Area County | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Agricultural Production | 0.20 | 0.33 | 4.68 | 0.08 | 16.62 | 3.72 |
| Catastrophic/Accidental Releases | 0.00 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chemical Transport | 0.00 | 3.58 | 0.00 | 0.00 | 0.00 | 0.00 |
| Commercial/Institutional | 5.30 | 89.15 | 3.66 | 0.15 | 0.00 | 0.00 |
| Construction | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.79 |
| Degreasing | 0.00 | 12.23 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dry Cleaning | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fabricated Metals | 0.00 | 1.07 | 0.00 | 0.00 | 0.00 | 0.00 |
| Food and Kindred Products | 0.00 | 1.37 | 2.04 | 0.00 | 0.00 | 5.05 |
| Graphic Arts | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| Incineration, Burning, and Combustion | 2.36 | 5.26 | 73.28 | 0.06 | 0.00 | 7.09 |
| Industrial | 11.52 | 8.32 | 8.05 | 9.35 | 0.36 | 0.35 |
| Landfills | 0.00 | 3.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| Petroleum Refining, Storage, and Transport | 0.00 | 69.33 | 0.03 | 0.00 | 0.00 | 0.00 |
| Residential | 7.20 | 3.67 | 22.26 | 0.09 | 1.55 | 3.07 |
| Roads - Paved and Unpaved | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.50 |
| Rubber/Plastics | 0.00 | 3.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| Secondary Metal Production | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Surface Coating | 0.00 | 65.64 | 0.00 | 0.00 | 0.00 | 0.00 |
| Underground Storage Tanks | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 |
| Waste Animal Emissions | 0.00 | 0.00 | 0.00 | 0.00 | 10.95 | 0.00 |
| Wastewater Treatment | 0.00 | 0.36 | 0.00 | 0.00 | 0.07 | 0.00 |
| HGB Total | 26.58 | 268.74 | 113.99 | 9.72 | 29.55 | 96.58 |

The activity level for different area source categories differs between weekday and weekend day types. The EPS3 TMPRL module is used to adjust the average weekday emissions by SCC for creating Saturday and Sunday day types. Within each day type, TMPRL also allocates daily totals to each hour. After the CNTLEM and TMPRL adjustments are made, the EPS3 GRDEM module is used to spatially allocate the area source emissions with surrogates that vary based on SCC. For example, residential fuel use emissions are spatially allocated to grid cells as a function of households. The files output from GRDEM are in the binary gridded format required by the photochemical model. The area source output from GRDEM by day type for the eight-county HGB area are summarized for 2012 and 2017, respectively, in Table 4-40: *2012 HGB Area Source Emission Inventories by Day Type* and Table 4-41: *2017 HGB Area Source Emission Inventories by Day Type*.

**Table 4-40: 2012 HGB Area Source Emission Inventories by Day Type**

| 2012 Day Type | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Monday – Friday Average Weekday | 25.79 | 280.22 | 111.45 | 5.33 | 35.47 | 98.26 |

| 2012 Day Type | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Saturday | 19.65 | 164.91 | 70.52 | 3.74 | 35.35 | 94.33 |
| Sunday | 13.53 | 115.89 | 30.40 | 2.16 | 35.22 | 90.49 |

**Table 4-41: 2017 HGB Area Source Emission Inventories by Day Type**

| 2017 Day Type | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Monday – Friday Average Weekday | 26.58 | 268.74 | 113.99 | 9.72 | 29.55 | 97.17 |
| Saturday | 20.37 | 164.31 | 74.05 | 6.84 | 29.44 | 93.57 |
| Sunday | 14.19 | 116.83 | 34.89 | 3.97 | 29.33 | 90.04 |

For the non-HGB areas of Texas, the steps described above are similar for the area source emissions inventory development where TexAER datasets from 2011 and 2014 were adjusted to create 2012 and 2017 inventories, respectively. The EPS3 processing for Texas area source emissions is divided into streams for:

- the eight-county HGB area;
- the 10-county DFW area;
- the remaining 236 counties of Texas outside of DFW and HGB.

The complete EPS3 processing streams for the area sources are available for both 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/area/tex/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/area/tex/, respectively. The following pages contain graphical plots of the 2012 and 2017 area source $NO_X$ and VOC emissions for the HGB area. These plots are respectively titled Figure 4-15: *2012 HGB Area Source NOX Emissions Distribution*, Figure 4-16: *2012 HGB Area Source VOC Emissions Distribution*, Figure 4-17: *2017 HGB Area Source NOX Emissions Distribution*, and Figure 4-18: *2017 HGB Area Source VOC Emissions Distribution*.

For the non-Texas U.S. areas of the modeling domain, area source emission estimates from the EPA NEI were used. The 2011 area source NEI was projected to 2012 and 2017 to develop the non-Texas inputs. The area source emission estimates from the NEI datasets were processed through EPS3 in a manner similar to that described above for the area source emissions within Texas. The non-Texas EPS3 processing streams for area sources for both 2012 and 2017 are available at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/area/usa/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/area/usa/, respectively.

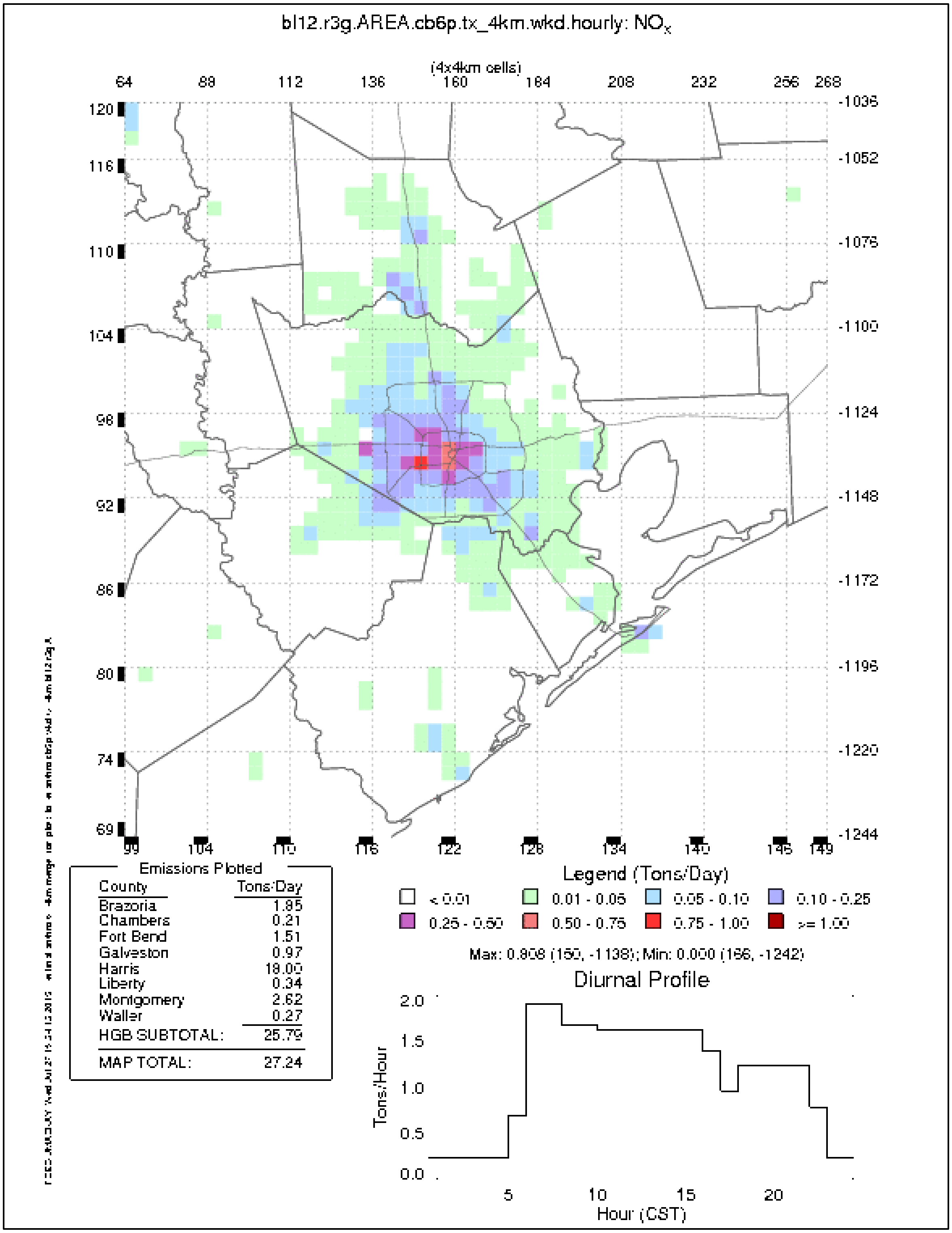


**Figure 4-15: 2012 HGB Area Source $NO_X$ Emissions Distribution**

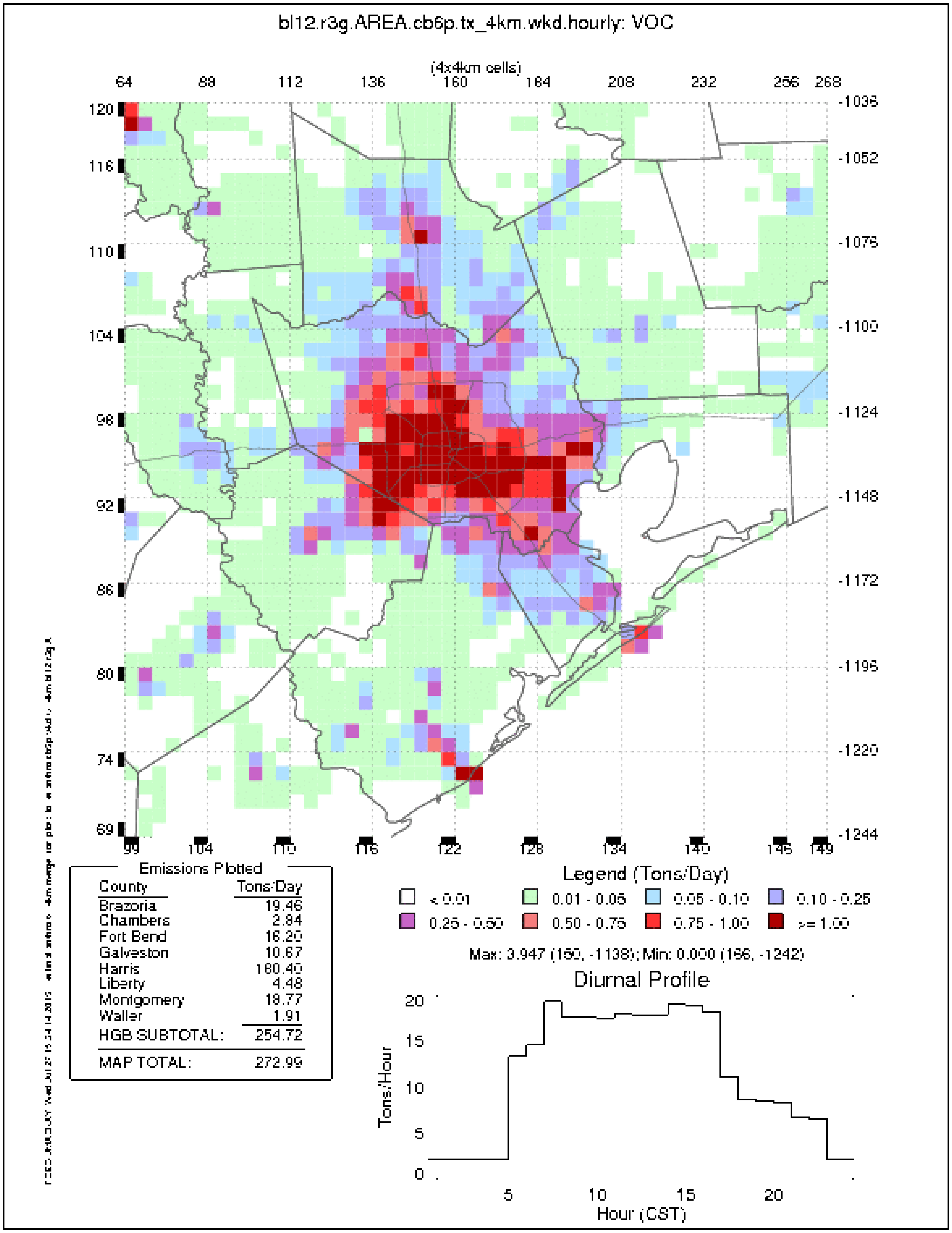


**Figure 4-16: 2012 HGB Area Source VOC Emissions Distribution**

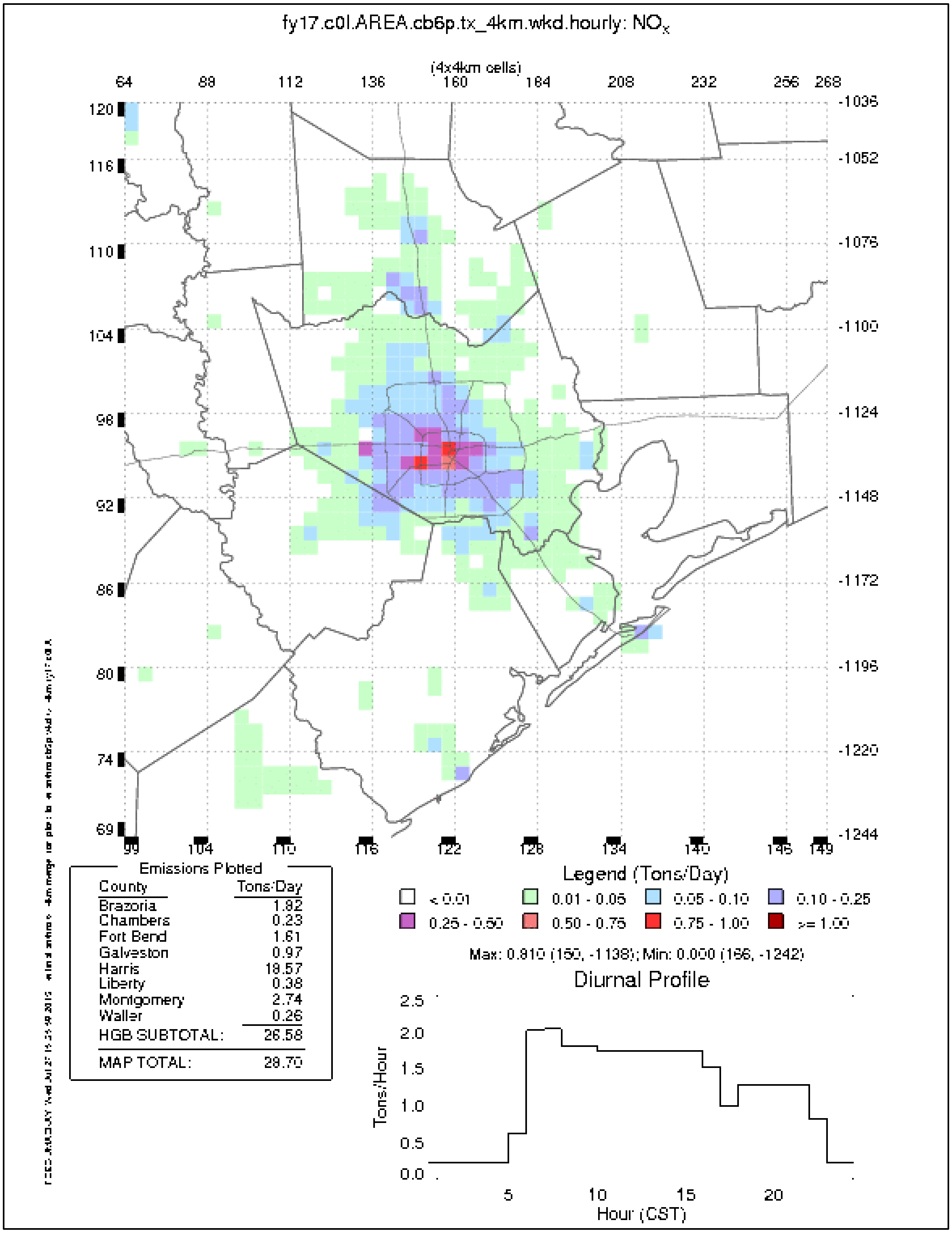


**Figure 4-17: 2017 HGB Area Source $NO_X$ Emissions Distribution**

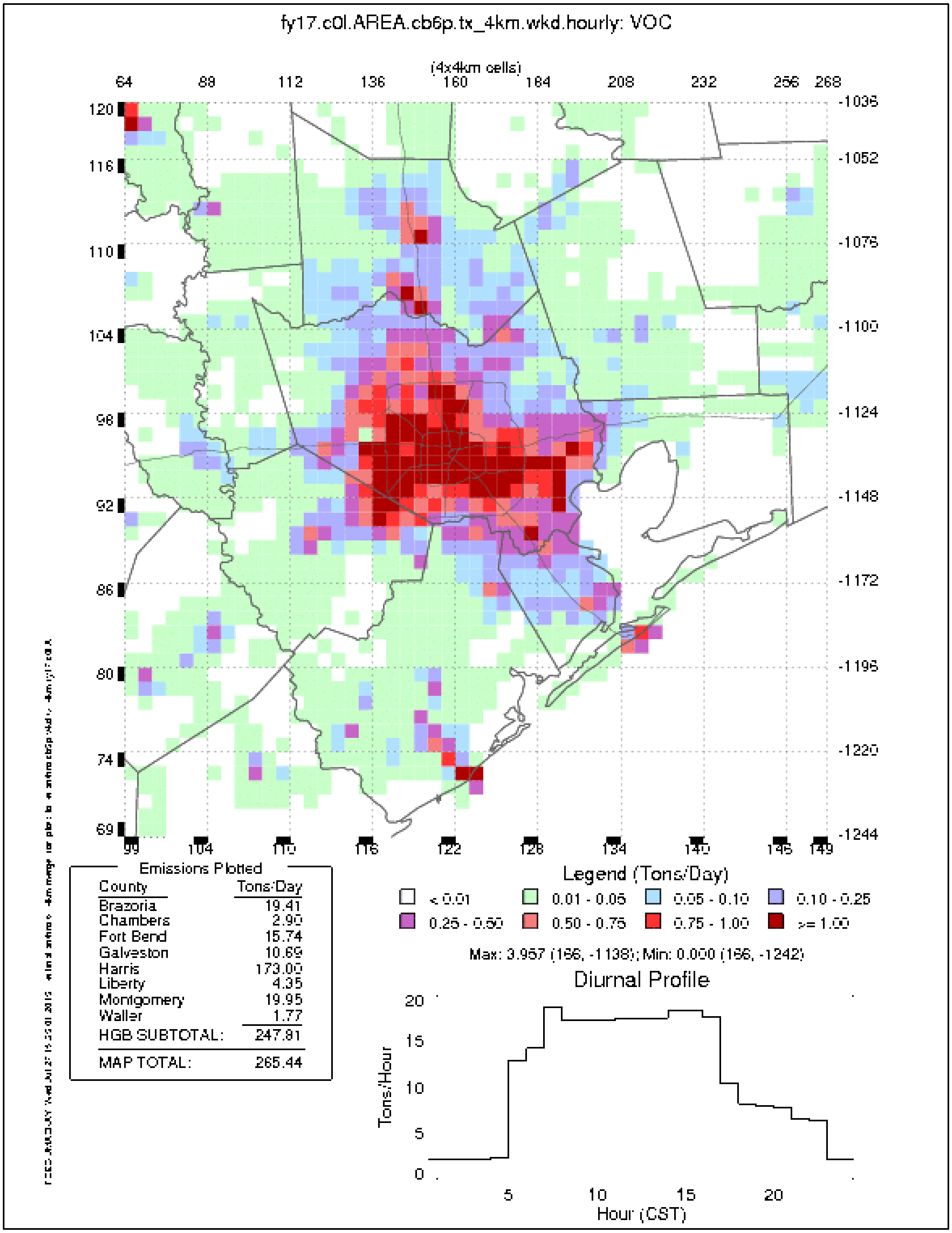


**Figure 4-18: 2017 HGB Area Source VOC Emissions Distribution**

## 4.6 Commercial Marine Emissions

Commercial marine emission estimates were developed under contract to Ramboll-Environ and detailed in *Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling*, which is available at https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784006FY1005-20100818-environ-HGBShipsEI.pdf. The emission estimates were projected to 2012 and 2017 based on expected changes in shipping activity and reductions in emission rates from engine turnover. The 2012 and 2017 eight-county HGB commercial marine emission estimates by vessel type are summarized in Table 4-42: *2012 HGB Commercial Marine Emissions by Source Category* and *Table 4-43: 2017 HGB Commercial Marine Emissions by Source Category*, respectively.

**Table 4-42: 2012 HGB Commercial Marine Emissions by Source Category**

| Commercial Marine Source Classification Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Chemical Tanker | 8.75 | 0.43 | 0.92 | 21.90 | 0.00 | 1.30 |
| Tow Boat | 5.05 | 0.22 | 1.60 | 0.11 | 0.00 | 0.26 |
| Crude Tanker | 2.95 | 0.15 | 0.31 | 6.75 | 0.00 | 0.41 |
| General Cargo | 2.16 | 0.10 | 0.22 | 2.60 | 0.00 | 0.22 |
| Container Ship | 2.07 | 0.14 | 0.26 | 1.82 | 0.00 | 0.19 |
| Bulk | 1.63 | 0.08 | 0.17 | 1.50 | 0.00 | 0.14 |
| LNG/LPG Tanker | 1.29 | 0.05 | 0.13 | 1.42 | 0.00 | 0.13 |
| Ocean Towing | 0.78 | 0.04 | 0.08 | 0.01 | 0.00 | 0.02 |
| Dredging | 0.70 | 0.03 | 0.25 | 0.01 | 0.00 | 0.04 |
| Auto Carrier | 0.68 | 0.03 | 0.07 | 0.55 | 0.00 | 0.06 |
| Refrigerated Cargo | 0.38 | 0.01 | 0.04 | 0.36 | 0.00 | 0.04 |
| Other Tanker | 0.37 | 0.02 | 0.04 | 0.31 | 0.00 | 0.03 |
| Tug Barge | 0.31 | 0.02 | 0.04 | 0.01 | 0.00 | 0.01 |
| Cruise Ship | 0.27 | 0.01 | 0.03 | 0.27 | 0.00 | 0.02 |
| Harbor Vessel | 0.20 | 0.01 | 0.04 | 0.00 | 0.00 | 0.01 |
| Miscellaneous | 0.13 | 0.01 | 0.01 | 0.11 | 0.00 | 0.01 |
| Assist Tug | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Drill Rig | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Military | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HGB Total | 27.74 | 1.33 | 4.21 | 37.73 | 0.00 | 2.89 |

**Table 4-43: 2017 HGB Commercial Marine Emissions by Source Category**

| Commercial Marine Source Classification Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Chemical Tanker | 6.67 | 0.44 | 0.93 | 5.41 | 0.00 | 0.20 |
| Tow Boat | 4.24 | 0.19 | 1.66 | 0.02 | 0.00 | 0.20 |
| Crude Tanker | 2.28 | 0.15 | 0.32 | 1.69 | 0.00 | 0.07 |
| Container Ship | 1.91 | 0.17 | 0.33 | 0.54 | 0.00 | 0.04 |
| General Cargo | 1.82 | 0.11 | 0.25 | 0.71 | 0.00 | 0.04 |

| Commercial Marine Source Classification Description | $NO_X$ (tpd) | VOC (tpd) | CO (tpd) | $SO_2$ (tpd) | $NH_3$ (tpd) | $PM_{2.5}$ (tpd) |
|---|---|---|---|---|---|---|
| Bulk | 1.33 | 0.08 | 0.18 | 0.40 | 0.00 | 0.02 |
| LNG/LPG Tanker | 1.00 | 0.06 | 0.13 | 0.36 | 0.00 | 0.02 |
| Ocean Towing | 0.65 | 0.04 | 0.09 | 0.00 | 0.00 | 0.00 |
| Auto Carrier | 0.60 | 0.03 | 0.08 | 0.15 | 0.00 | 0.01 |
| Dredging | 0.52 | 0.03 | 0.23 | 0.00 | 0.00 | 0.03 |
| Refrigerated Cargo | 0.32 | 0.02 | 0.04 | 0.10 | 0.00 | 0.01 |
| Other Tanker | 0.31 | 0.02 | 0.04 | 0.08 | 0.00 | 0.01 |
| Tug Barge | 0.26 | 0.01 | 0.04 | 0.00 | 0.00 | 0.01 |
| Cruise Ship | 0.19 | 0.01 | 0.03 | 0.07 | 0.00 | 0.00 |
| Harbor Vessel | 0.17 | 0.01 | 0.04 | 0.00 | 0.00 | 0.01 |
| Miscellaneous | 0.11 | 0.01 | 0.02 | 0.03 | 0.00 | 0.00 |
| Assist Tug | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Drill Rig | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Military | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| HGB Total | 22.41 | 1.37 | 4.41 | 9.56 | 0.00 | 0.65 |

The EPS3 processing streams for the commercial marine emissions are available for both 2012 and 2017 at ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/base_2012/offroad/marine/ and ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/future_2017/offroad/marine/, respectively. The following pages contain graphical plots of the 2012 and 2017 commercial marine $NO_X$ emissions for the HGB area. These plots are respectively titled *Figure 4-19: 2012 HGB Commercial Marine NOX Emissions* and *Figure 4-20: 2017 HGB Commercial Marine NOX Emissions*. Since the diesel engines that power commercial marine vessels are not significant contributors of VOC emissions, only $NO_X$ plots are provided here.

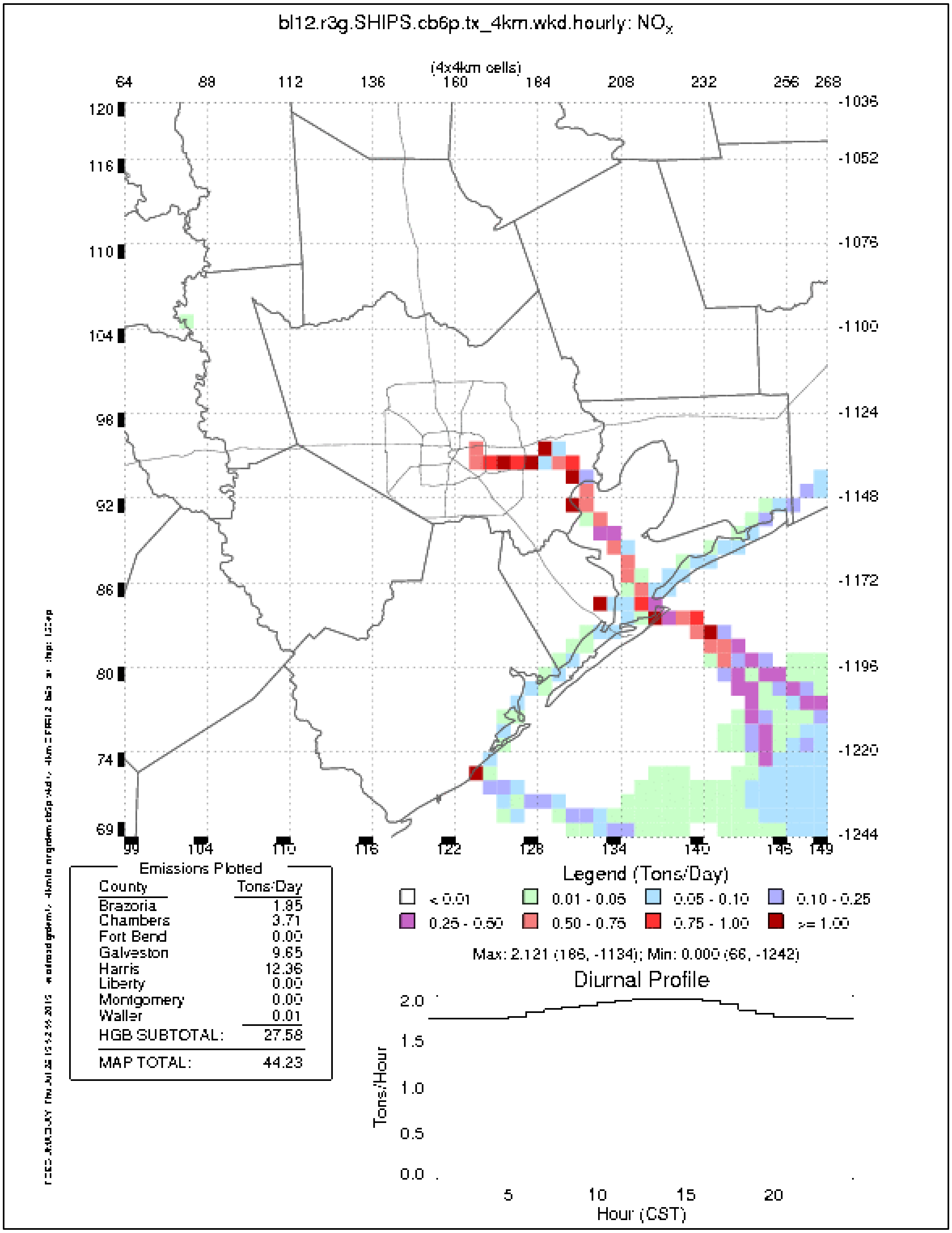


**Figure 4-19: 2012 HGB Commercial Marine $NO_X$ Emissions Distribution**

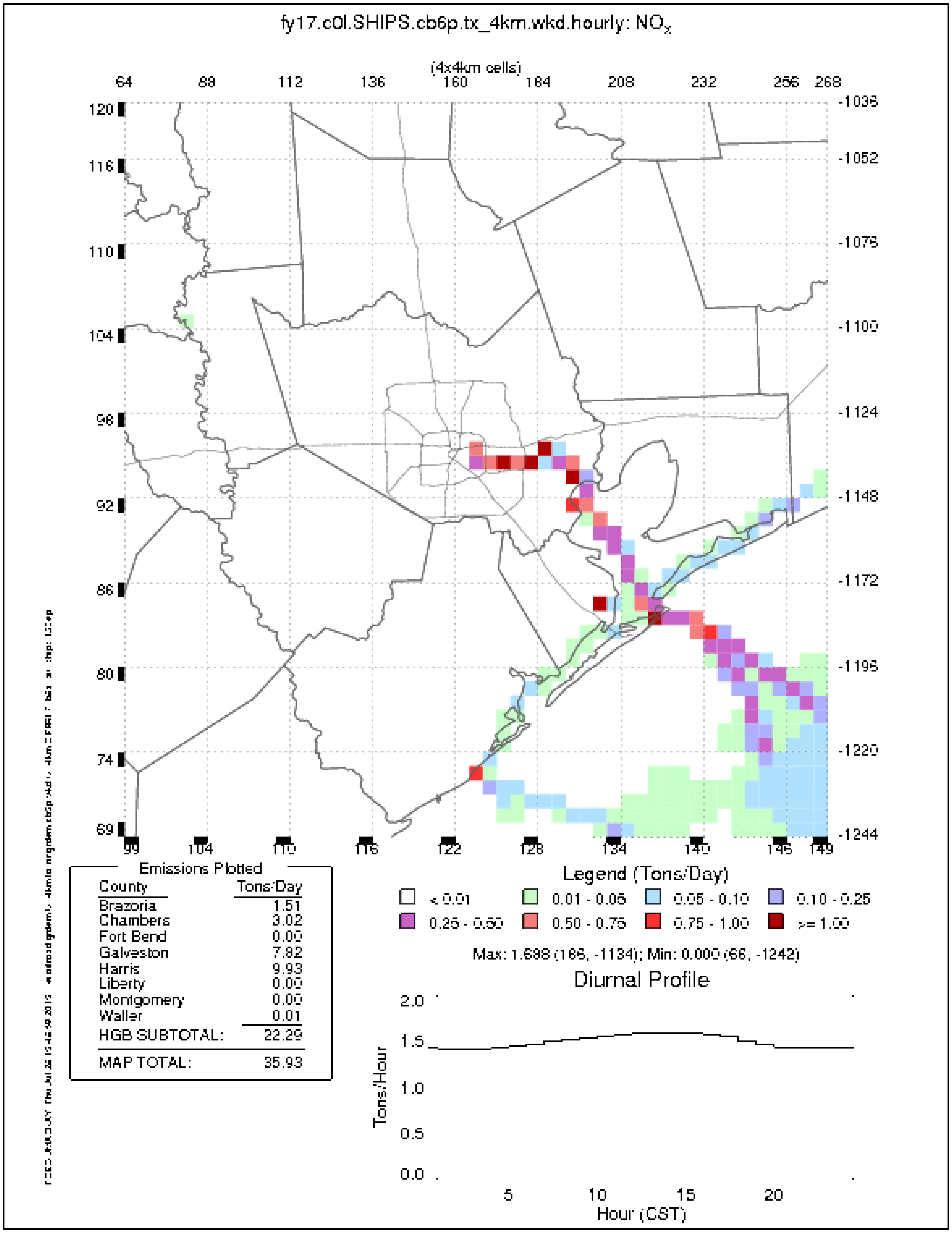


**Figure 4-20: 2017 HGB Commercial Marine $NO_X$ Emissions Distribution**

# 5. BIOGENIC MODELING EMISSIONS

The TCEQ used version 2.1 of the Model for Emissions of Gases and Aerosols from Nature (MEGAN) (Guenther, et al., 2012). The MEGAN model code, User's Guide, and default input data are available at http://lar.wsu.edu/megan/index.html. The MEGAN model requires inputs by model grid of:

- Emission factors for nineteen chemical compounds or compound groups;
- Plant Functional Types (PFTs);
- Fractional Vegetated Leaf Area Index (LAIv); and
- Meteorological information including air and soil temperatures, photosynthetically active radiation (PAR), barometric pressure, wind speed, water vapor mixing ratio and accumulated precipitation.

## 5.1 Emission Factor and PFT Inputs

The TCEQ used updated plant-specific basal emission factors and PFTs developed under the Air Quality Research Project 14-016, *Improved Land Cover and Emission Factor Inputs for Estimating Biogenic Isoprene and Monoterpene Emissions for Texas Air Quality Simulations* (AQRP, 2015). To process the emission factors and PFTs to the TCEQ air modeling domain structures, raster layers of each emission factor file were created in ArcMap version 9.3 using the *Make NetCDF Raster Layer* tool. The *Zonal Statistics as Table* tool was then used to tabulate averages per grid cell for each compound class and CAMx domain.

## 5.2 Fractional Vegetated Leaf Area Index Input

Leaf Area Index (LAI) is the one-sided leaf coverage over the same area of land. Fractional vegetated Leaf Area Index (LAIv) is LAI divided by the fraction of land defined as vegetated, and files for every eight-day period of 2008 are provided on the MEGAN website. The TCEQ created 2006-specific LAIv data using the level-4 Moderate-Resolution Imaging Spectroradiometer (MODIS) global LAI MCD15A2 product. For each eight-day period, the satellite tiles covering North America in a Sinusoidal grid were mosaicked using the MODIS Reprojection Tool (MRT). Urban LAI cells, which MODIS excludes, were filled according to a function that follows the North American average for four urban land cover types. An urban LAI maximum was chosen based on Loughner et al. (2012). MODIS' quality control flags were applied to use only high quality data from the main retrieval algorithm. The resultant LAI was divided by the annual maximum green vegetation fraction product from the U.S. Geological Survey per grid cell to yield the final LAIv.

## 5.3 Meteorological Input

The Weather Research and Forecasting (WRF) meteorological model provided the meteorological data needed for MEGAN input. The WRF modeling configuration is detailed in Appendix A: *Meteorological Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*.

## 5.4 Biogenic Emission Summary

The MEGAN model was run for each 2012 episode day. Since biogenic emissions are dependent upon the meteorological conditions on a given day, the same episode-specific emissions for the 2012 baseline were used in the 2017 future case modeling scenarios. Biogenic emission totals for one episode day per month are shown in Table 5-1: *Summary of Biogenic Emissions for Example 2012 Days*. The daily emission totals vary significantly depending on the available solar radiation and other meteorological parameters.

**Table 5-1: Summary of Biogenic Emissions for Example 2012 Days**

| Episode Day | Isoprene (tpd) | Monoterpenes (tpd) | Nitrogen Oxide (tpd) | Total VOC (tpd) |
|---|---|---|---|---|
| 5/15/2012 | 100.96 | 47.49 | 1.79 | 260.87 |
| 6/15/2012 | 429.90 | 109.84 | 4.81 | 821.89 |
| 7/15/2012 | 297.65 | 87.68 | 3.82 | 612.50 |
| 8/15/2012 | 508.60 | 125.13 | 5.40 | 952.72 |
| 9/15/2012 | 154.24 | 62.74 | 3.00 | 344.46 |

Isoprene and other biogenic VOC emissions were plotted to determine the location of emissions matched known forested areas as shown in Figure 5-1: *Biogenic Isoprene Emissions on June 26, 2012 for the 4 km Domain*. The highest isoprene concentrations are in the eastern part of the domain where dense forests exist in Texas, Louisiana, and Arkansas. CAMx output concentrations of the same VOC for the same time period are also plotted to ensure concentrations follow expected emission magnitudes and observations. An example concentration plot of isoprene with observations plotted as colored circles for June 26, 2012 at 15:00 is displayed in Figure 5-2: *Modeled CAMx Isoprene Concentrations for June 26, 2012 at 15:00 CST*.

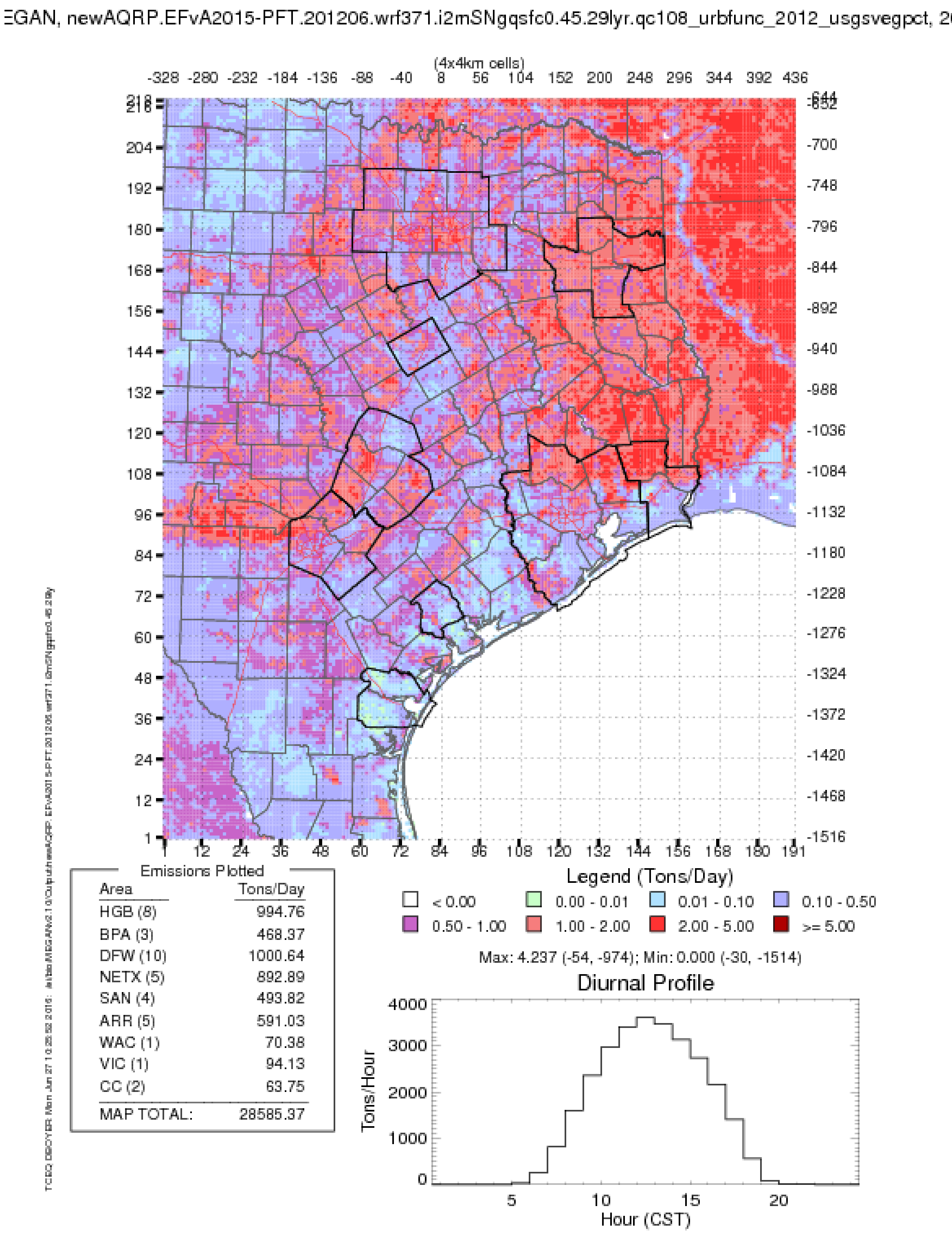


**Figure 5-1: Biogenic Isoprene Emissions on June 26, 2012 for the 4 km Domain**

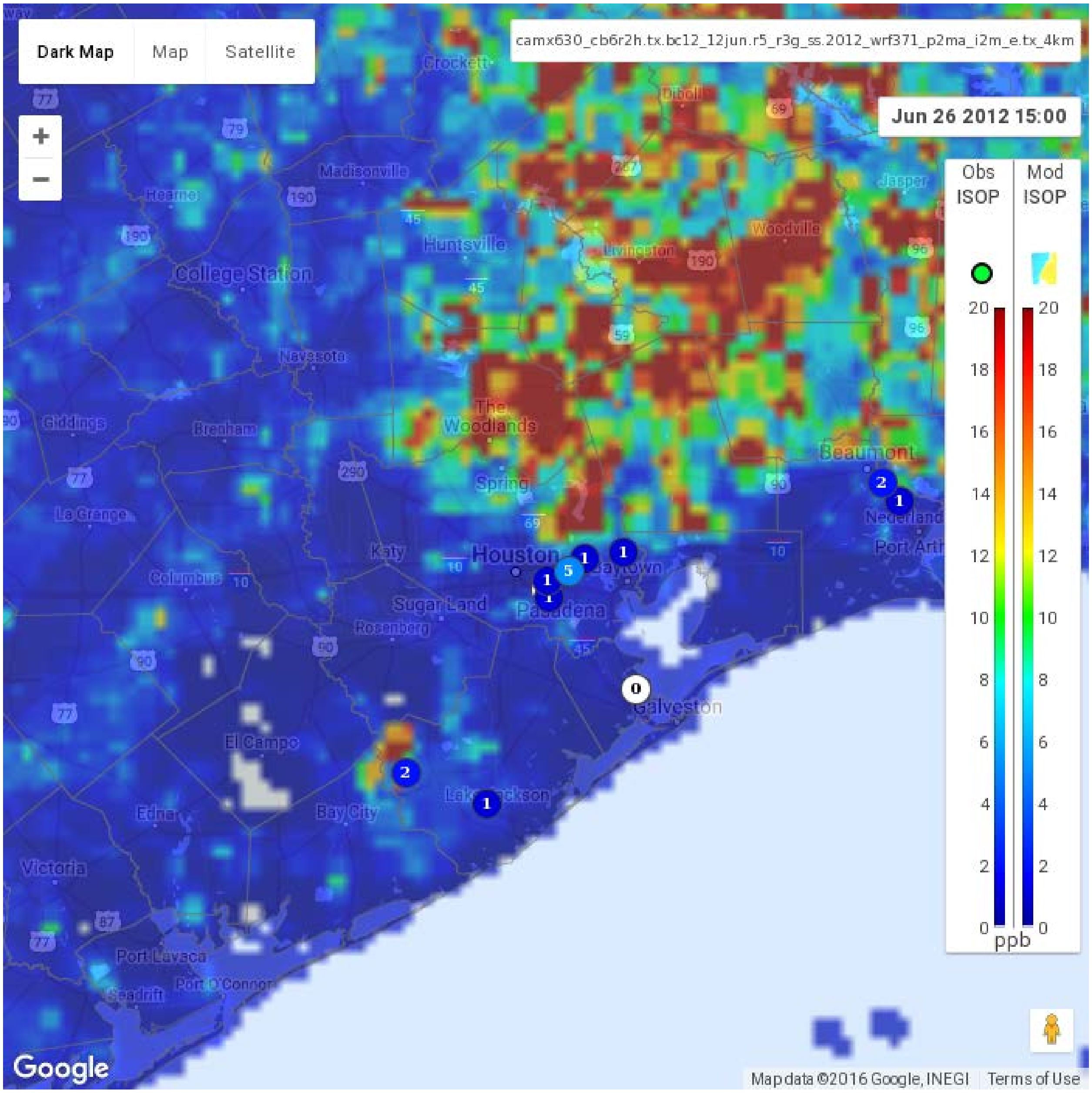


**Figure 5-2: Modeled CAMx Isoprene Concentrations for June 26, 2012 at 15:00 CST**

## 6. REFERENCES


EPA, 2014a. Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf, December 2014.

EPA, 2014b. SPECIATE Version 4.4 Database Development Documentation, February 2014, https://www3.epa.gov/ttn/chief/software/speciate/speciate_version4_4_finalreport.pdf.

EPA, 2016. EPA Petroleum Refinery National Case Results, https://www.epa.gov/enforcement/petroleum-refinery-national-case-results.

Guenther, A., Jiang, X., Heald, C., Sakulyanontvittaya, T., Duhl, T., Emmons, L., et al., 2012. The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions. Geoscientific Model Development, 1471-1492.

Loughner, Christopher P., Dale J. Allen, Da-Lin Zhang, Kenneth E. Pickering, Russell R. Dickerson, Laura Landry, 2012. Roles of Urban Tree Canopy and Buildings in Urban Heat Island Effects: Parameterization and Preliminary Results. J. Appl. Meteor. Climatol. 51, 1775–1793.

Ramboll Environ, 2015. User's Guide Emissions Processor, Version 3.22, July 2015, Ramboll Environ, Inc., Novato, CA.

Ramboll Environ, 2016. User's Guide Comprehensive Air Quality Model with Extensions (CAMx), Version 6.30, Ramboll Environ, Inc., April 2016, http://www.camx.com/files/camxusersguide_v6-30.pdf.

Thomas, Ron, Marvin Jones, Barry Exum, Dick Karp, Jim MacKay, 2010. Development of an Hourly Modeling Emissions Inventory from Several Sources of Regulatory Speciated Hourly Data for the Houston-Galveston-Brazoria Ozone Nonattainment Area, EPA-sponsored 17th Annual International Emission Inventory Conference, Portland, Oregon, June 2008. Poster Presentation, http://www.epa.gov/ttn/chief/conference/ei17/poster/thomas.pdf.

Yarwood, et al., 2012. Updates to the Carbon Bond Mechanism for Version 6 (CB6), CMAS conference, Oct. 2010. https://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf.