APPENDIX 8

2023 TEXAS STATEWIDE LOCOMOTIVE AND RAIL YARD AERR EMISSIONS INVENTORY AND 2011 THROUGH 2050 TREND INVENTORIES

Bexar County Serious Area Reasonable Further Progress State Implementation Plan Revision for the 2015 Eight-Hour Ozone National Ambient Air Quality Standard

Project Number 2024-040-SIP-NR

2023 Texas Statewide Locomotive and Rail Yard AERR Emissions Inventory and 2011 through 2050 Trend Inventories

FINAL REPORT

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FINAL REPORT

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ABSTRACT: This project aimed to develop a set of updated statewide emissions inventories for all locomotive and rail yard source categories in Texas. These EIs are needed to fulfill the federal 2023 Air Emissions Reporting Requirements (AERR) and to support state implementation plan development. Controlled and uncontrolled emissions estimates of criteria air pollutants and their precursors, along with select hazardous air pollutants species were developed using the latest available data. Locomotive and rail activity and emissions were developed for the following locomotive and rail categories: Class I and III line-haul and switching yards, as well as commuter and passenger rails. Currently, there are no Class II operators identified in Texas.

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AERR	Air Emissions Reporting Requirements
AEO	Annual Energy Outlook
BNSF	Burlington Northern Santa Fe
BPA	Beaumont-Port Arthur
CAP	Criteria Air Pollutant
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DART	Dallas Area Rapid Transport
DCTA	Denton County Transportation Authority
DERI	Diesel Emissions Reduction Incentive
DFW	Dallas-Fort Worth
EI	Emissions Inventory
EIA	Energy Information Administration
EIDP	Emissions Inventory Development Plan
EIS	Emissions Inventory System
EPA	Environmental Protection Agency
ERG	Eastern Research Group
ERIG	Emission Reduction Incentives Grants
ERTAC	Eastern Regional Technical Advisory Committee
FAF5	Freight Analysis Framework Version 5
FTA	Federal Transit Administration
GHG	Greenhouse Gases
HAP	Hazardous Air Pollutants
HGB	Houston-Galveston-Brazoria
KCS	Kansas City Southern
NARN	North American Rail Network
NEI	National Emissions Inventory
NH_3	Ammonia

NIS	Not In Service
NO_x	Nitrogen Oxides
NTD	National Transit Database
NTS	National Transportation Statistics
ORNL	Oak Ridge National Laboratory
Pb	Lead
PM_{10}	Particulate Matter under 10 Microns
$PM_{2.5}$	Particulate Matter under 2.5 Microns
PPM	Parts-Per Million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SCC	Source Classification Codes
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
STB	Surface Transportation Board
TCEQ	Texas Commissions on Environmental Quality
TERP	Texas Emissions Reduction Plan
TexAER	Texas Air Emissions Repository
TRE	Trinity Railway Express
TTI	Texas A&M Transportation Institute
TxLED	Texas Low Emission Diesel
ULSD	Ultra-Low Sulfur Diesel
UP	Union Pacific
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

The goal of this project was to develop a set of updated statewide emissions inventories (EI) for all locomotive and rail yard source categories in Texas. These EIs are needed to fulfill the federal 2023 Air Emissions Reporting Requirements (AERR) and to support state implementation plan development. Controlled (only Diesel Emissions Reduction Incentive [DERI] and DERI plus Texas Low Emission Diesel [TxLED]) and uncontrolled emissions estimates of criteria air pollutants and their precursors, along with select hazardous air pollutants species were developed using the latest available data. Locomotive and rail activity and emissions were developed for the following locomotive and rail categories: Class I and III line-haul and switching yards, as well as commuter and passenger rails. Currently, there are no Class II operators identified in Texas.

Fuel consumption for Class I line-haul were developed from national fuel consumptions for the three Class I carriers that operate in Texas: Burlington Northern Santa Fe (BNSF), Kansas City Southern (KCS), and Union Pacific (UP). Class I switching yards fuel consumptions were developed from Class I line-hauls based on the national ratio between line-hauls and switching yards for each Class I carrier. Class III fuel consumptions were developed from surveyed data, whereas Amtrak and commuter rail fuel consumptions were developed from Amtrak, Denton County Transportation Authority (DCTA), and Trinity Railway Express (TRE) annual reports.

Compared to the previous 2020 AERR study, the link assignment methodology has changed, based on the yard conflation performed in the Texas A&M Transportation Institute (TTI) study team's previous *Improvement of Locomotive and Rail Yard Activity Data Sourcing and Accuracy Project*. As there were no unexplained changes in the yard conflation, the TTI study team believes that this current link assignment is much more accurate than the assignment used in the previous 2020 AERR study, which relied only on yard assignments from the NARN. This new link assignment has a noticeable impact on the number of miles assigned to line-haul and switching yards. Compared to the previous 2020 AERR, the line-haul miles were lower whereas the switching yard miles were higher.

The following tables show the annual and average summer weekday controlled emissions for 2023.

Table 1. 2023 Annual Emissions (Tons)

SCC	CO	CO_2	NH3	NO_X	PM_{10}	$PM_{2.5}$	SO2	VOC
2285002006	6,033.1	2,300,022.4	18.8	27,489.0	696.2	675.3	21.1	1,109.2
2285002007	174.9	66,682.8	0.5	1,336.7	40.5	39.3	0.6	64.0
2285002008	121.4	46,266.4	0.4	704.8	23.8	23.1	0.4	38.0
2285002009	46.8	17,855.4	0.1	350.7	10.8	10.5	0.2	17.1
2285002010	494.3	180,358.7	1.5	3,115.1	80.7	78.3	1.7	203.3
Total	6,870.5	2,611,185.7	21.4	32,996.3	852.1	826.5	24.0	1,431.7

Table 2. 2023 Summer Weekday Emissions (Tons/Day)

SCC	CO	CO_2	NH3	NO_X	PM_{10}	$PM_{2.5}$	SO2	VOC
2285002006	16.53	6,301.43	0.052	75.31	1.91	1.85	0.058	3.04
2285002007	0.48	182.69	0.001	3.66	0.11	0.11	0.002	0.18
2285002008	0.33	126.76	0.001	1.93	0.07	0.06	0.001	0.10
2285002009	0.13	48.92	0.000	0.96	0.03	0.03	0.000	0.05
2285002010	1.35	494.13	0.004	8.53	0.22	0.21	0.005	0.56
Total	18.82	7,153.93	0.059	90.40	2.33	2.26	0.066	3.92

The second part of this study was to develop trend EI for 2011 through 2050 based on the analysis year 2023 EI. Projection factors were developed from the projections in the Energy Information Administration's (EIA's) 2022 Annual Energy Outlook (AEO).

1 INTRODUCTION

1.1 BACKGROUND

Rail networks play a major role in the state and national economy by connecting people and goods without congesting highways. As of 2020, at over 10,400 miles, Texas leads the nation in terms of the total length of railroad miles. A map of the Texas railroad system, which provides the state with access to every region in the United States and to Mexico and Canada, is shown in Figure 1.

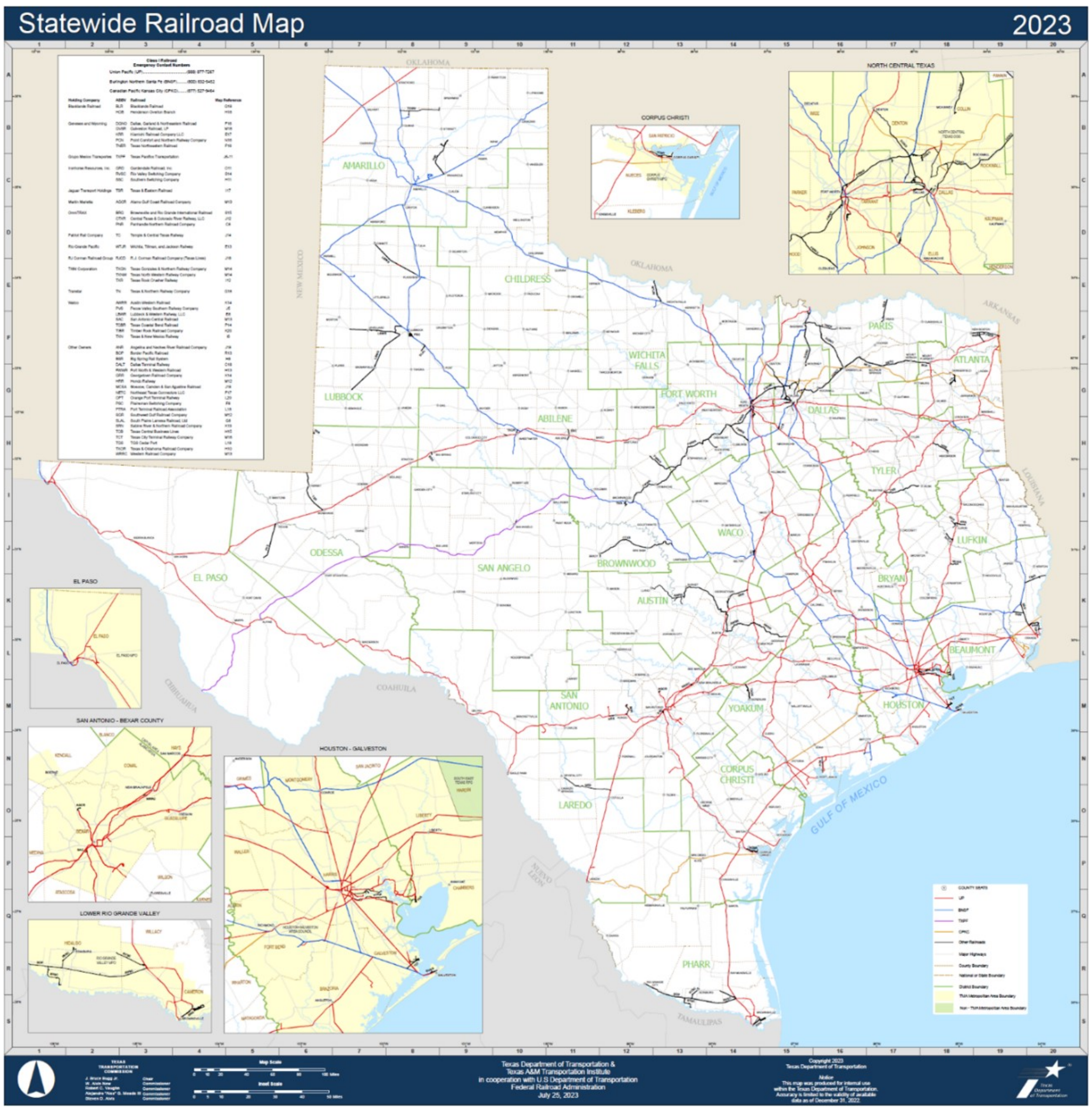


Figure 1. Texas Statewide Railroad Map

1.1.1 Railroad Carriers

Rail operations, or line-haul, refer to freight movement by a carrier over its line, excluding switching or pick-up and delivery. Railroad carriers can be broadly classified into Class I, II, and III based on their operations, operating revenues, and geographic extent of coverage.

Class I carriers cover major national and international networks, are more efficient than road transport in terms of moving cargo, averaging 10 pounds of freight over 500 miles per gallon of diesel fuel [1], and have the highest operating revenues among the three classes. According to the most recent Texas Rail Plan [2], the three major Class I rail carriers operating in Texas are:

- Burlington Northern Sante Fe Corp. Railway (BNSF) – headquartered in Fort Worth, Texas.
- Kansas City Southern Railway (KCS) – headquartered in Kansas City, Missouri.
- Union Pacific Railroad (UP) – headquartered in Omaha, Nebraska.

These Class I operators also connect freight rail traffic with other Class I and Class III carriers at interchange points throughout the state.

Class II operators are mid-sized in terms of freight-hauling capacities and operating revenues. Currently, there are no Class II operators in Texas.

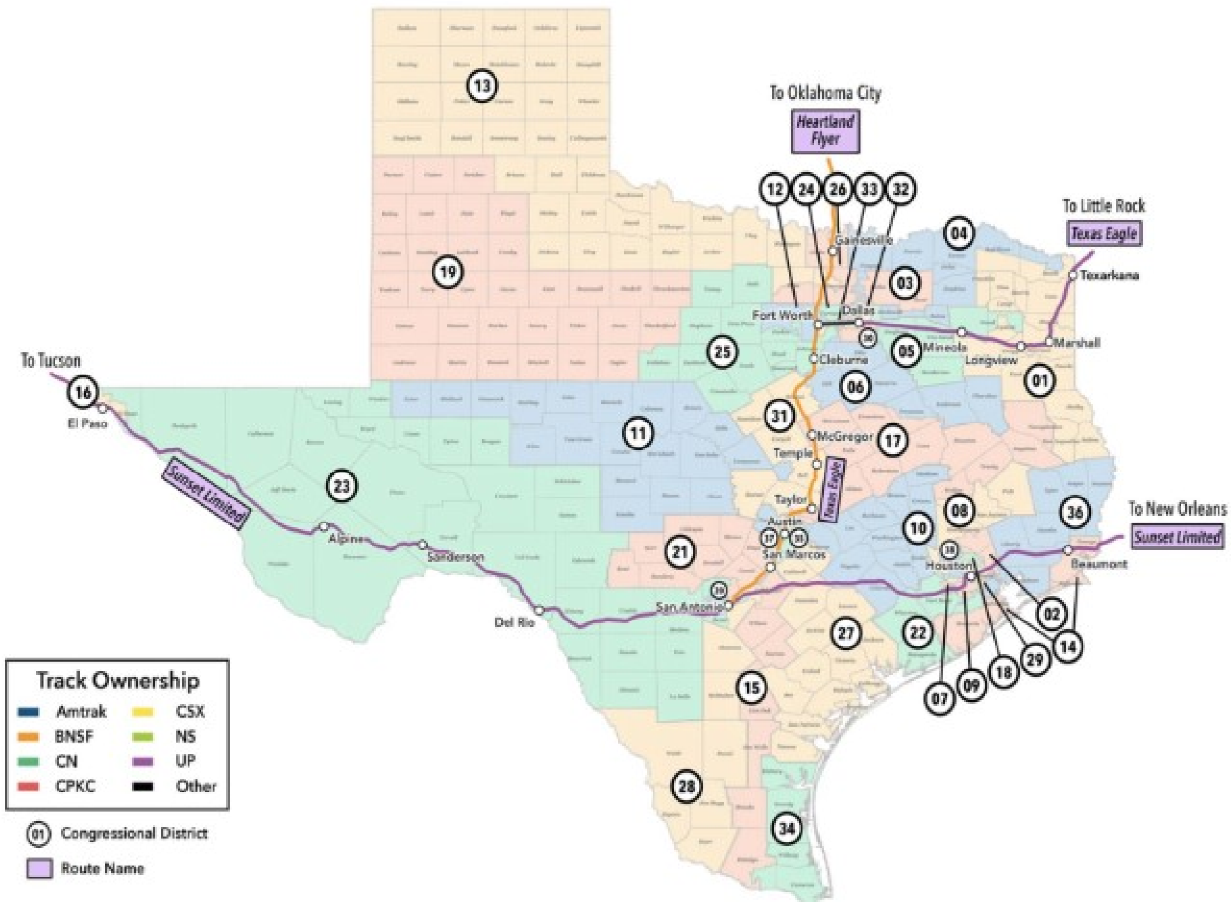
Class III operators are local short-line railroads within the state, considered small in terms of operating revenues, and are privately owned for specialized operations.

1.1.2 Railyards

Railyards are located at strategic points along railroad corridors to perform activities related to sorting, storing, loading, and unloading freight. Depending on the type of activity performed, railyards are classified into different categories, such as: switching, marshaling, shunting, freight, and other classifications. Compared to line-haul operations, yard switching operations generally involve more idling activity and use older locomotives [3].

1.1.3 Passenger Trains and Regional Commuter Rail

Passenger trains are considered cross-country passenger carriers. Amtrak is the only passenger train service that operates in Texas, and it relies on other railroads in Texas to operate routes using tracks not owned or controlled by Amtrak. Host railroads are statutorily required to provide Amtrak train 'preference' over freight transportation. A map of the Amtrak operating network in Texas is shown in Figure 2 [4].



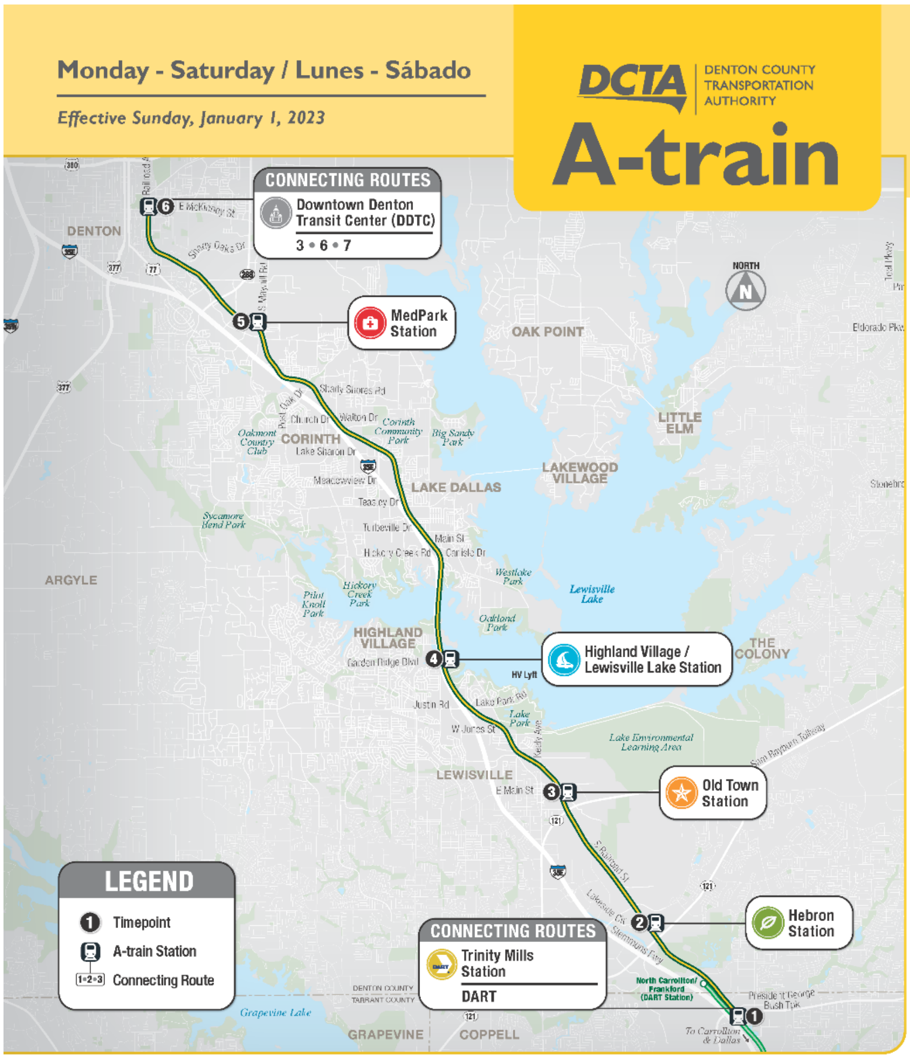
Source: Amtrak (2024). Amtrak Fiscal Year 2023 State of Texas Fact Sheet. https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/statefactsheets/TEXAS23.pdf.

Figure 2. Map of Amtrak Operating Network in Texas.

Regional commuter lines operate in smaller geographic areas, transferring daily commuters between home and work and serving other local trip purposes. These include Dallas Area Rapid Transit (DART), Trinity Railway Express (TRE), Denton County Transit Authority (DCTA), Capital Metro, El Paso Streetcar, and METRORail. TRE and DCTA are the only two commuter rail operators that utilize diesel locomotive engines.

Emissions from electric locomotives operated by the other commuter lines were assumed to be zero and were ignored for this study.

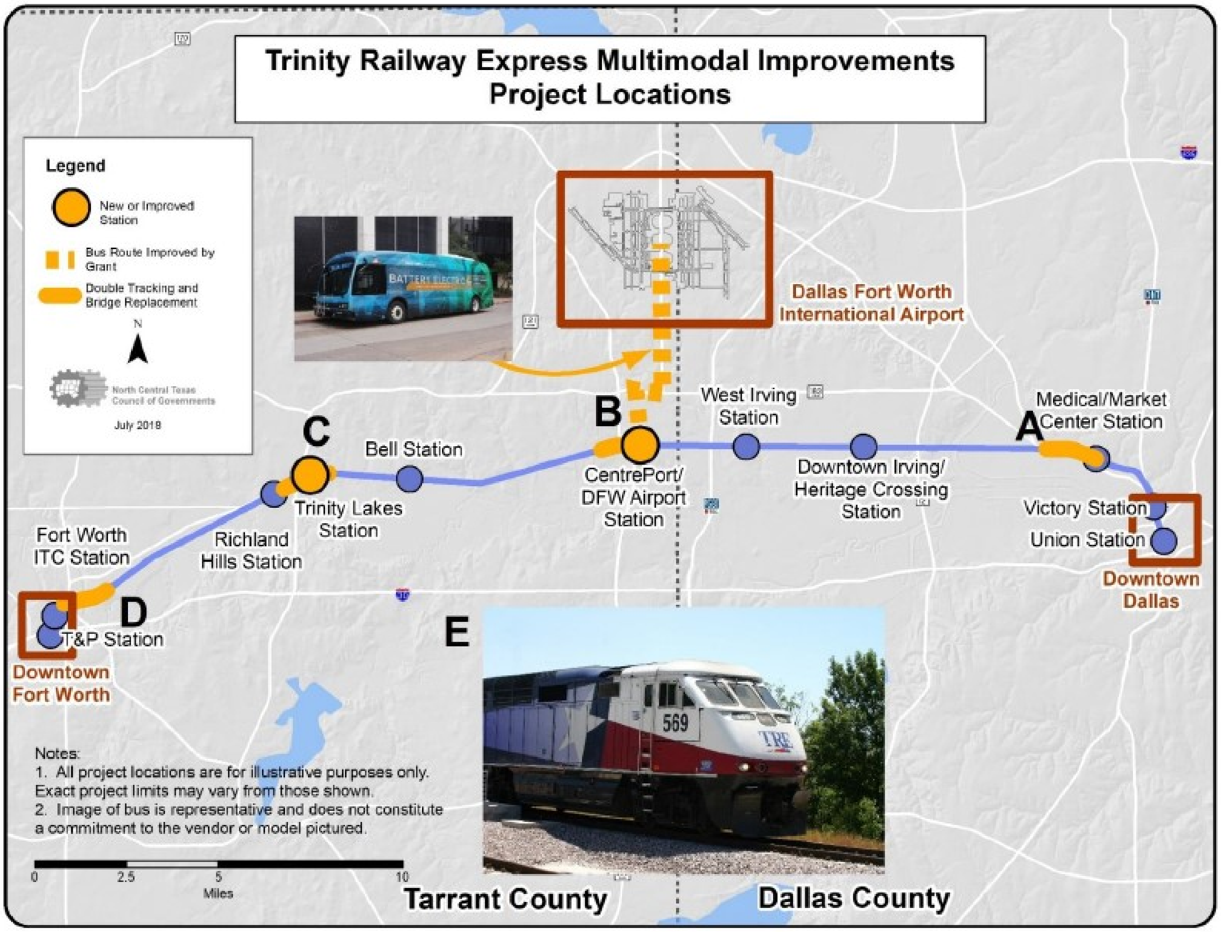
- **DCTA A-train** - The A-train is DCTA's 21-mile commuter rail line connecting Denton and Dallas Counties. The A-train connects with the DART Green Line at the Trinity Mills Station in Carrollton, Texas. A map of the DCTA operating commuter lines is shown in Figure 3 [5].



Source: DCTA. A-train. https://www.dcta.net/getting-around/rail-bus-services/a-train.

Figure 3. Map of DCTA A-train Operating Network in Texas.

- **TRE** - The TRE is a 34-mile commuter rail corridor in the Dallas–Fort Worth (DFW) Metroplex established by an interlocal agreement between DART and Trinity Metro. A map of the TRE operating commuter lines is shown in Figure 4 [6].



Source: North Central Texas Council of Governments (2018). TRE Multimodal Improvements. https://www.nctcog.org/getmedia/1c1ef091-0878-4c21-acd6-dc74d3c0f494/TRE-Submitted-BUILD-Grant-Application-Package-2018.pdf.

Figure 4. Map of TRE Operating Network in Texas

1.2 Project Overview

The objective of this project is to provide the requisite locomotive and rail yard non-road mobile source emissions inventory (EI) estimates required to be submitted to the United States Environmental Protection Agency (EPA) per the Air Emissions Reporting Requirements (AERR). A comprehensive statewide non-road mobile EI under the federal AERR is required every three years to support state implementation plan (SIP) development. The goal of this project is to develop the required EI submission for calendar year 2023 due to the EPA by January 15th, 2025.

The emissions sources for this EI include six Source Classification Codes (SCCs): four for line-haul locomotives source categories and two for yard locomotives source categories. The line-haul SCCs are all reported under the nonpoint data category. Yard locomotives may be reported using either the SCC nonpoint or point data category, depending on the applicable reporting requirement. Table 3 summarizes the SCCs, their descriptions, and associated EPA Emissions Inventory System (EIS) data categories.

Table 3. Mobile – Locomotives Sector Emissions Sources by SCC and Data Category

SCC	SCC Description (Levels 1 through 4)	Data Category
2285002006	Mobile Sources; Railroad Equipment; Diesel; Line-Haul Locomotives: Class I Operations	Nonpoint
2285002007	Mobile Sources; Railroad Equipment; Diesel; Line-Haul Locomotives: Class II / III Operations	Nonpoint
2285002008	Mobile Sources; Railroad Equipment; Diesel; Line-Haul Locomotives: Passenger Trains (Amtrak)	Nonpoint
2285002009	Mobile Sources; Railroad Equipment; Diesel; Line-Haul Locomotives: Commuter Lines	Nonpoint
2285002010	Mobile Sources; Railroad Equipment; Diesel; Yard Locomotives	Nonpoint
28500201	Internal Combustion Engines; Railroad Equipment; Diesel; Yard Locomotives	Point

This report describes the activities performed by the Texas A&M Transportation Institute (TTI) study team for Task 4 and 5 of the project: *Development of Statewide 2023 AERR EI for all Locomotive and Rail Yard Sources*. The methods were previously outlined and approved in the EI development plan (EIDP) from Task 3[1]. The TTI study team developed the calendar year 2023 statewide AERR EI for all locomotive and rail yard source categories for all criteria air pollutants (CAPs), CAP precursors, and indicated hazardous air pollutants (HAPs) as stated in the EIDP, and listed in Table 4 and Table 5. HAP emissions were estimated by applying speciation profiles (or HAP fractions) to the VOC or $PM_{2.5}$ estimates. The latest available HAP fractions were applied[2] to produce EI estimates for the HAPs.

[1] The draft EIDP was submitted on March 22nd, 2024 while the final EIDP was submitted on April 2nd, 2024.

[2] Currently, the latest HAP fractions are available in the spreadsheet supplement "2017Rail_HAP_AugmentationProfileAssignmentFactors_20200128.xlsx" to the 2020 NEI Technical Support Document [16] (See Section 12.3.1.1).

Table 4. Criteria Air Pollutants and Precursors

Pollutant	Description
VOC	Volatile organic compounds
NO_X	Nitrogen oxides
CO	Carbon monoxide
PM_{10} Primary	Primary (filterable + condensable) particulate matter with an aerodynamic diameter equal to or less than 10 microns
$PM_{2.5}$ Primary	Primary (filterable + condensable) particulate matter with an aerodynamic diameter equal to or less than 2.5 microns
Pb and Pb compounds	Lead and lead compounds
NH_3	Ammonia
SO_2	Sulfur dioxide

Table 5. Mobile–Hazardous Air Pollutants

Pollutant	Pollutant Code	Base Pollutant (Fraction of)
1,3-Butadiene	106990	VOC
2,2,4-Trimethylpentane	540841	VOC
Acenaphthene	83329	VOC
Acenaphthylene	208968	VOC
Acetaldehyde	75070	VOC
Acrolein	107028	VOC
Benzene	71432	VOC
Ethyl Benzene	100414	VOC
Formaldehyde	50000	VOC
Hexane	110543	VOC
Naphthalene	91203	VOC
Propionaldehyde	123386	VOC
Toluene	108883	VOC
Xylenes (Mixed Isomers)	1330207	VOC
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394	$PM_{2.5}$ Primary
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	35822469	$PM_{2.5}$ Primary
1,2,3,4,7,8-Hexachlorodibenzofuran	70648269	$PM_{2.5}$ Primary
1,2,3,6,7,8-Hexachlorodibenzofuran	57117449	$PM_{2.5}$ Primary
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	57653857	$PM_{2.5}$ Primary
1,2,3,7,8,9-Hexachlorodibenzofuran	72918219	$PM_{2.5}$ Primary
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	19408743	$PM_{2.5}$ Primary
1,2,3,7,8-Pentachlorodibenzofuran	57117416	$PM_{2.5}$ Primary
2,3,4,7,8-Pentachlorodibenzofuran	57117314	$PM_{2.5}$ Primary
2,3,7,8-Tetrachlorodibenzofuran	51207319	$PM_{2.5}$ Primary
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746016	$PM_{2.5}$ Primary
Anthracene	120127	$PM_{2.5}$ Primary
Arsenic	7440382	$PM_{2.5}$ Primary

Pollutant	Pollutant Code	Base Pollutant (Fraction of)
Benz[a]Anthracene	56553	$PM_{2.5}$ Primary
Benzo[a]Pyrene	50328	$PM_{2.5}$ Primary
Benzo[b]Fluoranthene	205992	$PM_{2.5}$ Primary
Benzo[g,h,i,]Perylene	191242	$PM_{2.5}$ Primary
Benzo[k]Fluoranthene	207089	$PM_{2.5}$ Primary
Chromium (VI)	18540299	$PM_{2.5}$ Primary
Chrysene	218019	$PM_{2.5}$ Primary
Dibenzo[a,h]Anthracene	53703	$PM_{2.5}$ Primary
Fluoranthene	206440	$PM_{2.5}$ Primary
Fluorene	86737	$PM_{2.5}$ Primary
Indeno[1,2,3-c,d]Pyrene	193395	$PM_{2.5}$ Primary
Manganese	7439965	$PM_{2.5}$ Primary
Mercury	7439976	$PM_{2.5}$ Primary
Nickel	7440020	$PM_{2.5}$ Primary
Octachlorodibenzofuran	39001020	$PM_{2.5}$ Primary
Octachlorodibenzo-p-Dioxin	3268879	$PM_{2.5}$ Primary
Phenanthrene	85018	$PM_{2.5}$ Primary
Pyrene	129000	$PM_{2.5}$ Primary

This report covers the activities performed by the TTI study team for Tasks 4 and 5 of this study. Chapter 2 provides details on how the projection factors were developed, including the datasets and methodologies followed in their development for all locomotive/line-haul and rail yard source categories. To develop the projection factors, the TTI study team identified different data sources, including the Surface Transportation Board (STB), Annual Energy Outlook (AEO), Eastern Regional Technical Advisory Committee (ERTAC), and other prior studies. Chapter 3 details the development of the statewide 2023 AERR EI for all locomotive and rail yard sources (Task 4), whereas Chapter 4 details the development of statewide trend EIs for 2011 through 2050 (Task 5) using the projection factors developed in Chapter 2. Chapter 5 includes a thorough report on the quality assurance/quality control (QA/QC) of the procedures and input data, including comparing the efficacy of methodologies and datasets used in the previous 2020 AERR report [7] and other studies.

2 DEVELOPMENT OF PROJECTION FACTORS

This chapter summarizes the process employed to develop the projection factors for projecting the base 2022 values from 2011 through 2050. Originally, when the 2023 AERR was designed, the 2022 values were the latest available, and thus, TTI planned to project these values to 2023. This method is consistent with the preivous 2020 AERR, which projected 2019 values to 2020. However, since the 2023 values were made available, the TTI study team decided to use the 2023 values directly instead.

This chapter is organized as follows:

- **Chapter 2.1** provides an overview of prior studies, including studies developing locomotive and rail yard projection factors for developing EIs.
- **Chapter 2.2** identifies key data sources utilized for the development of projection factors.
- **Chapter 2.3** outlines the steps and, assumptions involved in developing the projection factors for locomotive and rail yard categories.

2.1 Prior Studies

This section provides an overview of studies that developed projection factors as part of locomotive and rail yard EIs. This section only describes the methodology and assumptions made from these studies to develop projection factors.

- **2014 Texas Statewide Locomotive Emissions Inventory and 2008 through 2040 Trend Inventories** [8]
  - The Eastern Research Group (ERG) developed projection factors to backcast and forecast activity data from 2008 to 2040 using 2013 as the baseline year.
  - For Class I railroads, ERG acquired the 2013 line-haul and switching yard fuel consumption data directly from UP and KCS; however, the only data acquired from BNSF was for 2011. Thus, ERG calculated the projection factors by estimating the ratio of annual fuel consumption (gallons) between the baseline and prior years up to 2008. These ratios were calculated for the combined Class I (BNSF, UP, and KCS) to backcast projection factors to 2008.

  - Fuel usage data were not available for future years (Class I), as well as Class II and III. ERG used the Energy Information Administration's (EIA) 2013 AEO as the baseline year to backcast Class II and III activities to 2008 and to forecast future Class I, II, and III activity levels through 2040.
  - The ERG projection factors for Class I locomotives are the same as the ones used for the Class III railroads. ERG did not consider regional commuter rail in their EI development. Based on projection factors developed, ERG noted that there were little to no growth in the rail activity from 2013 onwards.

- **2020 Texas Statewide Locomotive and Rail Yard Emissions Inventory and 2011 through 2050 Trend Inventories** [7]
  - TTI developed projection factors to backcast and forecast activity data from 2011 to 2050 using 2019 as the baseline year.
  - For Class I railroads, TTI downloaded the STB Class I Railroad Annual Report (Form R-1) annual reports by the three Class I railroads that operated in Texas (BNSF, KCS, and UP) between 2011 and 2019, which contains the national fuel consumption values for the operators. By applying a Texas consumption factor (to be discussed in more detail in Chapter 2.2.1), the Texas fuel consumption values for these Class I railroads were identified and used to forecast the fuel consumption from 2020 through 2050. Based on the forecasted values, projection factors were developed by normalizing the fuel consumption values for every year from 2011 through 2050 to the 2019 base year fuel consumption. This projection factor also carried over to the Class III railroads.
  - For passenger rails, TTI developed the projection factors based on passenger rail energy use data extracted from the AEO for years 2019 to 2050. Data from intercity, transit, and commuter rail were averaged to develop the passenger rail projection factors. The fuel consumption values were backcasted from 2011 through 2018, and projection factors were developed by normalizing the fuel consumption value for every year to fuel consumption values for 2019.
  - Based on QA/QC, it was determined that the projection factors developed were comparable to those projected by other studies.

2.2 Input Data

This section provides an overview of the inputs utilized for developing the projection factors for Class I, Class III, Passenger, and Commuter categories.

2.2.1 Class I Fuel Consumption

The TTI study team downloaded the national level fuel usage for Class I carriers from the publicly available Class I Form R-1 reports that were submitted to the STB annually[3]. The Form R-1 data for BNSF, KCS, and UP for the years 2011 through 2023 were downloaded and processed. Key information extracted from Form R-1 includes national fuel usage, gross ton-miles, gross ton-miles/gallon for all Class I railroad line operators, and hours of operations for all Class I railroad yard switching operations in Texas.

The TTI study team downloaded the latest 2020 National Emissions Inventory (NEI) for locomotives and filtered for Class I line-hauls (SCCs = 2285002006). The Class I line-haul NO_x emissions were then summed for Texas and the entire nation, and estimated for fuel consumption using a composite NO_x emission factor reported in the NEI's supporting documentation [9]. The Texas-to-nationwide fuel consumption ratio was estimated at 10.2%. The Class I Form R-1 line-haul fuel (freight + work train) consumption for BNSF, KCS, and UP was then multiplied by this factor to obtain the Texas-specific fuel consumption for each carrier.

A more detailed discussion on the process by which the TTI study team selected the methodology to estimate Class I fuel consumption for Texas is available in Chapter 5.2: *Class I Fuel Consumption QA/QC*.

2.2.2 Class III Fuel Consumption

Due to the absence of Class II operations in Texas, the TTI study team only developed projection factors for Class III operations. As Class III operations do not report their fuel consumption and activities, the TTI team contacted each Class III locomotive operator in Texas either via email or phone for survey. The TTI team then calculated the average fuel consumption per operating mile from the data provided by the Class III operators that had responded, and calculated the fuel consumption for the rest of the Class III line-haul

[3] The STB R-1 Reports were downloaded from https://www.stb.gov/reports-data/economic-data/annual-report-financial-data/.

operations based on their operating miles on the STB's latest North American Rail Network (NARN) lines shapefile[4].

2.2.3 AEO 2023

Passenger rail can be broadly classified into intercity, transit, and commuter rail. Intercity rail, such as Amtrak, is an express passenger train service that covers longer distances with limited stops between cities compared to commuter or transit trains. Transit rail generally available within an urban area connect between different destinations at a high frequency. Commuter rail, such as the DART, provides passenger services between central cities and their suburbs with a lower frequency compared to transit trains. Information related to passenger rail operating miles and energy use were obtained from the 2023 AEO [10] information. National-level information, which covers years 2022 through 2050, were extracted from the 2023 AEO as shown in Table 6.

Table 6. 2023 AEO Passenger Rail Energy Use (trillion BTU)

Year	Passenger Rail (trillion Btu)	Intercity Rail (trillion Btu)	Commuter (trillion Btu)	Transit Rail (trillion Btu)
2022	43.91	7.59	17.03	19.29
2023	45.56	8.27	17.33	19.96
2024	46.54	8.81	17.47	20.26
2025	47.21	9.24	17.51	20.45
2026	47.90	9.59	17.67	20.64
2027	48.57	9.87	17.92	20.78
2028	49.13	10.11	18.14	20.89
2029	49.71	10.30	18.29	21.11
2030	50.15	10.48	18.39	21.29
2031	50.60	10.63	18.45	21.53
2032	51.14	10.76	18.57	21.81
2033	51.73	10.88	18.73	22.12
2034	52.37	10.98	18.93	22.46
2035	52.92	11.07	19.09	22.76
2036	53.46	11.15	19.26	23.04
2037	53.97	11.23	19.42	23.33
2038	54.51	11.30	19.58	23.62

[4] The TTI study team downloaded the latest NARN from https://geodata.bts.gov/datasets/usdot::north-american-rail-network-lines/about on March 15th, 2024. The NARN shapefile downloaded was updated on March 1st, 2024.

Year	Passenger Rail (trillion Btu)	Intercity Rail (trillion Btu)	Commuter (trillion Btu)	Transit Rail (trillion Btu)
2039	55.03	11.38	19.75	23.90
2040	55.63	11.45	19.95	24.23
2041	56.18	11.52	20.13	24.53
2042	56.75	11.58	20.33	24.85
2043	57.26	11.65	20.48	25.13
2044	57.82	11.72	20.67	25.43
2045	58.37	11.78	20.84	25.74
2046	59.12	11.85	21.12	26.15
2047	59.75	11.91	21.33	26.51
2048	60.44	11.98	21.58	26.89
2049	61.08	12.04	21.79	27.25
2050	61.85	12.11	22.07	27.67

In addition to passenger rail, the TTI study team also developed the line-haul and switching yard projection factors using the AEO's freight rail energy use.

2.3 Projection Factors

This section describes the methodology that the TTI study team used to develop the projection factors for Class I and Class III operations, as well as passenger rail.

2.3.1 Class I Line-Haul and Switching Yard

The key parameters that were extracted from the Form R-1 annual reports were the freight, work train, and yard switching fuel consumption for Class I locomotives at the national level. Table 7 shows the nationwide and Texas-specific 2022 and 2023 fuel usage estimates for Class I line-haul operations. The nationwide line-haul and switching yard fuel usage from the 2023 Form R-1 reports were used to estimate the Texas switching yard operations fuel usage. For instance, the BNSF Texas line-haul fuel consumption is the reported national value multiplied by the 2023 Texas rail freight ratio (10.2%), and the calculated Texas BNSF line-haul value was multiplied by the 2023 BNSF line-haul to switching yard fuel consumption ratio to acquire the 2023 Texas-specific BNSF switching yard fuel consumption. The TTI team also repeated this process for each year from 2011 to 2021.

Table 7. 2022 and 2023 Class I Railroad National and Texas Fuel Consumption

Year	Railroad	National Line-Haul (gallon)	National Switching Yard (gallon)	Line-Haul to Switching Yard Ratio (%)	Texas Line-Haul (gallon)	Texas Switching Yard (gallon)
2023	BNSF	1,114,010,887	40,070,527.00	3.597%	113,348,032	4,077,083
2023	KCS	64,311,504	3,565,585.00	5.544%	6,543,547	362,790
2023	UP	842,077,512	77,309,216.00	9.181%	85,679,440	7,866,034
2022	BNSF	1,175,184,806	42,277,017.00	3.597%	119,572,337	4,301,589
2022	KCS	64,185,774	3,599,899.00	5.609%	6,530,754	366,281
2022	UP	839,457,293	77,961,443.00	9.287%	85,412,839	7,932,397

Next, the 2023 AEO freight rail energy use projections (in quadrillion BTU) from 2022 through 2050 were used to project the 2023 nationwide Class I line-haul and switching yard fuel consumptions for 2024 through 2050 and then the projections were normalized to 2023. To do so, the TTI study team first downloaded the STB Form R-1 reports for all Class I carriers for the year 2022 and 2023, which are the two years that overlapped with the 2023 AEO projections. Then, the 2023 AEO projections were converted into gallons and then normalized to the actual fuel consumption values as reported in the Form R-1s. The TTI study team then estimated the average fuel consumption ratio of Class I carriers that operated within Texas over all Class I carriers (i.e., national fuel consumption of BNSF, KCS, and UP over national fuel consumption of all seven Class I carriers.) This ratio is multiplied to the normalized AEO projections to acquire a projected national fuel consumption for BNSF, KCS, and UP. Then, the Texas-to-nationwide fuel consumption ratio (see Chapter 2.2.1) was used to estimate the TX BNSF, KCS, and UP fuel consumptions from the national projections. Lastly, the values were normalized to the 2023 consumption estimates, as listed in Table 7, to generate the projection factors as shown in Table 8.

Table 8. Class I Projection Factors

Year	Class I Projection Factor	Year	Class I Projection Factor
2011	1.1599	2031	0.9350
2012	1.1492	2032	0.9435
2013	1.1701	2033	0.9503
2014	1.2323	2034	0.9545
2015	1.1731	2035	0.9605
2016	1.0909	2036	0.9613

Year	Class I Projection Factor	Year	Class I Projection Factor
2017	1.1468	2037	0.9634
2018	1.2111	2038	0.9664
2019	1.1277	2039	0.9650
2020	0.9866	2040	0.9660
2021	1.0229	2041	0.9735
2022	1.0289	2042	0.9797
2023	1.0000	2043	0.9804
2024	1.0420	2044	0.9804
2025	1.0168	2045	0.9801
2026	0.9740	2046	0.9822
2027	0.9407	2047	0.9872
2028	0.9273	2048	0.9939
2029	0.9374	2049	0.9966
2030	0.9318	2050	1.0032

QA/QC of the Class I projection factors are available in Chapter 5.1.

2.3.2 Class III Line-Haul and Switching Yard

Class III rails are typical "short-line" critical connectors serving to connect Class I freight to local industries. They typically serve as the last-mile connection between Class I and the respective destination. As the operation of Class III rail is dependent on the operation of Class I, it is assumed that Class III projection rates would be the same as the Class I projection factors.

2.3.3 Passenger Rail

Projection factors for passenger rail were developed based on passenger rail energy use (in trillion BTU) extracted from the 2023 AEO [10] for years 2022 to 2050. The energy use data was available for each of intercity, transit, and commuter rail.

For fuel consumption for years 2011 through 2021, the TTI study team downloaded energy consumption data for intercity rail (Amtrak) from the BTS's National Transportation Statistics (NTS) page while the commuter and transit rail energy consumption data were downloaded from the Federal Transit Administration's (FTA's)

National Transit Database (NTD) annual Fuel and Energy reports[5]. For commuters, the TTI study team filtered the Fuel and Energy reports for commuter rails modes (noted as "CR"), converted the energy consumption to trillion BTUs, and then summed them together. For transit rails, the methodology was similar to commuter rails except for the modes; for transit rails, the TTI study team summed up the energy consumption for the modes: "HR" (heavy rail), "LR" (light rail), "MG" (monorail), "SR" (street car rail), and "YR" (hybrid rail). Then, the TTI study team normalized the AEO projections to the historic data using the 2022 energy consumption (in trillion Btu) for normalization.

Finally, projection factors were developed by normalizing the fuel consumption value (in trillion Btu) for each year to fuel consumption values for 2023. The projection factors developed are listed in Table 9.

Table 9. Passenger Rail Projection Factors

Year	Intercity	Commuter	Transit Rail	Average Passenger Rail
2011	1.0667	0.9986	1.0372	1.0342
2012	1.0600	1.0095	1.0326	1.0341
2013	1.1101	1.0410	1.0658	1.0723
2014	1.1047	0.9869	1.0707	1.0541
2015	1.0501	1.0259	1.0738	1.0499
2016	1.0122	1.0559	1.0644	1.0442
2017	1.0761	1.0655	1.0635	1.0684
2018	1.1005	1.0517	1.0959	1.0827
2019	1.0559	1.0681	1.1226	1.0822
2020	1.0620	0.9238	1.0206	1.0021
2021	0.7387	0.8668	0.9577	0.8544
2022	0.9178	0.9827	0.9664	0.9556
2023	1.0000	1.0000	1.0000	1.0000
2024	1.0653	1.0081	1.0150	1.0295
2025	1.1173	1.0104	1.0245	1.0507
2026	1.1596	1.0196	1.0341	1.0711
2027	1.1935	1.0340	1.0411	1.0895
2028	1.2225	1.0467	1.0466	1.1053
2029	1.2455	1.0554	1.0576	1.1195
2030	1.2672	1.0612	1.0666	1.1317

[5] The BTS NTS page for Energy Consumption by Mode of Transportation is available at https://www.bts.gov/content/energy-consumption-mode-transportation, while the FTA NTD Fuel and Energy reports can be downloaded from https://www.transit.dot.gov/ntd/ntd-data.

Year	Intercity	Commuter	Transit Rail	Average Passenger Rail
2031	1.2854	1.0646	1.0787	1.1429
2032	1.3011	1.0716	1.0927	1.1551
2033	1.3156	1.0808	1.1082	1.1682
2034	1.3277	1.0923	1.1253	1.1818
2035	1.3386	1.1016	1.1403	1.1935
2036	1.3482	1.1114	1.1543	1.2046
2037	1.3579	1.1206	1.1688	1.2158
2038	1.3664	1.1298	1.1834	1.2265
2039	1.3761	1.1396	1.1974	1.2377
2040	1.3845	1.1512	1.2139	1.2499
2041	1.3930	1.1616	1.2290	1.2612
2042	1.4002	1.1731	1.2450	1.2728
2043	1.4087	1.1818	1.2590	1.2832
2044	1.4172	1.1927	1.2740	1.2946
2045	1.4244	1.2025	1.2896	1.3055
2046	1.4329	1.2187	1.3101	1.3206
2047	1.4401	1.2308	1.3282	1.3330
2048	1.4486	1.2452	1.3472	1.3470
2049	1.4559	1.2574	1.3652	1.3595
2050	1.4643	1.2735	1.3863	1.3747

QA/QC of the passenger rail projection factors, which will be used for both Amtrak and commuter rails, are available in Chapter 5.1.

3 DEVELOPMENT OF THE 2023 AERR EI

This chapter summarizes the process for the development of the 2023 locomotive AERR EI (Task 4), which included the following elements:

i. Finalizing 2023 annual and average summer weekday fuel estimates, by county, for all locomotive and rail yard sources.

ii. Finalizing the locomotive emission factors.

iii. Estimation of 2023 line-haul and yard emissions.

iv. Accounting for control strategy benefits.

3.1 FINALIZING 2023 ANNUAL FUEL CONSUMPTION

The NARN railroad owner (RROWNER) and track rights (TRKRGHTS) information are crucial in distributing the fuel consumption values estimated in the previous section to each county. Furthermore, the "NET" column in the NARN specifies the type of operation occurring on the specific link. For this study, it was assumed that most of the line-haul freight operations happen on mainline (NET = M), passing sidings (NET = S), and major industrial leads (NET = I); thus, the TTI study team grouped these three link categories into line-haul/freight. The study team also assumed that most of the yard switching operations are limited to yard tracks (NET = Y) and other tracks/minor industrial leads (NET = O); thus, both of these link categories were grouped into yard switching. All abandoned rail lines were grouped as not in service (NIS) and excluded from the analysis. Table 10 shows the NARN network grouping used in this study.

Table 10. TTI Grouping of NARL Rail Network Links

NET	Rail Network Link Description	Network Group
A	Abandoned rail line	NIS
F	Rail ferry connection	Ferry Slip
I	Major Industrial Lead	Line-haul/freight
M	Main Line	Line-haul/freight
O	Other track (minor industrial leads)	Yard Switching
R	Abandoned line that has been physically removed	NIS
S	Passing sidings over 4000 feet long	Line-haul/freight
T	Trail on former rail right-of-way	NIS
X	Out of service line	NIS

NET	Rail Network Link Description	Network Group
Y	Yard Tracks	Yard Switching

The following sections discuss how the TTI study team estimated the fuel consumption values for each of the 254 Texas counties.

3.1.1 Class I Line-Haul

When the EIDP was prepared and submitted on March 22nd, 2024, the latest available fuel usage data on the STB Form R-1 report were for the year 2022. Thus, to acquire a set of estimated 2023 fuel consumption values, the TTI study team originally planned on projecting the 2022 fuel consumption values for each of the three Class I carriers to 2023 using a projection factor. This method was consistent with the previous 2020 AERR, where the then-latest 2019 fuel consumption values were used to project the 2020 fuel consumptions. However, the STB had since published the 2023 Form R-1 reports; thus, the 2023 values were used directly, and no projections from 2022 were required for Class I operations. This latest 2023 fuel consumption was listed in Table 7.

The Texas statewide 2023 estimated fuel consumption data for the Class I line-haul/freight category were mapped to each county using the county percent contribution. Using the link-level tonnage distribution on the STB's confidential TRAGIS Carload Waybill Sample for Texas, the TTI study team distributed each Class I line-haul carrier's Texas fuel consumption to the applicable links based on the Class I carrier's tonnage per indicated link and Rail Fuel Consumption Index (ton-mi/gal). For links with multiple Class I carriers listed in either their RROWNER and TRKRGHTS columns, the rows were duplicated based on the number of Class I carriers, and one row was assigned to each of the Class I carriers operating on that link. For example, if BNSF and KCS both were listed for a link, either in the RROWNER or TRKRGHTS columns, that link will be listed on both carrier's list of links for the county, as both carriers use them. This does not constitute as double counting as different carriers share the same link and each will produce its own set of emissions. For each county, the total fuel consumption for all three Class I carriers and its total line-haul operating miles on the NARN were summed up.

The estimated 2023 Class I line-haul fuel consumption are available in Appendix A.

3.1.2 Class III Line-Haul

For Class III, the TTI study team conducted a survey of all Class III operators in April 2024, and the operators that responded were able to provide the study team with their 2023 fuel consumption numbers. However, only eight carriers responded to the surveys, of which two of them noted that they could not provide updates at this time. Table 11 lists fuel consumption values from the Class III operators that responded to the survey, as well as the operating miles as reported in the latest NARN. To increase the sample size, the TTI study team used the AEO's 2020 and 2023 activity estimations for freight rail, which are 0.43 and 0.47 quadrillion BTUs, respectively, to project fuel consumption for Class III carriers that did not respond to the survey. This method was identical to the methodology used by ERG in the 2020 locomotive NEI report [9].

Table 11. Class III Locomotive 2023 Fuel Consumption and Operating Miles that Responded to TTI's Survey

Railroad Carrier	Fuel Consumption (gallon)	Line-Haul Operating Miles	Switching Yard Operating Miles
Angelina & Neches River Railroad Company	9,129.10	18.7	2.4
Moscow, Camden & San Augustine Railroad	5,601.40	7.4	0.0
Texas City Terminal Railway Company	105,000.00	5.0	13.8
Texas & Oklahoma Railroad Company	36,500.00	20.4	6.5
Texas Pacifico Transportation Limited	341,000.00	393.8	11.9
Wichita, Tillman, & Jackson Railway Company	27,885.60	18.7	4.1
Austin Western Railroad*	300,581.40	168.4	20.6
Port Terminal Railroad Association *	1,125,813.95	59.1	194.3
Texas, Gonzales & Northern Railway Company*	245,930.23	11.7	1.0
Texas & Northern Railway Company*	53,968.02	11.6	23.6

*Projected based on average change in fuel consumption between 2019 and 2023.

** Central Texas & Colorado River Railway, which is one of the Class III operators that responded to the previous survey, is no longer in service. Its total operating miles on the NARN is 70.4 miles

Based on the values in Table 11, the TTI study team estimated the average fuel consumption per operating mile to be 2,645.5 gallons/mile. For the Class III operators that did not respond to the survey, the TTI study team estimated their 2023 fuel consumption values by multiplying the average fuel consumption per operating mile by their operating miles on the NARN. Then, the fuel consumption values for all Class III carriers operating within each county were summed up to get the county's Class III county-level fuel consumption value. For average summer weekday fuel consumption estimates, the TTI team assumed equal distribution throughout all 365 days of the year; thus, the estimates are the annual values divided by 365.

3.1.3 Class I and Class III Switching Yards

For Class I carriers, the statewide switching yard fuel consumption was estimated from values reported in the STB's 2023 Form R-1 report, previously listed in Table 7.

For Class III switching yards, using data from the Class III railroad carriers that responded to the survey (see Table 11), the statewide annual fuel consumption from these carriers was divided by their total switching yard miles in Texas to estimate their average fuel consumption rate (in gallons/mile). The average switching yard fuel consumption rate from all reported Class III carriers, which was 5,640.5 gallons/mile, was applied to the Class III carriers that did not respond to the survey.

To assign fuel consumption for switching yards, the TTI study team first filtered the NARN for switching yard links. For links with multiple carriers listed in either their RROWNER or TRKRGHTS columns, the rows were duplicated based on the number of carriers, and one row was assigned to each of the carriers operating on that link. The assigned fuel consumption rate was multiplied by the link's operating miles to estimate the link-level switching yard fuel consumption. Next, the switching yard fuel consumption for all carriers by Class I or Class III was summed up to get the statewide total switching yard fuel consumption. This statewide value was then redistributed across the railyards in Texas, which were previously identified in the TTI study team's FY 2022 *Improvement of Locomotive and Rail Yard Activity Data Sourcing and Accuracy Project* (Grant No: 582-21-10369). Sensitivity analysis performed in the study showed Class III switching yard fuel consumption would increase from the previous 2020 AERR due to more links attributed to yards, which led to a drop in Class III line-haul fuel consumption [11]. Based on the TTI study team's latest link assignment, the Class III line-haul miles total to 2,590 miles, which is lower than the previous 2020 AERR's 2,721 miles. In the previous 2020 AERR, only links with NET = Y were considered yards; the TTI study team's FY 2022 project had identified many major and minor industrial leads that feed into yards, which the TTI study team considered to be part of the yard.

The estimated 2023 Class I switching yard fuel consumption are available in Appendix A.

3.1.4 Amtrak/Passenger Trains

In the United States, all passenger train network links were either owned and operated by Amtrak or by TRKRGHTS. Since the 2023 Amtrak fuel consumption values were not yet available at the time, the 2023 AEO [10] projection of the 2023 Amtrak fuel consumption was utilized instead. The projected diesel consumption for Amtrak in 2023 is 8.17 trillion BTU nationally, equivalent to 59,485,576 gallons of diesel[6].

The TTI study team filtered the NARN for links where Amtrak operated. Next, the operating miles for each Amtrak link were divided by the total operating miles of all Amtrak links to acquire a link-miles-to-total Amtrak miles percentage and multiplied by the 2023 national Amtrak fuel consumption. The county-level fuel consumption was calculated by summing up the fuel consumption across all the links in the county. The total link-miles for Amtrak in Texas are about 7% of the national total and the 2023 Amtrak fuel consumption in Texas was 4,138,406 gallons.

3.1.5 Commuter Rail

For commuter rails, the DCTA A-Train and the TRE operators provided the TTI study team with the 2023 fuel consumption values for their respective lines via email. The fuel consumption for DCTA and TRE were 245,473 gallons and 1,466,373 gallons, respectively. The TTI study team estimated the county- and link-level fuel consumption similarly to passenger trains. The DCTA links are reported as DART on the NARN; the DCTA links are the DART links operating in Denton County.

3.1.6 Texas Statewide Fuel Consumption Summary

The total 2023 fuel consumption values by railroad category are shown in Table 12.

Table 12. Total Estimated 2023 Annual Fuel Usage in Texas

Railroad Carrier	2023 Annual Fuel Usage (gallons)
Class I Line-Haul	205,571,019
Class I Switching Yard	12,305,908
Class III Line-Haul	5,959,965
Class III Switching Yard	3,814,160

[6] BTU was converted to diesel gallons using the conversion factor of 137,381 Btu/gallon of diesel fuel

Railroad Carrier	2023 Annual Fuel Usage (gallons)
Passenger (Amtrak)	4,171,911
Commuter	1,711,846

3.2 Locomotive Emission Calculation and Factors

Locomotive emissions for each pollutant can be calculated using the following equation:

$$E = A * EF$$

Where, E = emissions (g), A = activity of fuel usage (gallons), and EF = emission factor (g/gal).

The EPA has established emission standards for newly manufactured and remanufactured locomotives [12]. These standards include several sets of emission standards with applicability dependent on the date a locomotive is first manufactured and are codified at 40 CFR part 1033. The first set of standards (Tier 0) applies to most locomotives originally manufactured before 2001, and the most stringent set of standards (Tier 4) applies to locomotives originally manufactured in 2015 and later. The steady decline due to the penetration of the various tiers of locomotives into the fleet over time has been included in estimating locomotive emission factors for Class I, II, and III line-haul and switching yards, as well as passenger/commuter rail services.

Emission factors by locomotive engine tiers for NO_x, particulate matter (PM, both PM_{10} and $PM_{2.5}$), hydrocarbon (HC), VOC, and CO from the EPA's *Emission Factors for Locomotive* document [12], as shown in Table 13, were used in this study. Fuel consumption can be converted to usable power (in bhp-hr), and vice versa, using the conversion factors in Table 14. To be consistent with the 2020 NEI, the conversion factor for large line-hauls (20.8 bhp-hr/gal) were utilized for Class III line-hauls [9].

Table 13. Line-haul and Switchers Emission Factors (g/bhp-hr)

Locomotive Type	Tier Level	NO_x	PM_{10}	$PM_{2.5}$	HC	VOC	CO
Line-haul	Uncontrolled	13	0.32	0.31	0.48	0.505	1.28
Line-haul	Tier 0	8.6	0.32	0.31	0.48	0.505	1.28
Line-haul	Tier 0+	7.2	0.2	0.194	0.3	0.316	1.28
Line-haul	Tier 1	6.7	0.32	0.31	0.47	0.495	1.28
Line-haul	Tier 1+	6.7	0.2	0.194	0.29	0.305	1.28
Line-haul	Tier 2	4.95	0.18	0.175	0.26	0.274	1.28
Line-haul	Tier 2+	4.95	0.08	0.078	0.13	0.137	1.28
Line-haul	Tier 3	4.95	0.08	0.078	0.13	0.137	1.28

Locomotive Type	Tier Level	NO_x	PM_{10}	$PM_{2.5}$	HC	VOC	CO
Line-haul	Tier 4	1	0.015	0.015	0.4	0.421	1.28
Line-haul[2]	Tier 4C	4.95	0.08	0.078	0.13	0.137	1.28
Switchers	Uncontrolled	17.4	0.44	0.427	1.01	1.064	1.83
Switchers	Tier 0	12.6	0.44	0.427	1.01	1.064	1.83
Switchers	Tier 0+	10.6	0.23	0.223	0.57	0.6	1.83
Switchers	Tier 1	9.9	0.43	0.417	1.01	1.064	1.83
Switchers	Tier 1+	9.9	0.23	0.223	0.57	0.6	1.83
Switchers	Tier 2	7.3	0.19	0.184	0.51	0.537	1.83
Switchers	Tier 2+	7.3	0.11	0.107	0.26	0.274	1.83
Switchers	Tier 3	4.5	0.08	0.078	0.26	0.274	1.83
Switchers	Tier 4	1.0	0.015	0.015	0.08	0.084	1.83

[1] EPA (2009). Emission Factors for Locomotive [12]

[2] As the 2009 EPA report did not include Tier 4C engines, the TTI study team back-calculated the emission factors from the ERG's 2022 EI report [13].

Table 14. Fuel Consumption to Usable Power Conversion

Locomotive Applications	Conversion Factor (bhp-hr/gal)
Large Line-Haul and Passenger	20.8
Small line-Haul	18.2
Yard Switching	15.2

Source: EPA (2009). Emission Factors for Locomotive. [12]

EPA emission factors were available for the years 2006 to 2040 for NO_x, HC, and PM_{10} [12]. These factors decrease over time, simulating the retirement of older engines from the fleet. However, using the latest available fleet mix (refer to Chapter 3.3), the weighted emission factors for most locomotive categories, aside from Class III line-hauls, were higher than the trend factors derived by the EPA in 2009. For example, the Class I line-haul NO_x emission factor calculated using the latest available fleet mix [13] is 121.76 grams per gallon of diesel, whereas the EPA's trend factor for 2023 is 84 grams per gallon. The TTI study team infers this to be caused by fleet replacement being slower than the EPA had anticipated back in 2009. Thus, EPA's trend factors were normalized to the 2023 weighted emission factors calculated for this study. For all future years 2040 and later, the 2040 emission factors were used.

The SO_2 and carbon dioxide (CO_2) emission factors were derived using the following formulas:

$$SO_2\left(\frac{g}{gal}\right) = (fuel\ density) \times (conversion\ factor) \times \left(\frac{64\ g\ of\ SO_2}{32\ g\ of\ S}\right) \times (S\ Content\ of\ fuel)$$

$$CO_2\left(\frac{g}{gal}\right) = (fuel\ density) \times \left(\frac{44\ g\ of\ CO_2}{12\ g\ of\ C}\right) \times (C\ Content\ of\ fuel)$$

Lastly, NH_3 emissions were calculated based on EPA recommended emission factors for nonroad engines, Pb emissions were calculated by speciating PM_{10} using speciation factors from the 2020 NEI [14], while HAP emissions factors were estimated based on the EPA augmentation factors.

Appendix B of this report contains the emission rates for all CAP, greenhouse gases (GHG), and HAPs for 2011 through 2050.

3.3 Locomotive Fleet Mix

Locomotive fleet mixes are required for the TTI study team to generate weighted emission rates to be used in emission calculation. The TTI study team acquired the latest available 2023 nationwide locomotive fleet mix, which was included within the *2022 NEI Locomotive Methodologies* report by ERG [13], from the EPA through email. Table 15, Table 16, and Table 17 shows the Class I line-haul, Class I yard switching, and Class III line-haul fleet mixes used in this study, respectively. Locomotive engines that were not classified were treated as Tier 0s.

Table 15. Class I Line-haul Fleet Mix by Engine Tier Levels

Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
Not Classified	256	1.326%
Tier 0 (1973-2001)	951	4.927%
Tier 0+ (Tier 0 rebuilds)	3,024	15.666%
Tier 1 (2002-2004)	64	0.332%
Tier 1+ (Tier 1 rebuilds)	5,672	29.384%
Tier 2 (2005-2011)	389	2.015%
Tier 2+ (Tier 2 rebuilds)	4,451	23.059%
Tier 3 (2012-2014)	2,455	12.718%
Tier 4 (2015 and later)	1,250	6.476%
Tier 4C (Tier 3 specifications, build after 2014)	782	4.051%
Exempt	9	0.047%

Source: ERG (2024). 2022 NEI Locomotive Methodologies [13]

Table 16. Class I Switching Yard Fleet Mix by Engine Tier Levels

Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
Tier 0 (1973-2001)	485	19.644%

Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
Tier 0+ (Tier 0 rebuilds)	1,565	63.386%
Tier 1 (2002-2004)	85	3.443%
Tier 1+ (Tier 1 rebuilds)	0	0.000%
Tier 2 (2005-2011)	31	1.256%
Tier 2+ (Tier 2 rebuilds)	5	0.203%
Tier 3 (2012-2014)	1	0.041%
Tier 4 (2015 and later)	20	0.810%
Not Classified	273	11.057%
Exempted	4	0.162%

Source: ERG (2024). 2022 NEI Locomotive Methodologies [13]

Table 17. Class III Line-haul Fleet Mix by Engine Tier Levels

Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
Tier 0 (1973-2001)	1,664	48.274%
Tier 1 (2002-2004)	31	0.899%
Tier 2 (2005-2011)	169	4.903%
Tier 3 (2012-2014)	160	4.642%
Tier 4 (2015 and later)	64	1.857%
Not Classified	1,359	39.426%

Source: ERG (2024). 2022 NEI Locomotive Methodologies [13]

The 2022 NEI locomotive methodologies report did not provide an update to the Amtrak fleet mix. Thus, the TTI study team utilized the fleet mix from ERG's previous 2020 NEI locomotive methodologies report [9], as shown in Table 18.

Table 18. Amtrak Line-haul Fleet Mix by Engine Tier Levels

Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
Not Classified	36	10.909%
Tier 0 (1973-2001)	217	65.758%
Tier 2+ (Tier 2 rebuilds)	13	3.939%
Tier 4 (2015 and later)	64	19.394%

Source: ERG (2022). 2020 NEI Locomotive Methodologies [9]

For commuter rails, the TTI study team performed literature review to acquire the current fleet at both DCTA and TRE, as shown in Table 19.

Table 19. Commuter Rail Fleet Mix by Engine Tier Levels

Railroad Carrier	Class I Line Haul Tier Levels	Locomotive Count	Percent of Fleet
DCTA[1]	Tier 2 (2005-2011)	11	100.000%
TRE[2]	Tier 0 (1973-2001)	4	36.364%
TRE[2,3]	Tier 0+ (Tier 0 rebuilds)	7	63.636%

[1] From an email with DCTA.
[2] Railroad Photographic Records. http://rrpicturearchives.net/locoList.aspx?id=TRE
[3] Trains.com (2010). Trinity Railway Express receives upgraded F59PHs NEWSWIRE. https://www.trains.com/trn/news-reviews/news-wire/trinity-railway-express-receives-upgraded-f59phs/.

3.4 Emission Control Measures

To estimate the uncontrolled and controlled emissions, the TTI study team reviewed various published resources, including EPA rulemaking and TCEQ programs.

3.4.1 Review of Control Measure

In terms of EPA rulemakings, the two major ones that affect locomotive emissions were the requirement of ultra-low sulfur diesel (ULSD) to be fully phased in by calendar year 2014 and expected fleet average emission factors that account for fleet turnover by calendar year and locomotive type (i.e., emissions tier levels of Tier 0, Tier 1, Tier 2, Tier 3, and Tier 4). Table 20 summarizes federal rules affecting diesel locomotive emissions.

Table 20. Federal Rules for Controlling Emissions from Locomotive Engines

Programs and Rule Makings	Year	Locomotives
Nonroad Diesel Fuel Standards **[15]**	2007 to 2014	Low sulfur diesel fuel (specified at 500 ppm) and ULSD fuel were phased in for nonroad, locomotive, and marine (NRLM) diesel fuel. All NRLM diesel fuel must be ULSD, and all NRLM engines and equipment must use this fuel (with some exceptions for older locomotive and marine engines)
Control of Emissions of Air Pollution for Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder **[16]**	2008	Tighten emission standards for existing locomotives and large marine diesel engines when they are remanufactured.
	2008 to 2011	Set near-term engine-out emissions standards, referred to as Tier 3 standards, for newly-built locomotives and marine diesel engines.
	2015 to 2040	Set longer-term standards, referred to as Tier 4 standards, for newly-built locomotives and marine diesel engines that reflect the application of high-efficiency after-treatment technology

For Texas-specific control programs, the TTI study team identified the following:

- **Texas Low Emission Diesel (TxLED) Program** - TxLED fuel, implemented in October 2005, conforms to federal diesel sulfur standards but changes other properties of the conventional diesel (including increasing the cetane number and lowering aromatic HC content). Texas implemented these changes in diesel specifications to reduce NO_x emissions from diesel-powered motor vehicles and nonroad equipment, as a part of the plan to control ozone air pollution. Under the rule, diesel supplied in the 110 counties, which includes the Houston-Galveston-Brazoria (HGB), Beaumont-Port Arthur (BPA), and Dallas-Fort Worth (DFW) ozone nonattainment or maintenance area counties, must comply with the TxLED requirements.
- **Diesel Emissions Reduction Incentive (DERI) Program** - The DERI Program is managed by TCEQ (within Texas Emissions Reduction Plan [TERP]) and provides grants to fund projects that focus on reducing NO_x emissions in DERI-eligible counties, including counties designated nonattainment. This program funds projects in emissions source categories, including on-road, nonroad, marine, stationary, and locomotive.
    - **Emission Reduction Incentives Grants (ERIG) Program** [17] **–** The ERIG program, under DERI, aims to repower or replace older locomotives, marine vessels, stationary equipment, and select non-road equipment by providing financial incentives. The goal is to reduce NO_x emissions in nonattainment areas and affected counties in Texas. Qualifying locomotives for replacement or repowering include line-hauls and switchers that are subject to EPA locomotive emission standards. The replacement engine must be certified to emit at least 25% less NO_x than the engine being replaced, and the manufacturer year of the replacement engine cannot be more than three years older than the year it was purchased. Lastly, the replacement locomotive must be of the same type as the locomotive being replaced and must serve a similar purpose.
- **Seaport and Rail Yard Areas Emissions Reduction Program (SPRY)** – This program is part of TERP and provides grants to upgrade or replace cargo handling equipment or drayage trucks at rail yards. However, the list of eligible

equipment does not include yard locomotives. Thus, benefits from this program cannot be included in this study.

3.4.2 Application of Control Measures

Similar to the previous *2020 locomotive and rail AERR study* [7], the TTI study team included the impacts of the EPA rules on emissions for both the controlled and uncontrolled emission scenarios, whereas the emission reductions due to TCEQ rules are only reflected in the controlled scenario.

Based on the EPA's 2004 *Clean Air Nonroad Diesel Rule* [18], which requires the sulfur levels for locomotives to be under 500 ppm starting in 2007 and under 15 ppm starting in 2012. The TTI study team used a sulfur content of 500 parts-per million (ppm) to obtain SO_2 emission rate for the year 2011 and used a sulfur content of 15 ppm to obtain SO_2 emission rate for years 2012 to 2050.

The impacts of the TCEQ's TxLED and DERI program emission control strategies were reflected in the controlled scenario emission inventory.

3.4.2.1TxLED Emission Reduction Benefits

TxLED benefits for the affected counties were estimated based on methodologies in the EPA's 2023 *Guidance on Quantifying NO_x Benefits for Cetane Improvement Programs for Use in SIPs and Transportation Conformity* report [19]. In total, 110 counties are affected by the TxLED program including the eight counties in the HGB nonattainment area, the nine counties in the DFW nonattainment area, the three counties in the BPA ozone maintenance area, and ninety counties in eastern and central Texas.

The per-vehicle NO_x benefits of TxLED can be calculated using the below [19]:

$$(\%NO_x)_{pv} = k \times 100\% \times \{1 - \exp[-0.015151\,AC + 0.000169AC^2 + 0.000223 \times AC \times RC]\}$$

Where,

$(\%NO_x)_{pv}$ = per-vehicle percent reduction in NO_x emissions;

k= constant representing fraction of NO_x inventory associated with cetane-sensitive diesel trucks or nonroad engines;

RC = reference cetane, which has a default value of 47 for for non-road diesel fuel after calender year 2007.

AC = additized cetane, which the TTI study team calculated by subtracting the base cetane number by the RC;

$$k_{nonroad,area} = (f_{dieselPre1988} + f_{dieselTier0} + f_{dieselTier1} + f_{dieselTier2})/f_{dieselTotal}$$

Where,

$k_{nonroad,area}$ = the constant "k" for nonroad diesel engines for the specific area and year;

$f_{dieselTierX}$=the number of nonroad diesel engines certified to pre-1988, Tier 0, Tier 1, and Tier 2 emissions standards in the area in the analysis year;

$f_{dieselTotal}$= the total number of nonroad diesel engines in the area and analysis year.

After the per vehicle percent reductions were calculated, the fleet-wide NOx benefits can be calculated using the equation below:

$$(\%NO_x)_{fw} = (\%NO_x)_{pv} \times F_1 \times F_2 \times F_3 \times F_4$$

Where,

$(\%NO_x)_{fw}$ = Fleet-wide percent reduction in NO_x emissions;

F_1 =Program factor representing 2-stroke engines, which defaults to 1 for general distribution of cetane improver additives through the system of terminals, pipelines, and service stations;

F_2 =Program factor representing nonroad fuel, which is the volume of off-highway fuel used in nonroad engines divided by the volume of off-highway fuel used in nonroad engines and heaters. For locomotive, this is 1;

F_3=Program factor representing vehicle migration, which is 1 for nonroad engines;

F_4 =Program factor representing the use of proxy fuel properties, which allows for the use of cetane index and/or additive concentration as proxy properties for representing cetane number measurements.

A special dye is added to on-road diesel fuel to ensure it is sold as locomotive fuel. Thus, the TTI study team believes the sources of diesel fuel in TxLED counties for on-road and locomotive use are the same. The base cetane number was retrieved from the latest *2023 Texas Fuel Field Survey* [20] that the TTI study team developed alongside ERG in 2023. The TTI study team then used the smallest cetane number among the TxLED counties represented by each locomotive classification for all counties represented by the locomotive classification, which would yield the most conservative emission reduction benefits. For example, the lowest cetane number for Class I line-haul is 48.741, whereas for DCTA and TRE, the lowest cetane number in the counties they operated in were 54.282. The list of Texas counties affected by TxLED and their estimated TxLED factors are provided in Table 21.

Table 21. Off-road TxLED Factors by County and Classification

FIPS	County	AMTRAK	Class I Line-Haul	Class I Switching Yard	Class III Line-Haul	Class III Switching Yard	Commuter Rail (TRE)	Commuter Rail (DCTA)
48001	Anderson		0.58%	0.75%	0.71%			
48005	Angelina		0.58%	0.75%	0.71%	0.71%		
48007	Aransas		0.58%	0.75%				
48013	Atascosa		0.58%	0.75%				
48015	Austin		0.58%	0.75%				
48021	Bastrop		0.58%	0.75%	0.71%			
48027	Bell	0.61%	0.58%	0.75%	0.71%	0.71%		
48029	Bexar	0.61%	0.58%	0.75%	0.71%	0.71%		
48035	Bosque	0.61%	0.58%					
48037	Bowie	0.61%	0.58%	0.75%	0.71%			
48039	Brazoria		0.58%	0.75%	0.71%	0.71%		
48041	Brazos		0.58%	0.75%				
48051	Burleson		0.58%	0.75%				
48055	Caldwell	0.61%	0.58%					
48057	Calhoun		0.58%	0.75%	0.71%	0.71%		
48063	Camp		0.58%	0.75%	0.71%	0.71%		
48067	Cass	0.61%	0.58%	0.75%	0.71%	0.71%		
48071	Chambers		0.58%	0.75%				
48073	Cherokee		0.58%		0.71%			
48085	Collin		0.58%	0.75%	0.71%			
48089	Colorado	0.61%	0.58%	0.75%				
48091	Comal	0.61%	0.58%	0.75%	0.71%	0.71%		
48097	Cooke	0.61%	0.58%	0.75%				
48099	Coryell		0.58%	0.75%				
48113	Dallas	0.61%	0.58%	0.75%	0.71%	0.71%	2.47%	
48119	Delta				0.71%			
48121	Denton	0.61%	0.58%	0.75%	0.71%	0.71%		2.47%
48123	De Witt		0.58%					
48139	Ellis		0.58%	0.75%				
48145	Falls		0.58%					
48147	Fannin				0.71%			
48149	Fayette	0.61%	0.58%	0.75%				
48157	Fort Bend	0.61%	0.58%	0.75%	0.71%	0.71%		

FIPS	County	AMTRAK	Class I Line-Haul	Class I Switching Yard	Class III Line-Haul	Class III Switching Yard	Commuter Rail (TRE)	Commuter Rail (DCTA)
48159	Franklin		0.58%		0.71%			
48161	Freestone		0.58%	0.75%				
48167	Galveston		0.58%	0.75%	0.71%	0.71%		
48175	Goliad		0.58%					
48177	Gonzales	0.61%	0.58%	0.75%	0.71%	0.71%		
48181	Grayson		0.58%	0.75%	0.71%	0.71%		
48183	Gregg	0.61%	0.58%	0.75%				
48185	Grimes		0.58%	0.75%	0.71%			
48187	Guadalupe	0.61%	0.58%	0.75%				
48199	Hardin		0.58%	0.75%	0.71%	0.71%		
48201	Harris	0.61%	0.58%	0.75%	0.71%	0.71%		
48203	Harrison	0.61%	0.58%	0.75%	0.71%			
48209	Hays	0.61%	0.58%	0.75%				
48213	Henderson		0.58%					
48217	Hill	0.61%	0.58%	0.75%				
48221	Hood		0.58%		0.71%	0.71%		
48223	Hopkins		0.58%	0.75%	0.71%	0.71%		
48225	Houston		0.58%					
48231	Hunt		0.58%	0.75%	0.71%			
48239	Jackson		0.58%	0.75%	0.71%	0.71%		
48241	Jasper				0.71%	0.71%		
48245	Jefferson	0.61%	0.58%	0.75%				
48251	Johnson	0.61%	0.58%	0.75%	0.71%	0.71%		
48257	Kaufman	0.61%	0.58%					
48277	Lamar				0.71%	0.71%		
48285	Lavaca		0.58%					
48287	Lee		0.58%		0.71%			
48289	Leon		0.58%	0.75%				
48291	Liberty	0.61%	0.58%	0.75%				
48293	Limestone		0.58%					
48297	Live Oak		0.58%	0.75%				
48309	McLennan	0.61%	0.58%	0.75%				
48313	Madison		0.58%					
48315	Marion	0.61%	0.58%	0.75%				
48321	Matagorda		0.58%	0.75%	0.71%	0.71%		
48331	Milam		0.58%		0.71%	0.71%		
48339	Montgomery		0.58%	0.75%				
48343	Morris		0.58%		0.71%	0.71%		
48347	Nacogdoches		0.58%	0.75%				
48349	Navarro		0.58%	0.75%				

FIPS	County	AMTRAK	Class I Line-Haul	Class I Switching Yard	Class III Line-Haul	Class III Switching Yard	Commuter Rail (TRE)	Commuter Rail (DCTA)
48351	Newton		0.58%		0.71%			
48355	Nueces		0.58%	0.75%	0.71%	0.71%		
48361	Orange	0.61%	0.58%	0.75%	0.71%	0.71%		
48365	Panola		0.58%	0.75%	0.71%	0.71%		
48367	Parker		0.58%		0.71%			
48373	Polk		0.58%		0.71%			
48391	Refugio		0.58%	0.75%				
48395	Robertson		0.58%	0.75%				
48397	Rockwall				0.71%			
48401	Rusk		0.58%		0.71%	0.71%		
48403	Sabine				0.71%			
48405	San Augustine				0.71%			
48407	San Jacinto		0.58%					
48409	San Patricio		0.58%	0.75%				
48419	Shelby		0.58%	0.75%	0.71%			
48423	Smith	0.61%	0.58%	0.75%				
48425	Somervell				0.71%			
48439	Tarrant	0.61%	0.58%	0.75%	0.71%	0.71%	2.47%	
48449	Titus		0.58%	0.75%	0.71%	0.71%		
48453	Travis	0.61%	0.58%		0.71%	0.71%		
48455	Trinity		0.58%					
48459	Upshur	0.61%	0.58%					
48467	Van Zandt	0.61%	0.58%					
48469	Victoria		0.58%	0.75%				
48471	Walker		0.58%					
48473	Waller		0.58%	0.75%				
48477	Washington		0.58%	0.75%				
48481	Wharton	0.61%	0.58%					
48491	Williamson	0.61%	0.58%	0.75%	0.71%	0.71%		
48493	Wilson		0.58%	0.75%				
48497	Wise		0.58%	0.75%				
48499	Wood	0.61%	0.58%	0.75%				

3.4.2.2DERI Emission Reduction Benefits

For the DERI program, the TTI study team acquired the latest available DERI benefits from TCEQ, as summarized below in Table 22, which provide information on how much NO_x reduction has been or will be achieved, the years that the project or benefit spans, and the area that benefited or will benefit from the project. The TTI study team assumed the reductions were uniformly distributed across all yards within the area and project life. Then, the TTI study team assumed that the NO_x reductions for implemented projects were already reflected in the fuel consumption of the affected railroad carriers, and the uncontrolled scenario NO_x emissions at the affected areas were increased by the estimated DERI benefits, as listed in Table 23.

Table 22. DERI Program Locomotive Projects Funded and NO_x Reductions in Texas

Area	No. of Projects	No. of Replaced/Repowered Switchers	Total NOx Reduction (tons)
Austin	2	9	405.91
Beaumont/Port Arthur	7	30	4,648.22
Corpus Christi	2	3	477.90
Dallas/Fort Worth	23	225	41,455.92
Houston/Galveston/Brazoria	18	42	4,349.87
San Antonio	2	4	603.53
Tyler/Longview	1	4	128.47
Total	55	317	52,069.83

Source: TCEQ. Diesel Emissions Reduction Incentive (DERI) Programs Project List. 2001 Through August 2023. Last updated in February 2024. Available at: https://www.tceq.texas.gov/airquality/terp/leg.html.

Table 23. DERI NO_x Emission Reduction from 2011 through 2050 by Area (Tons)

Year	Austin	BPA	Corpus Christi	DFW	HGB	San Antonio	Tyler/Longview
2011	28.4	216.5	0.0	3,741.7	269.9	9.9	0.0
2012	28.4	167.9	0.0	3,741.7	259.8	9.9	0.0
2013	28.4	167.9	0.0	3,580.6	212.6	9.9	0.0
2014	0.0	167.9	0.0	3,580.6	212.6	9.9	0.0
2015	0.0	249.9	0.0	3,644.1	222.8	9.9	0.0
2016	0.0	228.9	0.0	1,174.3	93.3	9.9	0.0
2017	0.0	228.9	0.0	350.6	93.3	9.9	0.0
2018	0.0	228.9	0.0	350.6	81.8	9.9	0.0
2019	0.0	228.9	0.0	324.8	81.8	9.9	0.0
2020	0.0	228.9	0.0	324.8	81.8	9.9	0.0
2021	0.0	228.9	0.0	324.8	81.8	9.9	0.0
2022	0.0	228.9	11.8	324.8	81.8	9.9	25.7
2023	0.0	228.9	11.8	324.8	81.8	9.9	25.7
2024	0.0	228.9	11.8	324.8	100.8	50.4	25.7
2025	0.0	228.9	11.8	324.8	100.8	50.4	25.7
2026	0.0	173.5	36.0	273.2	133.9	50.4	25.7
2027	0.0	173.5	36.0	273.2	133.9	50.4	25.7
2028	0.0	173.5	36.0	273.2	133.9	40.5	0.0

Year	Austin	BPA	Corpus Christi	DFW	HGB	San Antonio	Tyler/Longview
2029	0.0	173.5	36.0	273.2	133.9	40.5	0.0
2030	0.0	90.5	36.0	205.7	126.4	40.5	0.0
2031	0.0	8.5	36.0	63.5	84.6	40.5	0.0
2032	0.0	8.5	36.0	63.5	84.6	40.5	0.0
2033	0.0	8.5	36.0	63.5	84.6	40.5	0.0
2034	0.0	8.5	36.0	63.5	52.1	40.5	0.0
2035	0.0	8.5	36.0	63.5	33.1	0.0	0.0
2036	0.0	8.5	36.0	0.0	33.1	0.0	0.0
2037	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2038	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2039	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2040	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2041	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2042	0.0	0.0	11.8	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2046	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2047	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2048	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2049	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2050	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.5 Emissions Summary and Reporting

The 2023 emission summary and XML format output were prepared for:

- Class I Operations (SCC: 2285002006)
- Class II / III Operations (SCC: 2285002007)
- Passenger Trains-Amtrak (SCC: 2285002008)
- Commuter Lines (SCC: 2285002009)
- Yard Locomotives (TCEQ TexAER SCC: 2285002010, EPA EIS SCC: 28500201)

Appendix C provides the 2023 annual and daily controlled and uncontrolled county-level emissions for line-haul and yard switching operations for Texas in EPA's EIS XML format. The detailed 2023 AERR EI in a comma-delimited file format are also provided in

Appendix E. The following tables show the annual and average summer weekday controlled emissions for 2023.

Table 24. 2023 Annual Emissions (Tons)

SCC	CO	CO_2	NH3	NO_X	PM_{10}	$PM_{2.5}$	SO2	VOC
2285002006	6,033.1	2,300,022.4	18.8	27,489.0	696.2	675.3	21.1	1,109.2
2285002007	174.9	66,682.8	0.5	1,336.7	40.5	39.3	0.6	64.0
2285002008	121.4	46,266.4	0.4	704.8	23.8	23.1	0.4	38.0
2285002009	46.8	17,855.4	0.1	350.7	10.8	10.5	0.2	17.1
2285002010	494.3	180,358.7	1.5	3,115.1	80.7	78.3	1.7	203.3
Total	6,870.5	2,611,185.7	21.4	32,996.3	852.1	826.5	24.0	1,431.7

Table 25. 2023 Summer Weekday Emissions (Tons/Day)

SCC	CO	CO_2	NH3	NO_X	PM_{10}	$PM_{2.5}$	SO2	VOC
2285002006	16.53	6,301.43	0.052	75.31	1.91	1.85	0.058	3.04
2285002007	0.48	182.69	0.001	3.66	0.11	0.11	0.002	0.18
2285002008	0.33	126.76	0.001	1.93	0.07	0.06	0.001	0.10
2285002009	0.13	48.92	0.000	0.96	0.03	0.03	0.000	0.05
2285002010	1.35	494.13	0.004	8.53	0.22	0.21	0.005	0.56
Total	18.82	7,153.93	0.059	90.40	2.33	2.26	0.066	3.92

4 DEVELOPMENT OF THE STATEWIDE TREND EI FOR 2011 THROUGH 2050

This chapter covers the activities performed for Task 5 of this study. As the data and emission calculation methodology remained similar to those in Task 4, please refer to the previous chapter for more information.

The trend EIs were developed by projecting the 2023 AERR controlled and uncontrolled emission values, previously discussed in Chapter 3, to all years from 2011 through 2050 using the projection factors previously developed in Chapter 2. For example, to acquire the Class I line-haul NO_x controlled emissions for Dallas County in 2050, the TTI study team would first multiply the Dallas County 2023 Class I line-haul base NO_x emissions by the projection factor of 1.0032 (refer to Table 8). Then, the emission benefits from control measures, previously discussed in Chapter 3.4, would be applied. The exception to this rule is SO_2 emissions for the year 2011, which requires the use of a sulfur content of 500 ppm to obtain the SO_2 emission rate instead of the 15 ppm used for the years 2012 to 2050.

The emission summary and TexAER XML format outputs were prepared for:

- Class I Operations (SCC: 2285002006)
- Class II / III Operations (SCC: 2285002007)
- Passenger Trains-Amtrak (SCC: 2285002008)
- Commuter Lines (SCC: 2285002009)
- Yard Locomotives (SCC: 2285002010)

Appendix D provides the 2011 through 2050 annual and daily county-level controlled and uncontrolled trend EI for line-haul and yard switching operations for Texas in TCEQ's TexAER XML format. The detailed 2011 through 2050 trends EI in a comma-delimited file format are also provided in Appendix F.

More detailed discussion of the QA/QC performed for Task 5 is provided in Chapter 5.

5 QUALITY ASSURANCE AND QUALITY CHECKS

The TTI study team performed QA/QC on the gathered datasets and estimated activity as outlined in the quality assurance project plan (QAPP). All resulting EIs developed during this project were subjected to internal review and QA/QC procedures outlined in the QAPP, consistent with the requirements of *American Society for Quality, American National Standard ASQ/ANSI: E4:2014: Quality Management Systems for Environmental Information and Technology Programs – Requirements with Guidance for Use*, February 2014, and the TCEQ's *Quality Management Plan*. All analyses and results obtained were subjected to appropriate internal review and QA/QC procedures, including independent verification and reasonableness checks. Any deficiencies found during development and end-product quality checks were noted and corrected.

5.1 Projection Factor QA/QC

The projection factors are crucial in developing the 2011 through 2050 trend EIs from the 2023 AERR EI results. As shown in Figure 5, the TTI study team compared the Class I and III projection factors developed for this study, as shown in Table 8 in Chapter 2.3.1, with the following data:

- ERTAC: Growth factors obtained from ERTAC for the years 2016 to 2032 were back- and forecasted from 2011 to 2015 and from 2033 through 2050, respectively, and were normalized to the 2023 baseline year to compare with the projection factors developed in this study.
- TTI: Projection factors developed by TTI for the 2020 AERR study [7] for the years 2011 through 2050 were normalized to the 2023 baseline year to compare with TTI's projection factors.

Based on the comparison, this study's projection factors closely follow those developed in the previous 2020 AERR study [7]. While the ERTAC's projection factors were not as closely aligned, this was likely due to the data manipulation (back- and forecasted from 2016 through 2032 to 2011 through 2050) and normalization that needed to occur to put the projection factors into the same scale. In addition, the ERTAC projection factors were developed in 2015; thus, did not account for the impacts of the COVID-19 pandemic.

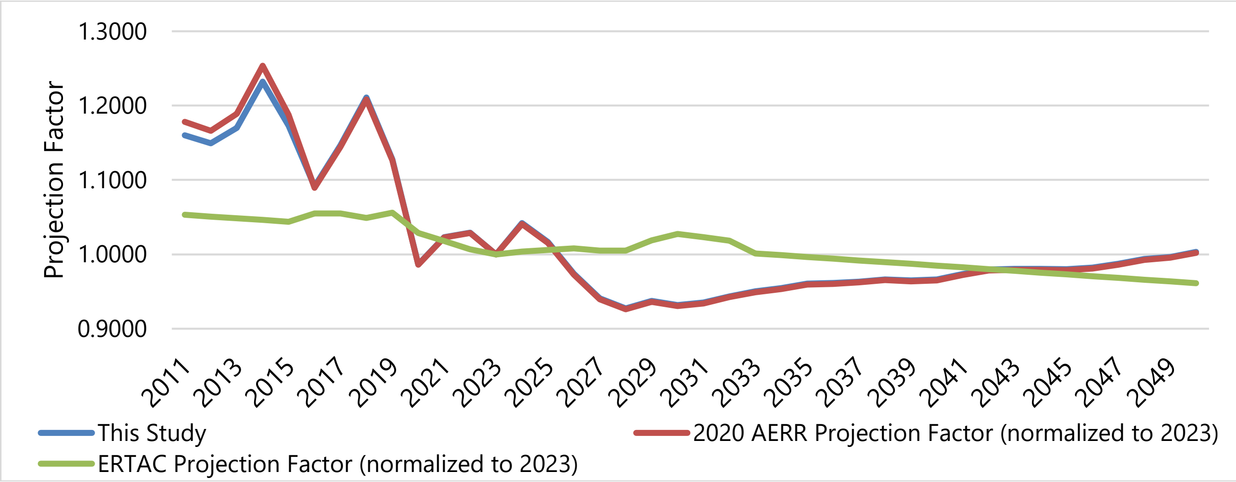


Figure 5. Comparison between this Study's Projection Factors to the 2020 AERR's and ERTAC's

For the passenger rail projection factors (used for both Amtrak and commuter rails), the TTI study team then normalized the ERTAC projection factors for 2023 and compared the passenger rail projection factors developed in this study to the ERTAC values, as shown in Figure 6. The projection factors developed in this study were very close to ERTAC's values post-2023 for three of the four projections, minus intercity rail. The ERTAC values were developed before the COVID-19 pandemic and thus did not account for the drop in energy consumption between 2020 and 2022. Overall, the passenger rail projection factors that were developed based on the 2023 AEO's energy use were found to be similar to the projection factors developed by ERTAC.

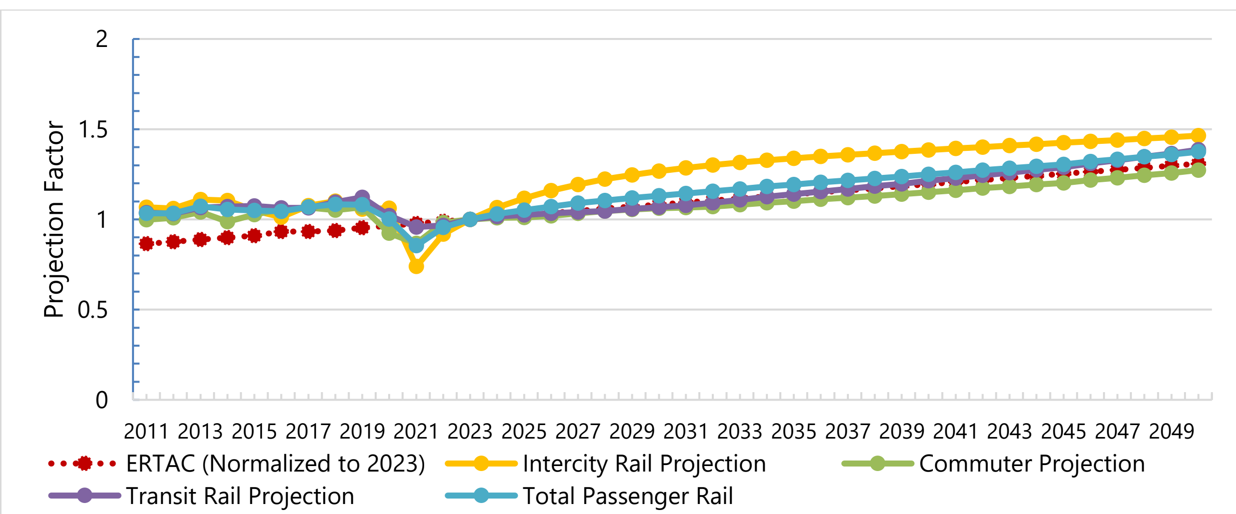


Figure 6. Comparing this Study's Passenger Rail Projection Factors to ERTAC's

5.2 Class I Fuel Consumption QA/QC

Due to data constraints in the previous 2020 AERR study [7], the TTI study team applied a Texas consumption factor to the national fuel consumption to acquire the Texas state-level fuel consumption [21] for each of the three Class I carriers. The Texas consumption factor previously used were developed based on national freight commodity flow data. For the 2020 AERR, the TTI study team developed Texas consumption factors of 13.57% in analysis year 2020, which yielded an estimated Texas fuel consumption of 270,489,711 gallons. Note that this freight flow data includes all freight modes and not just rail. Since then, the EPA released the 2020 NEI [14], and the TTI study team was able to estimate the fuel consumption from Class I locomotives in Texas based on the reported NO_x emissions and emission factors provided in the 2020 NEI's documentation [9]. The 2020 fuel consumption estimated by the TTI team in the 2020 AERR was about 33% larger than the 2020 NEI.

To acquire a value closer to the NEI for this current study, the TTI study team looked towards other methods or datasets to scale down the 2023 national-level fuel consumption data to Texas.

- **Freight Analysis Framework Version 5 (FAF5)** – TTI study team downloaded the latest *Tonnage/Value for shipments Within, From, and To State by Trade Type and Mode* data from the Oak Ridge National Laboratory's (ORNL's) latest FAF5[7] model [22]. FAF5 contains a detailed breakdown of all transportation modes by state for the years 2012, 2017 through 2023, 2025, 2030, 2035, 2040, 2045, and 2050. Based on the rail commodity flow, the TTI study team estimated a Texas consumption factor of 8.31% for the year 2020, which yielded a fuel consumption of 165,607,446 gallons. This value is about 18% lower than EPA's 2020 NEI estimates [14]. The TTI study team believes using this methodology would cause an underestimation of emissions; thus, it was rejected. The Texas and nationwide rail freight flow (in million ton-miles), as well as the Texas rail freight flow ratio, are shown in Table 26.

[7] The FAF5 Summary Statistics, updated on July 28th, 2023, were downloaded from https://faf.ornl.gov/faf5/SummaryTable.aspx.

Table 26. Texas Rail Freight Flow Percentage 2010 through 2050

Year	Texas (million ton-miles)	Nationwide (million ton-miles)	Texas Rail Freight Flow Ratio
2010	85,694.36	1611715.253	5.32%
2011	82,493.41	1,537,526.43	5.37%
2012	79,292.46	1,463,337.61	5.42%
2013	76,091.51	1,389,148.79	5.48%
2014	72,890.56	1,314,959.96	5.54%
2015	69,689.61	1,240,771.14	5.62%
2016	66,488.66	1,166,582.32	5.70%
2017	63,287.71	1,092,393.50	5.79%
2018	77,560.72	1,116,753.85	6.95%
2019	78,994.59	1,068,067.36	7.40%
2020	78,416.34	943,815.09	8.31%
2021	82,135.30	981,389.33	8.37%
2022	80,007.13	997,847.21	8.02%
2023	67,370.13	982,011.74	6.86%
2024	70,644.36	994,388.99	7.10%
2025	73,918.59	1,006,766.23	7.34%
2026	75,860.15	1,006,020.37	7.54%
2027	77,801.71	1,005,274.50	7.74%
2028	79,743.27	1,004,528.64	7.94%
2029	81,684.83	1,003,782.77	8.14%
2030	83,626.38	1,003,036.90	8.34%
2031	85,671.91	1,007,103.48	8.51%
2032	87,717.44	1,011,170.05	8.67%
2033	89,762.97	1,015,236.63	8.84%
2034	91,808.49	1,019,303.20	9.01%
2035	93,854.02	1,023,369.77	9.17%
2036	96,225.31	1,032,273.51	9.32%
2037	98,596.59	1,041,177.25	9.47%
2038	100,967.88	1,050,080.99	9.62%
2039	103,339.16	1,058,984.73	9.76%
2040	105,710.45	1,067,888.48	9.90%
2041	108,457.98	1,081,312.41	10.03%
2042	111,205.52	1,094,736.34	10.16%
2043	113,953.05	1,108,160.27	10.28%
2044	116,700.59	1,121,584.20	10.40%
2045	119,448.12	1,135,008.13	10.52%

Year	Texas (million ton-miles)	Nationwide (million ton-miles)	Texas Rail Freight Flow Ratio
2046	122,605.04	1,154,745.34	10.62%
2047	125,761.95	1,174,482.54	10.71%
2048	128,918.86	1,194,219.75	10.80%
2049	132,075.78	1,213,956.95	10.88%
2050	135,232.69	1,233,694.16	10.96%

- **NARN Line Miles** – The TTI study team compared the national and Texas NARN miles attributable to the three Class I carriers that operate in Texas: BNSF, KCS, and UP. Nationally, the line-haul operating miles attributable to BNSF, KCS, and UP are 34,849, 7,054, and 35,883 miles, respectively, whereas the corresponding Texas operating miles are 5,247, 1,098, and 6,951 miles, respectively. Thus, the Texas-to-national line-haul operating miles was calculated to be 15.1% for BNSF, 15.6% for KCS, and 19.4% for UP. Applying these factors to the 2020 national fuel consumption for the three carriers yielded a fuel consumption that was 65% larger than the 2020 NEI estimates [14]. The TTI study team rejected this method as it would produce fuel estimates that were even larger than the previous methodology utilized in the 2020 AERR [7].
- **Direct comparison with the 2020 NEI** – The 2020 NEI does not report fuel consumption nor was the emissions attributable to carriers. Using the reported NO_x emission and emission factors, the TTI study team estimated the 2020 fuel consumption within Texas to be around 202,807,844 gallons. From the STB's R-1 report for 2020, the three Class I carriers that operated in Texas had a combined fuel consumption of 1,966,838,651 gallons nationwide for line-haul operations. The 2020 NEI fuel consumption estimate for Texas is 10.2% of the national fuel consumption of the three Class I carriers. When developing the 2020 NEI, the ERG acquired permission to access the confidential nationwide freight activity density dataset [9]. The TTI team believes this data is much more accurate than both top-down methodologies described above; since the TTI study team did not have permission to access this nationwide data, the team was not able to replicate this effort using more recent datasets. Thus, the factor from 2020 was utilized for all years from 2011 through 2023.

5.3 Class III Line-haul and Switching Yard Link Assignments

As previously discussed in Chapter 3.1.2, the TTI study assigned line-haul and railyards based on findings from a previous study [11], which resulted in the total Class III line-haul miles dropping to 2,590 miles from the 2020 AERR's 2,721 miles. The TTI study team performed manual QA/QC on each county where the change in total lane miles was substantial, defined as more than a 10% difference between the two studies. The TTI study team accounted for all of the changes, where around 40 miles previously assigned as yards, which included major and minor industrial leads, were now assigned as line-haul. Approximately 180 miles that were previously assigned as line-haul were now assigned as yards, all of which are EIS sites. As there were no unexplained changes in the yard conflation, the TTI study team believes that this current link assignment is much more accurate than the assignment used in the previous 2020 AERR study, which relied only on yard assignments from the NARN.

5.4 Emission Factor QA/QC

The TTI study team performed a QA/QC on the weighted emission factors utilized for this study against those from the previous 2020 AERR, the 2017 ERTAC study, the 2020 NEI, and ERG's 2022 EI. Emission factors were derived from EPA's locomotive emission factor report [12], and their variation were based on fleet mixes.

The CAP emission factors were compared in Table 27. When comparing this study to the previous 2020 AERR, the differences in analysis year 2023 emission factors were substantial, between 30% to 70%. Class III line-haul were the only category where the emission factors from the 2020 AERR study were higher than this current study. In the previous 2020 AERR study, the TTI study team utilized the emission trend factors from the 2009 EPA report directly [12]. In contrast, the latest available fleet mix from the ERG's 2022 EI [13] was utilized for this study. As explained in Chapter 3.2, the TTI study team believes the emission factors calculated using the most recently available fleet mix are much more accurate compared to values developed more than 15 years ago. However, the percent change in emission factors from the EPA's trend factors simulated changes in fleet composition, which the current fleet mix does not. Therefore, for the current study, the TTI study team normalized the EPA's trend factors to the 2023 values.

As the data sources were the same, this study's emission factors were almost identical to those reported in ERG's 2022 NEI reports. However, the VOC, NO_x, PM_{10}, and $PM_{2.5}$ emission factors for Class III carriers showed much greater variation than expected. The

TTI study team was able to reproduce the VOC, NO_x, PM_{10}, and $PM_{2.5}$ emission factors in the ERG report [13] by using the small line-haul conversion factor of 18.2 bhp-hr/gal [12]. However, this was in direct contrast to the methodologies described in that report, which noted that the large line-haul conversion factor (20.8 bhp-hr/gal) was used for the sake of being conservative [13]. In addition, the TTI study team was able to reproduce the CO emission factor for Class III line-hauls using the large line-haul conversion factor. Thus, the TTI study team believes our calculations are accurate, based on the described methodology.

Table 27. QA/QC on Emission Factors

SCC Description	Pollutant	This Study (g/gal)	TTI 2020 AERR (Year 2023) (g/gal) [7]	This Study – TTI 2020 (Year 2023) (%)	2020 NEI (g/gal) [9]	This Study – 2020 NEI (%)	2022 NEI (g/gal) [13]	This Study – 2022 NEI (%)
Amtrak	CO	26.62	26.62	0.00%	26.624	0.00%	NR	-
Amtrak	NH_3	0.08	0.08	-0.01%	0.083	-0.36%	NR	-
Amtrak	NO_X	155.22	78.00	49.75%	155.215	0.00%	NR	-
Amtrak	PM_{10}	5.23	1.70	67.49%	5.229	0.00%	NR	-
Amtrak	$PM_{2.5}$	5.07	1.65	67.49%	5.072	0.00%	NR	-
Amtrak	SO_2	0.09	0.09	-0.28%	0.094	-0.64%	NR	-
Amtrak	VOC	8.34	2.53	69.71%	8.342	0.00%	NR	-
Class I Line-haul	CO	26.62	26.62	0.00%	26.624	0.00%	26.624	0.00%
Class I Line-haul	NH_3	0.08	0.08	-0.01%	0.083	0.00%	0.083	-0.36%
Class I Line-haul	NO_X	121.76	84.00	31.01%	120.5	1.04%	121.14	0.51%
Class I Line-haul	PM_{10}	3.07	1.90	38.15%	3.042	0.99%	3.049	0.76%
Class I Line-haul	$PM_{2.5}$	2.98	1.84	38.15%	2.951	0.98%	2.957	0.78%
Class I Line-haul	SO_2	0.09	0.09	-0.28%	0.094	-0.74%	0.094	-0.64%
Class I Line-haul	VOC	4.90	3.16	35.46%	4.854	0.85%	4.856	0.81%
Class II/III Line-haul	CO	26.62	23.30	12.50%	26.624	0.00%	26.624	0.00%
Class II/III Line-haul	NH_3	0.08	0.08	-0.01%	0.083	-0.36%	0.083	-0.36%
Class II/III Line-haul	NO_X	204.43	223.00	-9.09%	178.9	14.27%	178.9	14.27%
Class II/III Line-haul	PM_{10}	6.16	5.20	15.64%	5.393	14.29%	5.393	14.29%
Class II/III Line-haul	$PM_{2.5}$	5.98	5.04	15.64%	5.231	14.30%	5.231	14.30%
Class II/III Line-haul	SO_2	0.09	0.09	-0.28%	0.094	-0.64%	0.094	-0.64%
Class II/III Line-haul	VOC	9.74	12.32	-26.49%	8.523	14.28%	8.523	14.28%
Commuter	CO	26.62	26.62	0.00%	NR	-	NR	-
Commuter	NH_3	0.08	0.08	0.00%	NR	-	NR	-

SCC Description	Pollutant	This Study (g/gal)	TTI 2020 AERR (Year 2023) (g/gal) [7]	This Study – TTI 2020 (Year 2023) (%)	2020 NEI (g/gal) [9]	This Study – 2020 NEI (%)	2022 NEI (g/gal) [13]	This Study – 2022 NEI (%)
Commuter	NO_X	204.43	78.00	61.84%	NR	-	NR	-
Commuter	PM_{10}	6.16	1.70	72.42%	NR	-	NR	-
Commuter	$PM_{2.5}$	5.98	1.65	72.42%	NR	-	NR	-
Commuter	SO_2	0.09	0.09	0.00%	NR	-	NR	-
Commuter	VOC	9.74	2.53	74.05%	NR	-	NR	-
Yard Locomotives	CO	27.82	27.82	0.00%	NR	-	NR	-
Yard Locomotives	NH_3	0.08	0.08	-0.01%	NR	-	NR	-
Yard Locomotives	NO_X	176.23	172.00	2.40%	NR	-	NR	-
Yard Locomotives	PM_{10}	4.54	3.70	18.57%	NR	-	NR	-
Yard Locomotives	$PM_{2.5}$	4.41	3.59	18.56%	NR	-	NR	-
Yard Locomotives	SO_2	0.09	0.09	-0.28%	NR	-	NR	-
Yard Locomotives	VOC	11.44	10.00	12.59%	NR	-	NR	-

NR – Not reported

5.5 2023 AERR Emission Estimates QA/QC

The TTI study team performed a QA/QC on the 2023 AERR emission estimates by comparing those to the emissions estimated in the previous 2020 AERR study [7], as shown in Table 28. The study team also took into account the sensitivity analysis performed in the locomotive and rail yard emissions improvement project [11] that served as a precursor to this study. Overall, the emissions calculated in this study are slightly lower than the estimates developed in the 2020 AERR study, with Class I emissions much lower than the previous estimates whereas the other categories had higher emissions.

Table 28. 2020 Annual Emissions form the 2020 AERR Study (Tons)

Locomotive Category	VOC	CO	NO_x	CO_2	SO_2	NH_3	PM_{10}	$PM_{2.5}$
Class I Line-haul	1,067.54	7,497.68	26,938.66	2,839,832.61	26.26	23.38	647.71	628.28
Class III Line-haul	74.48	140.83	1,345.44	60,960.95	0.56	0.50	32.04	31.08
Amtrak	10.06	82.01	275.24	31,062.52	0.29	0.26	6.47	6.27
Commuter	2.76	22.49	73.69	8,518.82	0.08	0.07	1.77	1.72
Yard Switching	215.63	542.48	3,460.67	196,664.79	1.82	1.62	79.96	77.56
Total	1,370.46	8,285.49	32,093.69	3,137,039.70	29.01	25.82	767.95	744.92

While the difference in the emissions estimates was not large, Class I emissions in 2023 are expected to be higher than those in 2020 due to the higher national fuel consumption by Class I carriers and the increased emission factors discussed in Chapter 5.4. The primary reason for the drop in Class I emission estimates in this study was the change in fuel consumption, as detailed in Chapter 5.2. To reiterate, the top-down methodology used by the TTI study team in the 2020 AERR study overestimated the fuel consumption by Class I carriers in Texas compared to the 2020 NEI [14]. Consequently, the 2020 fuel consumption estimated in the 2020 AERR study remained considerably higher than the 2023 values estimated in this study, despite the nationwide increase in fuel consumption by Class I carriers from 2020 to 2023. As the Class I switching yard fuel consumption was estimated directly from its line-haul fuel consumption, the total yard switching emissions were also affected by this change in methodology.

The Class III line-haul and yard switching emissions were most affected by the reallocation of rail yards and line-haul links. The overall change was in line with the sensitivity analysis conducted in the improvement project [11]. Therefore, the TTI study team did not identify any sources of concern.

The difference in emission estimates between Amtrak and commuter rail was mainly attributed to the significant difference in emission factors, as shown in Table 27.

Lastly, due to a change in methodology [19] for estimating TxLED emission benefits, the benefits attributable to TxLED decreased substantially from the previous 2020 AERR study. Based on the previous EPA guidance, the 2020 AERR study estimated that TxLED had contributed to a 6.2% reduction in NO_x in the 110 TxLED counties[8]. However, utilizing the updated methodology from the 2023 EPA documentation that superseded the previous guidance, the NO_x reduction attributable to TxLED, under conservative assumptions, was reduced to under 1%. Thus, NO_x emissions in the 110 TxLED counties were higher in this study compared to the previous one.

5.6 Automation Procedure QA/QC

The TTI study team developed codes and procedures to automate the EI development process. These codes take the curated inputs and develop three sets of outputs in comma separated value (CSV) format for each of these scenarios: baseline (which includes DERI benefits), controlled (which includes DERI and TxLED benefits), and uncontrolled (which do not include DERI and TxLED benefits). To QA/QC the codes and the outputs, the TTI study team manually spot checked the outputs and compared them to manually calculated values. The list of checks included:

i. **Processed Emission Rates** – As previously discussed in Chapters 3.2 and 5.4, the emission rates for NO_x, VOC, PM_{10}, and $PM_{2.5}$ are not constant and have the same rate of change as those in the 2009 EPA report [12], but normalized to the 2023 values. The TTI study team performed spot checks on the emission rates and compared them to manually calculated values, which were determined by multiplying the pollutant's emission change factor by its 2023 calculated weighted emission factors. In addition, since the SO_2 emission factor for the year 2011 is different from other years, the TTI study team checked the 2011 values to ensure they are correct.

[8] More information of the previous 2001 EPA guidance for TxLED fuel benefits is available at https://www.epa.gov/sites/default/files/2016-11/documents/tx-led-fuel-benefit-2001-09-27.pdf.

ii. **Fuel Consumption** – The TTI study team checked to ensure the total fuel consumption in the output matches that from the input data. The TTI study team performed spot checks on individual counties to ensure that the total fuel consumption from all the county links were summed up correctly and comparable to the input data.

iii. **Emission Calculation** - Each row in the output contains information on fuel consumption, emission rate, and emission value. The TTI study team spot-checked the output files to ensure the emissions equal fuel consumption multiplied by the emission rates.

iv. **Locomotive Projection Factor** – The TTI study team spot-checked the fuel consumption for years other than 2023, ensuring the values matched the manually calculated fuel consumption for each year. This was done by multiplying the 2023 fuel consumption by the projection factor, as previously calculated in Chapter 2.3. The TTI study team also performed spot checks to ensure the correct projection factors were assigned to each year.

v. **DERI Emission Benefits** – DERI emission benefits differ from year to year, and from county to county, as shown in Table 23. To ensure the DERI emission benefits were assigned correctly, the TTI study team performed spot checks on the railyard NO_x emissions from counties within the regions with DERI benefits. The difference in NO_x emissions between the base scenario (where DERI benefits apply) and the uncontrolled scenario (where the emission benefit of DERI was removed) were compared. The difference must equal the annual per yard DERI emission benefits for the year and region multiplied by the number of railyards in the checked county.

vi. **TxLED Emission Benefits** – The TTI study team performed spot checks to ensure that TxLED benefits only applied to the 110 TxLED counties. The outputs were also spot checked by comparing the NO_x emissions from the controlled scenario with TxLED (which includes benefits from both TxLED and DERI) to the NO_x emissions from the base scenario (which only included DERI benefits). The percentage difference between the NO_x emissions must equal those in Table 21.

Upon encountering any mistakes or when the spot-checked results did not match the input or calculated values, the TTI study team performed edits or revised the automation codes or how the input data was coded until the errors were resolved. For each iteration where the input data format or automation codes were revised or edited, the entire

QA/QC steps listed in this section were repeated. For minor changes, such as updating the fuel consumption estimates while keeping the same format, the TTI study team would only perform select checks, such as ensuring the fuel consumption was distributed correctly (Step ii) or ensuring that the projection factors multiplied as intended (Step iv). This check is still important to ensure the codes have successfully taken the input, which could be caused by human errors such as accidentally renaming the file path or not closing the input file before running the codes, which prevents it from accessing the input.

5.7 XML File Conversion QA/QC

The final outputs need to be submitted in XML format to ensure that they can be uploaded to the EPA's EIS and the TCEQ's TexAER databases. The TTI study team developed codes to extract information from the CSV file outputs and convert them to XML formats. Two XML files are required in the EPA EIS format for the year 2023 for each of the controlled with only DERI, controlled with DERI plus TxLED, and uncontrolled scenarios: one for point source and one for nonpoint sources. Rail yard emissions are reported alongside the other four categories for all years from 2011 through 2050 in the TCEQ TexAER format for each of the three scenarios: controlled with only DERI, controlled with DERI plus TxLED, and uncontrolled.

The TTI study team used the EPA's EIS Bridge Tool[9] to perform spot-checks and QA/QC the XML files. The TCEQ TexAER-formatted files needed to be separated into each individual year for QA/QC as the Bridge Tool only allowed for a single year's input at a time. The QA/QC steps are as follows:

i. **Import Error Check** – the Bridge Tool has a built-in checking mechanism that automatically detects errors in the XML input file. The TTI study team used this feature to ensure that the XML file produced matches the specifications needed by the EPA. When error is shown in the Bridge Tool window, the TTI study team made modifications to the codes to rectify the error.

ii. **Bridge Tool Emission Table** – the TTI study team then output the emission table from the Bridge Tool and manually compared it to the input CSV files to ensure all emissions matched correctly.

[9] The latest version of the Bridge Tool can be downloaded at: https://www.epa.gov/air-emissions-inventories/eis-bridge-tools.

6 SUMMARY OF REPORT

The TTI study team was able to develop the deliverables for Tasks 4 and 5 of this study as described in earlier chapters of this report. The primary deliverable included the *2023 AERR locomotive and rail yard emissions inventory* and the *2011 through 2050 locomotive and rail yard trends emissions inventory*. The TTI study team also performed adequate QA/QC to ensure the accuracy of the results and how they compared to previous studies. The challenges faced in this study are as listed:

- A lack of response to the survey from the Class III carriers, with only eight carriers responding, and two of them noting that they could not provide an update. As such, the Class III fuel consumption data for most carriers needed to be extrapolated from previous studies and grown using projections.
- The Class I line-haul ton-miles data utilized was not developed using 2023 data. The TTI study team inquired about an update from the STB and the Oak Ridge National Laboratory but was informed via email that the 2023 data would not be available until later this year. The TTI study team believes the Class I fuel distribution would be more accurate if the 2023 data were available.

The most significant improvements in methodology incorporated in this study are:

- The methodology to estimate Class I fuel consumption in Texas has been updated, improving accuracy compared to the top-down approach employed in the previous 2020 AERR study. Link-level ton-mile density data was incorporated to better distribute Class I line-haul activities. Previously, the 2020 AERR study used the 2017 NEI data to distribute Class I line-haul activities by percentage to each county.
- Updated rail yard lists and associated links have improved the accuracy of Class III fuel consumption estimates. 37 rail yards that currently do not have EIS IDs were identified. The emissions from these rail yards will be summed into line-haul emissions if the EPA or TCEQ cannot generate new EIS IDs for these yards.
- The latest fleet mix data was utilized to develop emission factors for 2023. This emission factor was then used to normalize NO_x, VOC, PM_{10}, and $PM_{2.5}$ emission factor trends to produce emissions that are closer to real-world situations.

The emissions estimated for this study were slightly lower than those in the previous 2020 AERR study, as discussed in Chapter 5.5, but the differences are not significant.

7 REFERENCES

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LIST OF APPENDIX

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Appendix	Description	Availability
Appendix A	This appendix includes a table listing the estimated Class I line-haul and switching yard fuel consumption values for the year 2023 by the Class I carriers and county.	This appendix is attached to this report.
Appendix B	This appendix includes a CSV file that lists the emission factors for all pollutants modeled by SCC and analysis years.	This appendix is available electronically only
Appendix C	This appendix contains the XML files for the 2023 Locomotive AERR as well as a readme file.	This appendix is available electronically only
Appendix D	This appendix contains the XML files for the TxAERR 2011 through 2050 trend EIs and a readme file. The XML files are contained within folders for each individual scenario (i.e., controlled with DERI, controlled with DERI and TxLED, etc.) Each analysis year is represented by its unique XML file.	This appendix is available electronically only
Appendix E	This appendix includes the 2023 Locomotive AERR EI in CSV format.	This appendix is available electronically only
Appendix F	This appendix includes TxAERR 2011 through 2050 trend EIs in CSV format.	This appendix is available electronically only

APPENDIX A: COUNTY-LEVEL CLASS I FUEL CONSUMPTION ESTIMATES

This appendix includes a table listing the estimated Class I line-haul and switching yard fuel consumption values for the year 2023 by the Class I carriers and county.

Class I Line-Haul Fuel Consumption Estimates for 2023

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48001	Anderson	987,562	0	1,025,199	2,012,761
48003	Andrews	0	0	0	0
48005	Angelina	27,516	0	25,707	53,223
48007	Aransas	0	0	0	0
48009	Archer	0	0	0	0
48011	Armstrong	942,590	0	880,597	1,823,187
48013	Atascosa	0	0	109,299	109,299
48015	Austin	1,208,726	0	772,119	1,980,846
48017	Bailey	93,320	0	0	93,320
48019	Bandera	0	0	0	0
48021	Bastrop	414,150	0	397,338	811,489
48023	Baylor	0	0	0	0
48025	Bee	0	0	0	0
48027	Bell	1,804,656	0	375,902	2,180,558
48029	Bexar	1,472,458	0	2,567,780	4,040,238
48031	Blanco	0	0	0	0
48033	Borden	0	0	0	0
48035	Bosque	1,305,497	0	0	1,305,497
48037	Bowie	758,827	485,439	734,813	1,979,078
48039	Brazoria	906,315	0	1,005,692	1,912,007
48041	Brazos	20	0	588,278	588,298
48043	Brewster	0	0	417,975	417,975
48045	Briscoe	0	0	0	0
48047	Brooks	0	0	0	0
48049	Brown	191,605	0	0	191,605
48051	Burleson	585,543	0	58,998	644,541
48053	Burnet	0	0	0	0
48055	Caldwell	242,995	0	320,848	563,843
48057	Calhoun	15,364	0	45,378	60,742
48059	Callahan	328,486	0	306,882	635,368
48061	Cameron	111,694	10,538	106,832	229,064
48063	Camp	0	79,920	5,835	85,754
48065	Carson	2,966,393	0	73,382	3,039,775
48067	Cass	1,210,736	155,879	1,132,040	2,498,655

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48069	Castro	290,828	0	0	290,828
48071	Chambers	138,904	0	131,157	270,062
48073	Cherokee	805,744	0	752,867	1,558,611
48075	Childress	1,021,152	0	953,992	1,975,145
48077	Clay	706,667	0	660,191	1,366,858
48079	Cochran	0	0	0	0
48081	Coke	0	0	0	0
48083	Coleman	273,550	0	0	273,550
48085	Collin	175,537	101,860	29,219	306,616
48087	Collingsworth	0	0	0	0
48089	Colorado	1,058,397	0	998,823	2,057,219
48091	Comal	0	0	1,138,707	1,138,707
48093	Comanche	4,755	0	0	4,755
48095	Concho	0	0	0	0
48097	Cooke	718,324	0	786,411	1,504,735
48099	Coryell	80,000	0	0	80,000
48101	Cottle	0	0	0	0
48103	Crane	0	0	29,578	29,578
48105	Crockett	0	0	0	0
48107	Crosby	0	0	0	0
48109	Culberson	0	0	428,914	428,914
48111	Dallam	559,998	0	523,167	1,083,165
48113	Dallas	1,845,279	767,264	2,236,172	4,848,714
48115	Dawson	0	0	0	0
48117	Deaf Smith	2,657,256	0	0	2,657,256
48119	Delta	0	0	0	0
48121	Denton	635,407	423,046	1,326,380	2,384,833
48123	DeWitt	0	0	98,493	98,493
48125	Dickens	0	0	0	0
48127	Dimmit	0	0	0	0
48129	Donley	1,099,703	0	1,027,376	2,127,079
48131	Duval	0	43,869	0	43,869
48133	Eastland	551,023	0	514,782	1,065,805
48135	Ector	0	0	622,921	622,921
48137	Edwards	0	0	0	0
48139	Ellis	215,439	0	181,695	397,134
48141	El Paso	1,481,134	0	1,853,480	3,334,614
48143	Erath	6,279	0	0	6,279
48145	Falls	189	0	269,940	270,129
48147	Fannin	0	0	0	0
48149	Fayette	985,819	0	970,260	1,956,078
48151	Fisher	139,094	0	67,665	206,759

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48153	Floyd	0	0	0	0
48155	Foard	0	0	0	0
48157	Fort Bend	1,762,674	858,961	1,626,578	4,248,213
48159	Franklin	0	24,187	0	24,187
48161	Freestone	78,409	0	24,314	102,723
48163	Frio	0	0	327,587	327,587
48165	Gaines	0	0	0	0
48167	Galveston	293,326	55,785	209,610	558,721
48169	Garza	155,630	0	0	155,630
48171	Gillespie	0	0	0	0
48173	Glasscock	0	0	0	0
48175	Goliad	0	0	2,924	2,924
48177	Gonzales	550,372	0	525,591	1,075,963
48179	Gray	3,013,910	0	0	3,013,910
48181	Grayson	564,987	0	940,133	1,505,120
48183	Gregg	1,267,066	0	1,779,014	3,046,080
48185	Grimes	7,980	0	284,973	292,953
48187	Guadalupe	848,354	0	792,558	1,640,912
48189	Hale	91,978	0	85,872	177,850
48191	Hall	785,502	0	733,840	1,519,342
48193	Hamilton	0	0	0	0
48195	Hansford	0	0	0	0
48197	Hardeman	1,103,608	0	1,026,034	2,129,642
48199	Hardin	21,077	5,183	5,176	31,437
48201	Harris	9,153,104	3,359,375	9,291,846	21,804,325
48203	Harrison	2,004,470	84,330	2,218,688	4,307,489
48205	Hartley	153,096	0	143,027	296,122
48207	Haskell	0	0	0	0
48209	Hays	0	0	1,432,358	1,432,358
48211	Hemphill	1,505,908	0	0	1,505,908
48213	Henderson	0	0	2,783	2,783
48215	Hidalgo	0	0	0	0
48217	Hill	460,163	0	846,543	1,306,706
48219	Hockley	47,250	0	0	47,250
48221	Hood	6,071	0	0	6,071
48223	Hopkins	0	84,056	0	84,056
48225	Houston	568,902	0	531,486	1,100,388
48227	Howard	0	0	1,032,578	1,032,578
48229	Hudspeth	657,066	0	942,692	1,599,758
48231	Hunt	0	96,199	0	96,199
48233	Hutchinson	0	0	0	0
48235	Irion	0	0	0	0

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48237	Jack	0	0	0	0
48239	Jackson	129,295	2,310	182,343	313,948
48241	Jasper	0	0	0	0
48243	Jeff Davis	0	0	167,314	167,314
48245	Jefferson	1,955,635	2,020,435	1,888,391	5,864,462
48247	Jim Hogg	0	12,531	0	12,531
48249	Jim Wells	0	50,063	0	50,063
48251	Johnson	748,353	0	353,823	1,102,176
48253	Jones	0	0	0	0
48255	Karnes	0	0	0	0
48257	Kaufman	0	0	314,114	314,114
48259	Kendall	0	0	0	0
48261	Kenedy	75,692	0	70,713	146,405
48263	Kent	0	0	0	0
48265	Kerr	0	0	0	0
48267	Kimble	0	0	0	0
48269	King	0	0	0	0
48271	Kinney	347,641	0	483,565	831,206
48273	Kleberg	47,307	0	44,196	91,503
48275	Knox	0	0	0	0
48277	Lamar	0	0	0	0
48279	Lamb	176,824	0	0	176,824
48281	Lampasas	239,603	0	0	239,603
48283	La Salle	0	0	649,961	649,961
48285	Lavaca	0	0	102,570	102,570
48287	Lee	0	0	65,766	65,766
48289	Leon	10,365	0	299,094	309,459
48291	Liberty	1,526,780	1,239,806	1,423,383	4,189,969
48293	Limestone	0	0	18,984	18,984
48295	Lipscomb	684,504	0	0	684,504
48297	Live Oak	0	0	5,068	5,068
48299	Llano	0	0	0	0
48301	Loving	0	0	0	0
48303	Lubbock	374,267	0	105,646	479,913
48305	Lynn	11,116	0	0	11,116
48307	McCulloch	0	0	0	0
48309	McLennan	616,877	0	1,195,300	1,812,177
48311	McMullen	0	0	0	0
48313	Madison	3,921	0	0	3,921
48315	Marion	529,348	132,597	498,463	1,160,409
48317	Martin	0	0	126,096	126,096
48319	Mason	0	0	0	0

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48321	Matagorda	314,639	0	284,876	599,515
48323	Maverick	252,059	0	235,481	487,540
48325	Medina	547,311	0	698,526	1,245,837
48327	Menard	0	0	0	0
48329	Midland	0	0	432,586	432,586
48331	Milam	585,376	0	494,315	1,079,692
48333	Mills	91,207	0	0	91,207
48335	Mitchell	0	0	357,291	357,291
48337	Montague	549,630	0	513,482	1,063,112
48339	Montgomery	599,986	0	626,418	1,226,404
48341	Moore	1,368,895	0	1,278,865	2,647,760
48343	Morris	0	102,834	5,601	108,435
48345	Motley	0	0	0	0
48347	Nacogdoches	54,173	0	50,610	104,783
48349	Navarro	110,410	0	18,520	128,930
48351	Newton	0	61,206	61,124	122,330
48353	Nolan	578,208	0	654,555	1,232,763
48355	Nueces	301,697	183,510	281,855	767,062
48357	Ochiltree	0	0	0	0
48359	Oldham	19,433	0	18,155	37,588
48361	Orange	652,893	241,256	690,163	1,584,312
48363	Palo Pinto	518,070	0	483,997	1,002,067
48365	Panola	212,464	0	0	212,464
48367	Parker	446,238	0	415,186	861,423
48369	Parmer	2,391,291	0	0	2,391,291
48371	Pecos	0	0	32,166	32,166
48373	Polk	26,887	0	25,118	52,005
48375	Potter	4,155,512	0	2,702,192	6,857,704
48377	Presidio	0	0	206,316	206,316
48379	Rains	0	0	0	0
48381	Randall	3,212,716	0	2,026,644	5,239,360
48383	Reagan	0	0	0	0
48385	Real	0	0	0	0
48387	Red River	0	0	0	0
48389	Reeves	0	0	480,319	480,319
48391	Refugio	301,945	282,465	282,087	866,497
48393	Roberts	821,404	0	0	821,404
48395	Robertson	0	0	1,057,450	1,057,450
48397	Rockwall	0	0	0	0
48399	Runnels	0	0	0	0
48401	Rusk	173,229	0	161,076	334,305
48403	Sabine	0	0	0	0

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48405	San Augustine	0	0	0	0
48407	San Jacinto	5,589	0	5,222	10,811
48409	San Patricio	269,897	243,165	264,898	777,960
48411	San Saba	0	0	0	0
48413	Schleicher	0	0	0	0
48415	Scurry	289,022	0	0	289,022
48417	Shackelford	0	0	0	0
48419	Shelby	213,131	0	174,124	387,256
48421	Sherman	674,137	0	629,799	1,303,936
48423	Smith	229,939	0	259,459	489,397
48425	Somervell	0	0	0	0
48427	Starr	0	0	0	0
48429	Stephens	37,005	0	34,571	71,576
48431	Sterling	0	0	0	0
48433	Stonewall	0	0	0	0
48435	Sutton	0	0	0	0
48437	Swisher	84,482	0	78,925	163,407
48439	Tarrant	6,800,128	270,580	7,180,429	14,251,137
48441	Taylor	586,547	0	440,903	1,027,450
48443	Terrell	0	0	192,996	192,996
48445	Terry	0	0	0	0
48447	Throckmorton	0	0	0	0
48449	Titus	0	26,683	10,680	37,363
48451	Tom Green	0	0	0	0
48453	Travis	22,374	0	596,402	618,775
48455	Trinity	284,444	0	265,737	550,181
48457	Tyler	0	0	0	0
48459	Upshur	0	0	146,477	146,477
48461	Upton	0	0	0	0
48463	Uvalde	701,216	0	656,416	1,357,632
48465	Val Verde	0	0	353,826	353,826
48467	Van Zandt	0	0	202,915	202,915
48469	Victoria	322,127	185,953	364,397	872,476
48471	Walker	395,160	0	370,237	765,397
48473	Waller	0	0	83,457	83,457
48475	Ward	0	0	574,565	574,565
48477	Washington	845,713	0	0	845,713
48479	Webb	0	678,259	940,593	1,618,852
48481	Wharton	354,740	913	331,409	687,061
48483	Wheeler	0	0	0	0
48485	Wichita	2,040,368	0	1,906,175	3,946,544

FIPS	County	BNSF (gallon)	KCS (gallon)	UP (gallon)	Total (gallon)
48487	Wilbarger	1,254,688	0	1,172,169	2,426,857
48489	Willacy	70,961	0	66,294	137,255
48491	Williamson	1,044,442	0	1,414,981	2,459,423
48493	Wilson	0	0	0	0
48495	Winkler	0	0	0	0
48497	Wise	785,186	0	949,288	1,734,474
48499	Wood	0	30,234	373,605	403,839
48501	Yoakum	0	0	0	0
48503	Young	0	0	0	0
48505	Zapata	0	0	0	0
48507	Zavala	0	0	0	0

Class III Line-Haul Fuel Consumption Estimates for 2023

FIPS	County	Total (gallon)
48001	Anderson	83,372.54
48003	Andrews	10,208.54
48005	Angelina	39,841.57
48007	Aransas	0.00
48009	Archer	0.00
48011	Armstrong	0.00
48013	Atascosa	0.00
48015	Austin	0.00
48017	Bailey	0.00
48019	Bandera	0.00
48021	Bastrop	47,543.98
48023	Baylor	0.00
48025	Bee	0.00
48027	Bell	15,024.19
48029	Bexar	36,746.23
48031	Blanco	0.00
48033	Borden	0.00
48035	Bosque	0.00
48037	Bowie	330,140.70
48039	Brazoria	0.00
48041	Brazos	0.00
48043	Brewster	30,948.05
48045	Briscoe	0.00
48047	Brooks	0.00
48049	Brown	78,791.33
48051	Burleson	0.00

FIPS	County	Total (gallon)
48053	Burnet	83,697.20
48055	Caldwell	0.00
48057	Calhoun	0.00
48059	Callahan	0.00
48061	Cameron	53,491.67
48063	Camp	0.00
48065	Carson	98,848.64
48067	Cass	0.00
48069	Castro	68,266.93
48071	Chambers	0.00
48073	Cherokee	71,761.53
48075	Childress	0.00
48077	Clay	0.00
48079	Cochran	3,091.10
48081	Coke	0.00
48083	Coleman	18,843.53
48085	Collin	158,710.39
48087	Collingsworth	0.00
48089	Colorado	0.00
48091	Comal	0.00
48093	Comanche	132,841.23
48095	Concho	0.00
48097	Cooke	0.00
48099	Coryell	0.00
48101	Cottle	0.00
48103	Crane	3,119.78
48105	Crockett	446.16
48107	Crosby	0.00
48109	Culberson	0.00
48111	Dallam	0.00
48113	Dallas	293,649.29
48115	Dawson	0.00
48117	Deaf Smith	0.00
48119	Delta	1,554.62
48121	Denton	71,138.21
48123	DeWitt	0.00
48125	Dickens	0.00
48127	Dimmit	0.00
48129	Donley	0.00
48131	Duval	0.00
48133	Eastland	3,068.87
48135	Ector	0.00

FIPS	County	Total (gallon)
48137	Edwards	0.00
48139	Ellis	0.00
48141	El Paso	10,045.42
48143	Erath	126,575.37
48145	Falls	0.00
48147	Fannin	139,936.60
48149	Fayette	0.00
48151	Fisher	0.00
48153	Floyd	0.00
48155	Foard	0.00
48157	Fort Bend	0.00
48159	Franklin	18,009.74
48161	Freestone	0.00
48163	Frio	0.00
48165	Gaines	10,891.00
48167	Galveston	36,461.49
48169	Garza	0.00
48171	Gillespie	0.00
48173	Glasscock	0.00
48175	Goliad	0.00
48177	Gonzales	226,682.73
48179	Gray	0.00
48181	Grayson	295,736.02
48183	Gregg	0.00
48185	Grimes	27,877.43
48187	Guadalupe	0.00
48189	Hale	62,620.40
48191	Hall	0.00
48193	Hamilton	0.00
48195	Hansford	2,032.46
48197	Hardeman	21,830.12
48199	Hardin	21,932.30
48201	Harris	262,626.71
48203	Harrison	18,120.83
48205	Hartley	0.00
48207	Haskell	0.00
48209	Hays	0.00
48211	Hemphill	0.00
48213	Henderson	0.00
48215	Hidalgo	58,092.89
48217	Hill	0.00
48219	Hockley	115,587.68

FIPS	County	Total (gallon)
48221	Hood	117,832.83
48223	Hopkins	104,299.58
48225	Houston	0.00
48227	Howard	0.00
48229	Hudspeth	0.00
48231	Hunt	179,077.86
48233	Hutchinson	61,108.29
48235	Irion	36,414.84
48237	Jack	0.00
48239	Jackson	0.00
48241	Jasper	276,508.03
48243	Jeff Davis	0.00
48245	Jefferson	0.00
48247	Jim Hogg	0.00
48249	Jim Wells	0.00
48251	Johnson	69,367.84
48253	Jones	0.00
48255	Karnes	0.00
48257	Kaufman	0.00
48259	Kendall	0.00
48261	Kenedy	0.00
48263	Kent	0.00
48265	Kerr	0.00
48267	Kimble	0.00
48269	King	0.00
48271	Kinney	0.00
48273	Kleberg	0.00
48275	Knox	0.00
48277	Lamar	54,148.87
48279	Lamb	0.00
48281	Lampasas	0.00
48283	La Salle	0.00
48285	Lavaca	0.00
48287	Lee	13,885.64
48289	Leon	0.00
48291	Liberty	0.00
48293	Limestone	0.00
48295	Lipscomb	0.00
48297	Live Oak	0.00
48299	Llano	32,595.45
48301	Loving	0.00
48303	Lubbock	139,737.86

FIPS	County	Total (gallon)
48305	Lynn	4,611.45
48307	McCulloch	0.00
48309	McLennan	0.00
48311	McMullen	0.00
48313	Madison	0.00
48315	Marion	0.00
48317	Martin	0.00
48319	Mason	0.00
48321	Matagorda	0.00
48323	Maverick	2,234.42
48325	Medina	4,634.63
48327	Menard	0.00
48329	Midland	0.00
48331	Milam	1,613.32
48333	Mills	0.00
48335	Mitchell	0.00
48337	Montague	0.00
48339	Montgomery	0.00
48341	Moore	62,532.52
48343	Morris	17,733.62
48345	Motley	0.00
48347	Nacogdoches	0.00
48349	Navarro	0.00
48351	Newton	49,996.17
48353	Nolan	42,569.02
48355	Nueces	0.00
48357	Ochiltree	0.00
48359	Oldham	0.00
48361	Orange	62,038.11
48363	Palo Pinto	0.00
48365	Panola	14,570.99
48367	Parker	1,129.91
48369	Parmer	0.00
48371	Pecos	59,569.40
48373	Polk	5,601.40
48375	Potter	0.00
48377	Presidio	68,319.88
48379	Rains	0.00
48381	Randall	0.00
48383	Reagan	26,244.99
48385	Real	0.00
48387	Red River	0.00

FIPS	County	Total (gallon)
48389	Reeves	81,079.36
48391	Refugio	0.00
48393	Roberts	0.00
48395	Robertson	0.00
48397	Rockwall	40,226.07
48399	Runnels	30,695.26
48401	Rusk	0.00
48403	Sabine	55,174.08
48405	San Augustine	49,743.76
48407	San Jacinto	0.00
48409	San Patricio	0.00
48411	San Saba	0.00
48413	Schleicher	0.00
48415	Scurry	0.00
48417	Shackelford	0.00
48419	Shelby	77,476.94
48421	Sherman	0.00
48423	Smith	0.00
48425	Somervell	5,254.41
48427	Starr	47,899.09
48429	Stephens	0.00
48431	Sterling	0.00
48433	Stonewall	0.00
48435	Sutton	0.00
48437	Swisher	4,943.91
48439	Tarrant	243,684.39
48441	Taylor	24,355.36
48443	Terrell	0.00
48445	Terry	106,026.33
48447	Throckmorton	0.00
48449	Titus	35,785.92
48451	Tom Green	30,085.67
48453	Travis	108,963.30
48455	Trinity	0.00
48457	Tyler	0.00
48459	Upshur	0.00
48461	Upton	29,424.97
48463	Uvalde	0.00
48465	Val Verde	0.00
48467	Van Zandt	0.00
48469	Victoria	0.00

FIPS	County	Total (gallon)
48471	Walker	0.00
48473	Waller	0.00
48475	Ward	19,497.54
48477	Washington	0.00
48479	Webb	0.00
48481	Wharton	0.00
48483	Wheeler	0.00
48485	Wichita	27,164.37
48487	Wilbarger	0.00
48489	Willacy	0.00
48491	Williamson	170,685.12
48493	Wilson	0.00
48495	Winkler	73,216.59
48497	Wise	0.00
48499	Wood	0.00
48501	Yoakum	0.00
48503	Young	0.00
48505	Zapata	0.00
48507	Zavala	0.00

Class I and III Switching Yard Fuel Consumption Estimates for 2023

FIPS	County	Total (gallon)
48001	Anderson	52,516.93
48003	Andrews	0.00
48005	Angelina	13,321.43
48007	Aransas	18,918.07
48009	Archer	0.00
48011	Armstrong	0.00
48013	Atascosa	13,479.86
48015	Austin	44,171.69
48017	Bailey	0.00
48019	Bandera	0.00
48021	Bastrop	22,682.20
48023	Baylor	0.00
48025	Bee	0.00
48027	Bell	173,656.60
48029	Bexar	587,636.62
48031	Blanco	0.00

FIPS	County	Total (gallon)
48033	Borden	0.00
48035	Bosque	0.00
48037	Bowie	53,823.83
48039	Brazoria	438,462.89
48041	Brazos	48,365.21
48043	Brewster	0.00
48045	Briscoe	0.00
48047	Brooks	0.00
48049	Brown	129,608.76
48051	Burleson	51,862.11
48053	Burnet	0.00
48055	Caldwell	0.00
48057	Calhoun	395,575.73
48059	Callahan	0.00
48061	Cameron	437,605.88
48063	Camp	47,727.35
48065	Carson	19,009.29
48067	Cass	4,936.00
48069	Castro	8,643.90
48071	Chambers	365,663.18
48073	Cherokee	0.00
48075	Childress	8,199.42
48077	Clay	7,304.91
48079	Cochran	0.00
48081	Coke	0.00
48083	Coleman	0.00
48085	Collin	19,783.01
48087	Collingsworth	0.00
48089	Colorado	18,716.88
48091	Comal	55,700.01
48093	Comanche	0.00
48095	Concho	0.00
48097	Cooke	56,368.63
48099	Coryell	102,214.88
48101	Cottle	0.00
48103	Crane	0.00
48105	Crockett	0.00
48107	Crosby	0.00

FIPS	County	Total (gallon)
48109	Culberson	0.00
48111	Dallam	69,330.38
48113	Dallas	729,769.38
48115	Dawson	0.00
48117	Deaf Smith	156,286.02
48119	Delta	0.00
48121	Denton	127,887.53
48123	DeWitt	0.00
48125	Dickens	0.00
48127	Dimmit	0.00
48129	Donley	0.00
48131	Duval	0.00
48133	Eastland	0.00
48135	Ector	209,771.37
48137	Edwards	0.00
48139	Ellis	36,439.32
48141	El Paso	588,868.56
48143	Erath	3,585.90
48145	Falls	0.00
48147	Fannin	0.00
48149	Fayette	54,283.22
48151	Fisher	0.00
48153	Floyd	0.00
48155	Foard	0.00
48157	Fort Bend	174,103.38
48159	Franklin	0.00
48161	Freestone	55,127.87
48163	Frio	0.00
48165	Gaines	0.00
48167	Galveston	170,759.55
48169	Garza	0.00
48171	Gillespie	0.00
48173	Glasscock	0.00
48175	Goliad	0.00
48177	Gonzales	24,938.07
48179	Gray	109,322.71
48181	Grayson	236,651.44
48183	Gregg	195,387.94

FIPS	County	Total (gallon)
48185	Grimes	45,781.84
48187	Guadalupe	28,306.99
48189	Hale	145,123.95
48191	Hall	0.00
48193	Hamilton	0.00
48195	Hansford	0.00
48197	Hardeman	27,804.77
48199	Hardin	58,010.84
48201	Harris	2,279,958.45
48203	Harrison	140,170.16
48205	Hartley	0.00
48207	Haskell	0.00
48209	Hays	17,617.86
48211	Hemphill	2,746.09
48213	Henderson	0.00
48215	Hidalgo	307,973.52
48217	Hill	6,771.67
48219	Hockley	0.00
48221	Hood	3,085.79
48223	Hopkins	8,966.63
48225	Houston	0.00
48227	Howard	47,843.23
48229	Hudspeth	0.00
48231	Hunt	1,653.01
48233	Hutchinson	45,675.16
48235	Irion	0.00
48237	Jack	0.00
48239	Jackson	210,656.74
48241	Jasper	16,896.57
48243	Jeff Davis	0.00
48245	Jefferson	584,888.18
48247	Jim Hogg	0.00
48249	Jim Wells	6,211.23
48251	Johnson	97,091.29
48253	Jones	0.00
48255	Karnes	0.00
48257	Kaufman	0.00
48259	Kendall	0.00

FIPS	County	Total (gallon)
48261	Kenedy	0.00
48263	Kent	0.00
48265	Kerr	0.00
48267	Kimble	0.00
48269	King	0.00
48271	Kinney	0.00
48273	Kleberg	0.00
48275	Knox	0.00
48277	Lamar	36,653.78
48279	Lamb	0.00
48281	Lampasas	28,425.23
48283	La Salle	0.00
48285	Lavaca	0.00
48287	Lee	0.00
48289	Leon	33,460.04
48291	Liberty	89,149.55
48293	Limestone	0.00
48295	Lipscomb	0.00
48297	Live Oak	38,742.61
48299	Llano	0.00
48301	Loving	0.00
48303	Lubbock	567,647.50
48305	Lynn	0.00
48307	McCulloch	31,484.28
48309	McLennan	118,071.34
48311	McMullen	0.00
48313	Madison	0.00
48315	Marion	6,692.60
48317	Martin	0.00
48319	Mason	0.00
48321	Matagorda	209,620.57
48323	Maverick	26,206.86
48325	Medina	23,362.78
48327	Menard	0.00
48329	Midland	0.00
48331	Milam	52,152.00
48333	Mills	0.00
48335	Mitchell	0.00

FIPS	County	Total (gallon)
48337	Montague	0.00
48339	Montgomery	23,872.55
48341	Moore	265,343.99
48343	Morris	29,852.47
48345	Motley	0.00
48347	Nacogdoches	52,252.65
48349	Navarro	33,973.71
48351	Newton	0.00
48353	Nolan	100,569.82
48355	Nueces	268,449.46
48357	Ochiltree	0.00
48359	Oldham	0.00
48361	Orange	292,247.97
48363	Palo Pinto	0.00
48365	Panola	147,210.71
48367	Parker	0.00
48369	Parmer	11,300.36
48371	Pecos	0.00
48373	Polk	0.00
48375	Potter	632,835.96
48377	Presidio	0.00
48379	Rains	0.00
48381	Randall	141,312.20
48383	Reagan	0.00
48385	Real	0.00
48387	Red River	0.00
48389	Reeves	4,571.55
48391	Refugio	45,789.63
48393	Roberts	0.00
48395	Robertson	38,785.63
48397	Rockwall	0.00
48399	Runnels	360.05
48401	Rusk	98,147.64
48403	Sabine	0.00
48405	San Augustine	0.00
48407	San Jacinto	0.00
48409	San Patricio	144,205.39

FIPS	County	Total (gallon)
48411	San Saba	0.00
48413	Schleicher	0.00
48415	Scurry	5,273.62
48417	Shackelford	0.00
48419	Shelby	17,472.28
48421	Sherman	0.00
48423	Smith	56,895.13
48425	Somervell	0.00
48427	Starr	0.00
48429	Stephens	0.00
48431	Sterling	0.00
48433	Stonewall	0.00
48435	Sutton	0.00
48437	Swisher	0.00
48439	Tarrant	1,029,201.24
48441	Taylor	23,013.93
48443	Terrell	0.00
48445	Terry	0.00
48447	Throckmorton	0.00
48449	Titus	135,303.97
48451	Tom Green	7,009.54
48453	Travis	3,732.60
48455	Trinity	0.00
48457	Tyler	0.00
48459	Upshur	0.00
48461	Upton	0.00
48463	Uvalde	109,224.96
48465	Val Verde	1,271.80
48467	Van Zandt	0.00
48469	Victoria	167,223.51
48471	Walker	0.00
48473	Waller	10,976.86
48475	Ward	62,750.04
48477	Washington	4,738.02
48479	Webb	277,219.75
48481	Wharton	0.00
48483	Wheeler	0.00
48485	Wichita	133,453.88

FIPS	County	Total (gallon)
48487	Wilbarger	15,430.87
48489	Willacy	0.00
48491	Williamson	131,274.66
48493	Wilson	19,298.80
48495	Winkler	0.00
48497	Wise	72,673.95
48499	Wood	22,174.87
48501	Yoakum	0.00
48503	Young	0.00
48505	Zapata	0.00
48507	Zavala	0.00

APPENDIX B: LOCOMOTIVE AND RAIL EMISSION RATES

This appendix is available electronically only.

APPENDIX C: 2023 ANNUAL AND DAILY COUNTY-LEVEL EMISSIONS IN EPA'S EIS XML FORMAT

This appendix is available electronically only.

APPENDIX D: 2011 THROUGH 2050 ANNUAL AND DAILY COUNTY-LEVEL TREND EIS IN TCEQ'S TEXAER XML FORMAT

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APPENDIX E: 2023 AERR EI IN A COMMA-DELIMITED FILE FORMAT

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APPENDIX F: 2011 THROUGH 2050 TRENDS EI IN COMMA-DELIMITED FILE FORMAT

This appendix is available electronically only.