United States-Mexico Land Ports of Entry Emissions and Border Wait-Time White Paper and Analysis Template

DTFH61-11-D-00030-T11-002 (EN 1002): Emissions and Border Wait-Time Analysis Support

Task#: T11-002

Contract #: DTFH61-06-D-00030

November 2012

U.S.Department of Transportation
Federal Highway Administration

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document. This report does not constitute a standard, specification, or regulation. The U.S. Government does not endorse products of manufacturers. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes for continuous quality improvement.

Technical Report Documentation Page

1. Report No. FHWA-HEP-13-004	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle United States-Mexico Land Ports of Entry Emissions and Border Wait-Time White Paper and Analysis Template		**5. Report Date** November 2012 **6. Performing Organization Code**
7. Author(s) Thomas P. Kear, Ph.D., P.E., James H. Wilson, and James J. Corbett, Ph.D.		**8. Performing Organization Report No.**
9. Performing Organization Name and Address Cambridge Systematics, Inc. 100 Cambridge Park Drive, Suite 400 Cambridge, MA 02140 Energy and Environmental Research Associates Two Babcock Farms Lane Pittsford, NY 14534 TranSystems Corporation 2400 Pershing Road, Suite 400 Kansas City, MO 64108		**10. Work Unit No.** **11. Contract or Grant No.** DTFH61-11-D-00030-T11-002
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Planning, Environment, and Realty 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code**
15. Supplementary Notes FHWA Task Manager (COTR), Sylvia Grijalva		

16. Abstract

This report summarizes background research and presents an analysis template for analyzing the emissions from vehicle delay at land ports of entry along the United States-Mexico border. The analyses template is presented along with two case studies. Results from the case studies identify candidate best practices and performance measures for use as an input during the initial phases of development for projects that alter the border infrastructure or the operational characteristics of the ports of entry. A set of operating mode distributions and average speed data for use with emission factor modes such as MOVES, EMFAC, or MOBILE is developed based on a detailed microsimulation analysis of the Bridge of the Americas and the Ysleta-Zaragoza port of entry. Vehicle activity is assigned to either uncongested movements or queues, with queues further broken down to stop-and-go queues or creeping queues. This breakout of the emissions and vehicle activity is then used to analysis specific case studies to add users in extending the analysis template to their own analysis needs. Background research is available separately.

17. Key Words Land port of entry, border crossing delay, border crossing emissions, MOVES, EMFAC, MOBILE	**18. Distribution Statement** No restrictions.		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No of Pages** 85	**22. Price** N/A

Form DOT F 1700.7 (8-72) **Reproduction of completed pages authorized**

Table of Contents

List of Tables

List of Figures

1.0 Executive Summary

1.1 Purpose

Delay and congestion at the ports of entry (POE) along the length of the United States (U.S.)-Mexico border present complicated problems for the commercial and private traffic using the facilities, and impact the surrounding communities and those employed at the border itself. There is a strong desire to implement strategies that reduce emissions at the border to both reduce potential exposure to unhealthy levels of exhaust pollutants and to help regions attain the national ambient air quality standards.

This project developed an analysis template for emissions associated with the ports of entry, and demonstrates its use through two case studies. Results from the case studies identify candidate best practices and performance measures for use as an input during the initial phases of development for projects that alter the border infrastructure or the operational characteristics of the ports of entry.

Projects, solutions, and strategies that can be directly evaluated by the emissions analysis protocol fall into three categories:

- **Staffing and Management –** Solutions that address the institutional, policy, or regulatory environment that governs the management of the region's cross-border network, including Customs and Border Protection (CBP) staffing levels and bridge hours of operation;
- **Technology –** Solutions that leverage existing technology or implement new technology applications to improve the efficiency of cross-border movements, inspections, or information available to passengers, carriers, or shippers; and
- **Traffic Engineering and Infrastructure –** Solutions that relate to the condition or physical capacity of the port of entry infrastructure or approach network, as well as operational solutions that relate to how the system is being utilized.

Additionally, other types of strategies such as pricing, and policies that effect travel behavior can be evaluated to the extent that changes in delay can be estimated through traffic operations analysis.

1.2 Approach

The framework for the approach is shown as the flowchart provided in Figure 1.1. The process involves developing representative emission rates and then combining those rates with the corresponding vehicle activity. Differences between scenarios can be quantified.

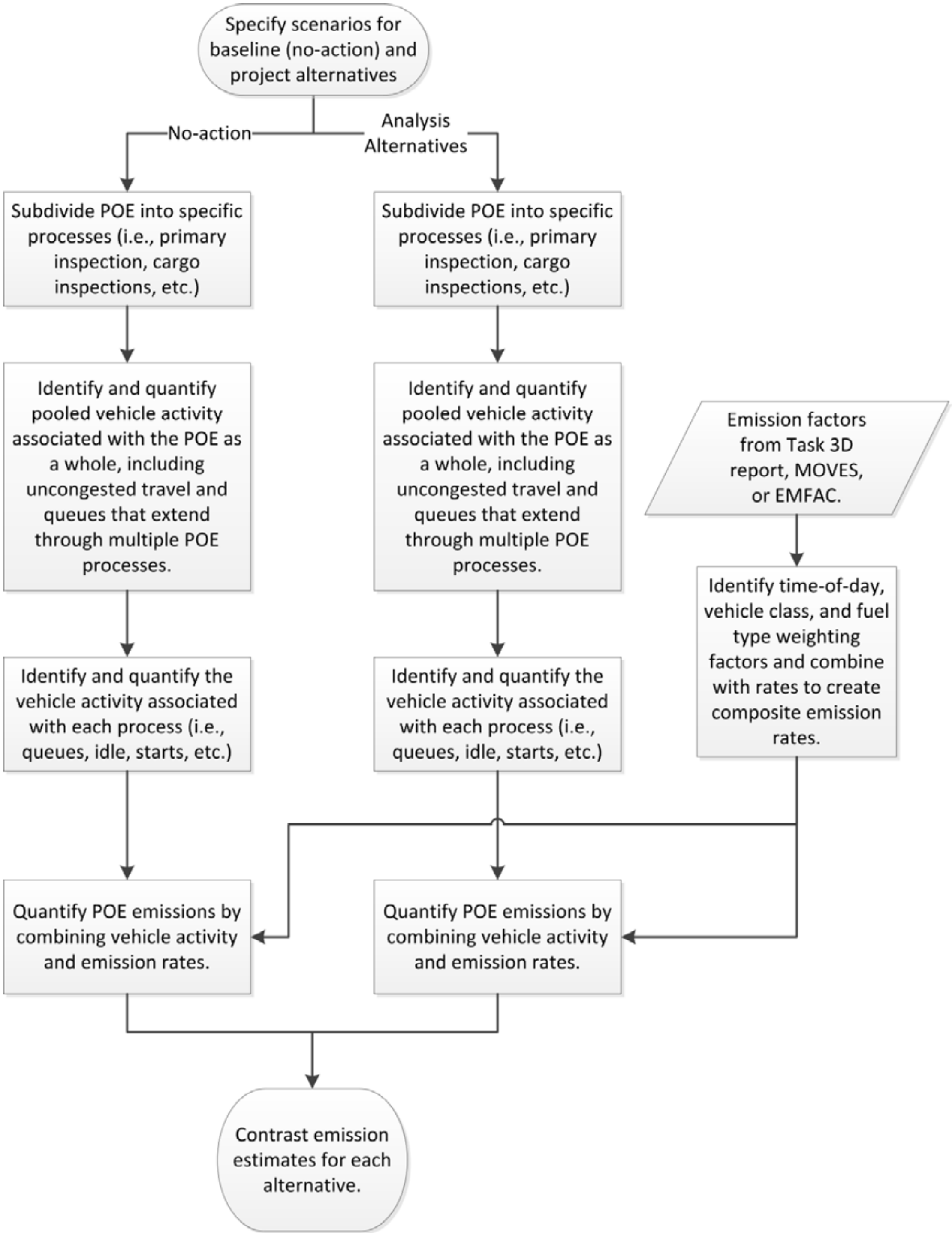
- **Stop-and-go queuing** reflecting dense congested traffic in storage lanes similar to that found in the storage lanes providing immediate service to the primary inspection booths. These types of queues were found to have average speeds of less than one mile per hour.

- **Creeping queues** characterizing vehicle behavior on congested roadway segments that feed the stop-and-go queue lanes. The queues have more of a creeping behavior than a stop-and-go behavior because each lane feeds multiple stop-and-go queue lanes. Speeds on links that have creeping queues average about five miles per hour.

- **Uncongested operation** is used to describe the travel on roadway segments leading up to queue links; average speeds for these links are in the 25 to 35 miles-per-hour range.

The vehicle idle and start emissions resulting from the secondary inspections process and the commercial cargo inspection process also are captured by the analysis template.

Figure 1.1 Analysis Template Approach



Source: Cambridge Systematics, Inc.

Note: The analysis protocol considers three types of vehicle movements that capture the range of emissions as vehicles approach the border crossing. The needed vehicle activity data and corresponding emissions are readily quantifiable for screening analysis or can be applied in a detailed manner for more sophisticated applications.

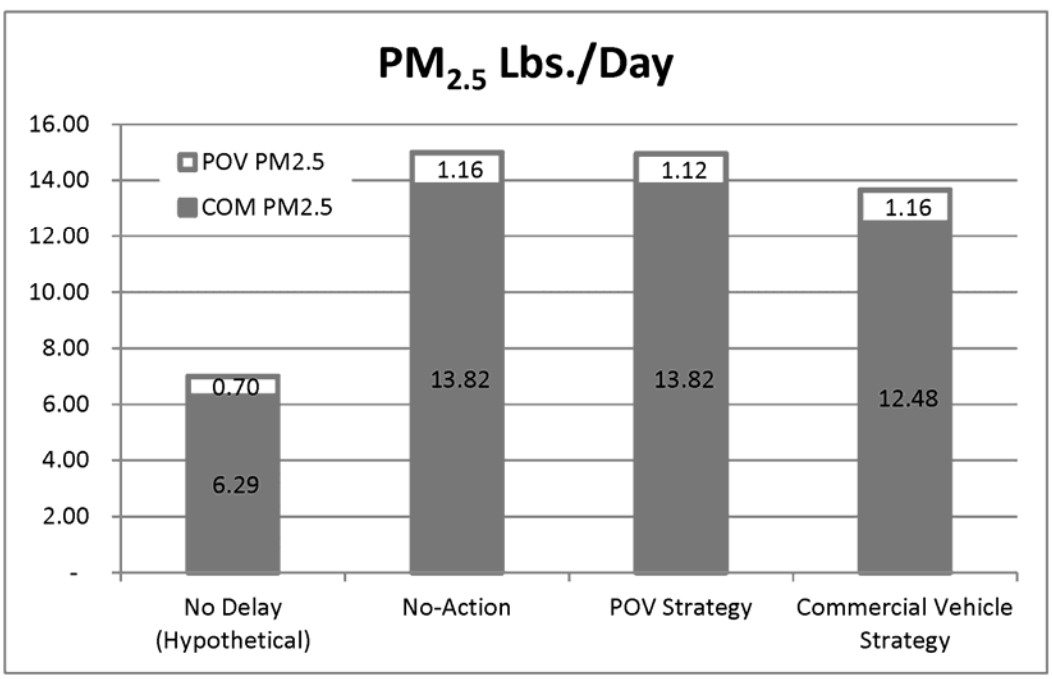
1.3 Case Study

The Ysleta-Zaragoza port near El Paso was used as a case study to demonstrate the approach. The case study focused on 2010 and demonstrates $PM_{2.5}$ and NO_x emission calculations for four scenarios:

- A "no delay" scenario representing a hypothetical best case where vehicles pass through the POE as if it did not exist. There are no inspections, no congestion, and no delays.
- A "no-action" scenario, reflecting typical daily emissions for 2010 traffic levels at the Ysleta-Zaragoza POE.
- A "Privately Owned Vehicle (POV) Strategy" that shifts vehicles from the general purpose lanes to the faster SENTRI lanes.
- A "commercial vehicle strategy" that assumes U.S. and Mexican cargo inspections are combined to eliminate the queuing and delay associated with duplicative inspections.

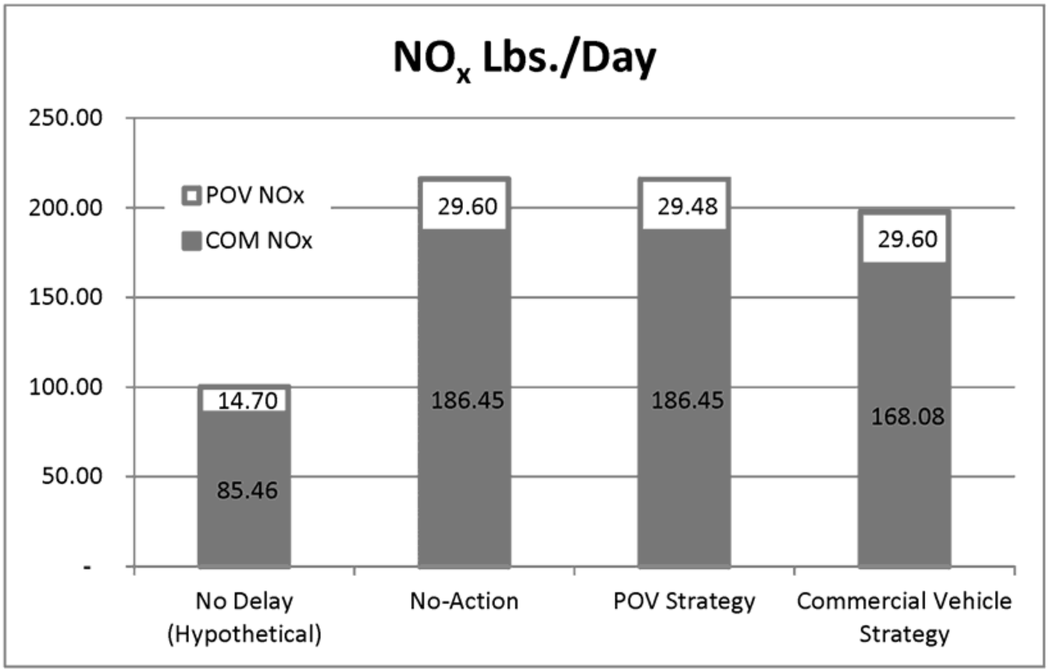
Results of the case studies are shown in Figure 1.2 and Figure 1.3. Even though the commercial traffic (generally consisting of heavy trucks) is much lower than private vehicle traffic (generally consisting of passenger vehicles), the commercial vehicles account for most of the $PM_{2.5}$ and NO_x emissions.

Figure 1.2 2010 Ysleta-Zaragoza Northbound Daily $PM_{2.5}$ Emissions



Source: Cambridge Systematics, Inc.

Figure 1.3 2010 Ysleta-Zaragoza Northbound Daily NO_x Emissions



Source: Cambridge Systematics, Inc.

1.4 Findings

Recommended best management practices focus on minimizing queue delay and congestion at the border.

- Minimize the number of booths and combine inspections. Each point where a vehicle needs to stop for a specific check has stop-and-go queuing leading up to the booth and idling at the booth itself. Emissions from each of these processes may be as much as five percent of the controllable emissions at the port of entry.
- Minimize queue vehicle miles of travel (VMT) and/or minimize delay. For queued vehicles, gram-per-mile emission rates are generally on the order of two times the emission rate for uncongested VMT. Minimizing delay is analogous to minimizing queue VMT; but time spent parked should not be included in the tabulation of delay.
- Park rather than stack vehicles. Some new border crossing designs include a storage parking lot where vehicles can be parked rather than idle/creep while waiting for cargo inspections. For commercial vehicles, the amount of creeping VMT inside of the cargo inspection areas may be similar to the queue lengths approaching the border.
- Combining redundant cargo and vehicle inspections (i.e., Mexican-, U.S.-, and state-level cargo inspections and safety checks).

Examples of strategies that would be compatible with these best management practices would be: consolidating toll and inspection booths; appointment systems; and preclearance of more vehicles and vehicle occupants through programs such as SENTRI, FAST, and the use of Ready Lanes.

Candidate performance measures include:

- Emissions in terms of grams per vehicle processed through the port of entry;
- The total mass of pollutants emitted at the port of entry, or process within the port of entry;
- The amount of VMT in creeping queues and stop-and-go queues;
- Tracking the number of booths that a vehicle must pass through; and
- Tracking the amount of non-parked delay.

All of the above metrics should be minimized.

2.0 Introduction and Summary

■ 2.1 Project Overview

Emissions at the border crossings along the U.S.-Mexico border are coming under increased scrutiny. This project examined the factors that affect emissions from vehicles idling and moving slowly through the land ports of entry. Project results are compiled into this white paper and analysis template. The analysis template estimates how policy and infrastructure changes will effect emissions, and is designed to allow consistent application of the procedures along both sides of the U.S.-Mexico border. Two case studies are presented to demonstrate the analysis template. The results of those case studies are then used to develop candidate best practices for emission reductions. Specific objectives of this project include the following:

- Support the Joint Working Committee (JWC) work plan, including long-range regional border master planning activities.
- Develop a quantitative relationship between border wait time and emissions and quantify this relationship at selected border crossing regions.
- Organize and identify data to improve border planning efforts. Border wait time data collected through other recent and ongoing studies will support this study.
- Establish (identify and inventory) a baseline of vehicle emissions data at U.S.-Mexico land border crossings needed for emissions modeling. Identify missing data, potential sources, and cost of collecting data, to complete the emissions estimations for modeling all land ports of entry along the U.S. -Mexico border.
- Provide information to support the prioritization of strategies that will improve real-time border crossing operations and support the development of performance measures to be utilized in developing emission reduction strategies.
- Create an emissions analysis template that can be used along the U.S.-Mexico border to measure emissions and impacts from vehicle delay at the border and for analyzing proposed infrastructure or operational improvements to existing or new facilities.

The emissions analysis template is intended to facilitate the use of air quality performance measures among the evaluation criteria for selecting projects along the U.S.-Mexico border for further consideration by the U.S.-Mexico Joint Working Committee on transportation planning.

■ 2.2 Purpose of This Document

This document presents the analysis protocol for emissions associated with the ports of entry, and demonstrates its use through two case studies. Results from the case studies are used to identify candidate best practices and performance measures for use as an input during the initial phases of project development. The analysis protocol considers commercial vehicles, privately owned vehicles, and transit buses. Different steps in both the northbound and southbound crossing process are accounted for, such as queuing on the approaches to inspection booths, and the delay associated with secondary inspections. The analysis protocol estimates how traffic characteristics affect emissions. It does not model how individual strategies affect the traffic itself; the analyst needs to provide relevant traffic data with and without the implementation of strategies being considered to alter the traffic flows or delay.

Projects, solutions, and strategies that can be directly evaluated by the emissions analysis protocol fall into three categories:

- **Staffing and Management –** Solutions that address the institutional, policy, or regulatory environment that governs the management of the region's cross-border network, including Customs and Border Protection (CBP) staffing levels and bridge hours of operation;

- **Technology –** Solutions that leverage existing technology or implement new technology applications to improve the efficiency of cross-border movements, inspections, or information available to passengers, carriers, or shippers; and

- **Traffic Engineering and Infrastructure –** Solutions that relate to the condition or physical capacity of the port of entry infrastructure or approach network, as well as operational solutions that relate to how the system is being utilized.

Additionally, other types of strategies such as pricing, and other policies that effect travel behavior, can be evaluated to the extent that changes in delay can be estimated through traffic operations analysis.

■ 2.3 Further Considerations

This white paper and analysis template has been constructed using the El Paso/Juarez region as the basis for research and examples. However, the approach used for the analysis is intended to be applicable along the entire U.S.-Mexico border. Transferability of the methods to other regions along the border is discussed in Section 4.3 of this document. The base components of the analysis can be used to reflect emissions from vehicle activity and delay, regardless of the size of the POE and surrounding community, the specifics of the port of entry, or the emission factor model used to estimate emission rates.

Task 3 encompassed all the technical components of the project scope. The Task 3 work products, available separately, provide emission rates from the U.S. EPA MOVES2010a model representing the El Paso/Juarez region for a variety of conditions and years. The attached Task 3 work products also include technical guidance on the extrapolation of those emission rates to other areas. Additionally, the technical guidance provides resources that will help in the application of the MOVES, MOBILE6-Mexico, or EMFAC for any region along the border that may be necessary.

3.0 Analysis Template Approach

This section provides guidance on how to conduct an emissions analysis for U.S.-Mexico land ports of entry, using an analysis template developed within the context of the El Paso/Juarez border crossing, but for application along the entirety of the U.S. – Mexico border. A flowchart for the approach is provided as Figure 3.1. The process involves developing representative emission rates and then combining those rates with vehicle activity data for all of the scenarios being analyzed. Differences between scenarios can then be quantified by contrasting the results from the emissions analysis. The following sections provide a general description of how emissions are characterized at the El Paso/Juarez ports of entry, the development of emissions factors, identifying and quantifying vehicle activity at the border, and how to combine these data to quantify emissions. The same set of procedures can be adapted for analysis of other ports of entry.

■ 3.1 Development of Emission Factors

This section encapsulates three related steps needed for estimating emissions at a border crossing: defining the types of vehicle behavior or activity that occur at ports of entry, developing emission rates corresponding to those types of activity, and finally compositing of those emission rates into a form that can be applied directly to the border activity.

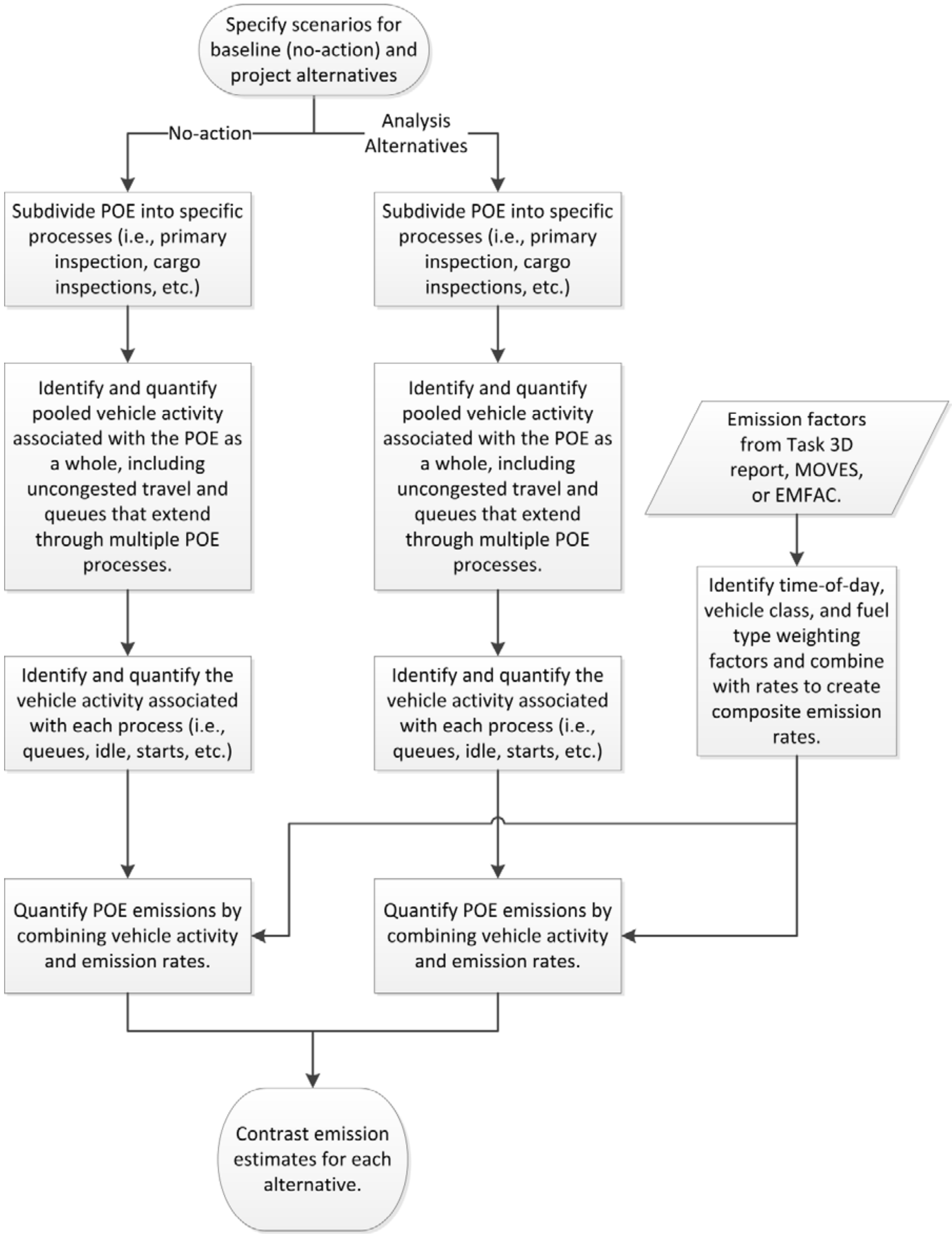
Defining Vehicle Behavior at Ports of Entry

A detailed analysis of vehicle behavior was conducted through the use of a VISSIM microsimulation model for both Bridge of the Americas and Ysleta-Zaragoza ports of entry. The analysis identified the difference between different types of approach lanes both in terms of the classes of vehicles that use the lane, and the Customs and Border Protection programs serviced by the lanes. Differentiation also was made between northbound and southbound vehicle movements.

Three types of vehicle behavior were selected for detailed analysis. These were defined as:

- **Stop-and-go queuing:** Stop-and-go queues reflect the dense congested traffic in storage lanes similar to that found in the storage lanes providing immediate service to the primary inspection booths. Within the VISSIM model, this activity was identified as travel on the links located at, or immediately upstream of, the primary inspection booths; with 5-minute average speeds at both ends of the link below 10 miles per hour. In practice, simulated speeds on links tagged as having stop-and-go queuing average less than 1 mile per hour.

Figure 3.1 Analysis Template Approach



Source: Cambridge Systematics, Inc.

- **Creeping queues:** Creeping queues characterize vehicle behavior on congested roadway segments that feed the stop-and-go queue lanes. The queues have more of a creeping behavior than a stop-and-go behavior because each lane feeds multiple stop-and-go queue lanes. Within the VISSIM model, this activity was identified as travel on links where the 5-minute average speeds at both ends of the link was below 10 miles per hour. In practice, simulated speeds on links that have creeping queues average about 5 miles per hour.

- **Uncongested operation**: Travel and roadway segments leading up to queue links is representative of the behavior considered to be uncongested vehicle operation. Within the VISSIM model this activity was identified as occurring on links with 5-minute average speeds at both ends of the link greater than 10 mph. The uncongested operations behavior identified in the VISSIM microsimulation had average speeds in the 25 to 35 miles-per-hour range (depending on vehicle class, type of link, etc.).

Table 3.1, Table 3.2, and Table 3.3 summarize the passenger vehicle-specific power (VSP) and commercial vehicle scales tractive power (STP) profiles for use with the MOVES model, and average speeds for use with EMFAC and MOBILE6 Mexico. The VSP profiles consist of the fraction of vehicle activity occurring in the various vehicle modes of operation, for stop-and-go queues, creeping queues, and uncongested movements for use with the U.S. EPA MOVES model (note that each column sums to 1.0). The MOVES operating modes used in this analysis include vehicle deceleration, idling, and cruise/acceleration; with cruise/acceleration broken into low (less than 25 mph), medium (25-50 mph), and high (greater than 50 mph) speeds at varying VSP levels indicative of the engine load. Seven types of lanes are represented in the vehicle activity characterizations: 1) Northbound FAST[1] trucks, 2) Northbound unladen trucks, 3) Northbound laden trucks, 4) Southbound trucks (all types), 5) Northbound autos, 6) Northbound SENTRI[2] autos, and 7) Southbound autos (all types). Note that data for SENTRI lanes are assumed to represent Ready[3] lanes as well. In addition the tables provide representative vehicle speeds for use with models such as MOBILE6 Mexico and EMFAC.

There are additional types of vehicle behavior that need to be quantified as the analysis is conducted. These consist of what is referred to as "off-network" vehicle activity within the framework of the MOVES model. Off-network area data include information about vehicles which are not driving on the links or roadways, but still contribute to

[1] Free And Secure Trade (FAST) program where drivers, vehicles, and cargo are pre cleared for entry into the U.S.

[2] Secured Electronic Network for Travelers Rapid Inspection (SENTRI) program is a transponder based program providing expedited inspection and clearance through primary inspection via dedicated commuter lanes.

[3] Ready lanes provide a dedicated lane for privately owned vehicles entering the U.S. for vehicles whose occupants have WHTI-compliant, RFID-enabled cards approved by the Department of Homeland Security.

port-of-entry vehicle emissions while idling, extended idling[4] or starting. In the case of most U.S.-Mexico border crossings, trucks stopping and restarting for inspections are accounted for in the off-network area. As was the case for running emissions, off-network emissions estimates were developed as emission rates (start emissions in gram/start and extended idling in grams per hour) and were generated by soak time (i.e., a specific start emission rate was developed for each specific soak). The soak times available in MOVES include:

- Soak < 6 minutes;
- 6 minutes ≤ Soak < 30 minutes;
- 30 minutes ≤ Soak < 60 minutes;
- 60 minutes ≤ Soak < 90 minutes;
- 90 minutes ≤ Soak < 120 minutes;
- 120 minutes ≤ Soak < 360 minutes;
- 360 minutes ≤ Soak < 720 minutes; and
- 720 minutes ≤ Soak.

More information on the how these activity profiles were developed is provided in the Task 3 technical reports (attached).

[4] Extended idle is used to power accessory loads such as air conditioning when a vehicle is parked.

Table 3.1 Stop-and-Go Queues

Fraction of Activity by Operating Mode For Use with MOVES, and Average Speed For Use With EMFAC and MOBILE6 Mexico

	VSP STP	MOVES OpModeID	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.229	0.330	0.212	0.266	0.267	0.244	0.203
Idle		1	0.627	0.549	0.659	0.590	0.629	0.597	0.610
Cruise/Acceleration 1 to 25 Miles Per Hour	< 0	11	0.044	0.044	0.042	0.047	0.038	0.055	0.001
	0-3	12	0.091	0.071	0.075	0.089	0.065	0.095	0.184
	3-6	13	0.004	0.002	0.003	0.003	0.001	0.002	0.001
	6-9	14	0.001	0.001	0.002	0.001	0.000	0.002	0.000
	9-12	15	0.001	0.000	0.001	0.001	0.000	0.001	0.000
	12+	16	0.003	0.003	0.005	0.002	0.001	0.003	0.000
Cruise/Acceleration 25 to 50 Miles Per Hour	< 0	21	N/A	N/A	N/A	N/A	0.000	N/A	N/A
	0-3	22	N/A	N/A	N/A	N/A	0.000	N/A	0.000
	3-6	23	N/A	N/A	N/A	0.000	0.000	N/A	0.000
	6-9	24	N/A	N/A	N/A	N/A	0.000	N/A	0.000
	9-12	25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	12-18	27	N/A	N/A	N/A	0.000	N/A	N/A	N/A
	18-24	28	N/A	N/A	0.000	N/A	0.000	N/A	N/A
	24-30	29	N/A	N/A	N/A	N/A	0.000	0.000	0.000
	30+	30	N/A	N/A	0.000	0.000	0.000	0.000	0.000
Cruise/Acceleration 50+ Miles Per Hour	< 6	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6-12	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	12-18	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	18-24	38	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	24-30	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30+	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Speed (mph)			1	1	1	1	1	1	1

Table 3.2 Creeping Queues

Fraction of Activity by Operating Mode For Use with MOVES, and Average Speed For Use With EMFAC and MOBILE6 Mexico

	VSP STP	MOVES OpModeID	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.295	0.364	0.294	0.286	0.276	0.259	0.259
Idle		1	0.504	0.439	0.495	0.521	0.525	0.505	0.507
Cruise/Acceleration 1 to 25 Miles Per Hour	< 0	11	0.060	0.071	0.073	0.065	0.073	0.081	0.002
	0-3	12	0.132	0.118	0.128	0.119	0.119	0.140	0.232
	3-6	13	0.004	0.004	0.006	0.005	0.004	0.004	0.000
	6-9	14	0.002	0.002	0.001	0.001	0.002	0.001	0.000
	9-12	15	0.001	0.001	0.001	0.001	0.001	0.001	0.000
	12+	16	0.001	0.001	0.001	0.001	0.001	0.002	0.000
Cruise/Acceleration 25 to 50 Miles Per Hour	< 0	21	0.000	0.000	0.000	0.000	0.000	0.000	N/A
	0-3	22	N/A	0.000	N/A	N/A	0.000	0.001	0.000
	3-6	23	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	6-9	24	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	9-12	25	0.000	0.000	0.000	0.000	0.000	0.000	N/A
	12-18	27	0.000	0.000	0.000	0.000	0.000	0.000	N/A
	18-24	28	N/A	0.000	0.000	0.000	0.000	0.000	N/A
	24-30	29	0.000	N/A	0.000	0.000	0.000	0.001	N/A
	30+	30	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Cruise/Acceleration 50+ Miles Per Hour	< 6	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6-12	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	12-18	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	18-24	38	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	24-30	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30+	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Speed (mph)			5	5	5	5	5	5	5

Table 3.3 Uncongested Movement

Fraction of Activity by Operating Mode For Use with MOVES, and Average Speed For Use With EMFAC and MOBILE6 Mexico

	VSP STP	MOVES OpModeID	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Deceleration		0	0.248	0.187	0.206	0.195	0.265	0.153	0.215
Idle		1	0.123	0.111	0.174	0.268	0.297	0.118	0.362
Cruise/Acceleration 1 to 25 Miles Per Hour	< 0	11	0.024	0.027	0.026	0.029	0.040	0.021	0.001
	0-3	12	0.034	0.028	0.036	0.041	0.053	0.025	0.118
	3-6	13	0.007	0.008	0.008	0.007	0.010	0.007	0.003
	6-9	14	0.004	0.006	0.004	0.004	0.005	0.004	0.000
	9-12	15	0.005	0.005	0.004	0.004	0.002	0.003	0.000
	12+	16	0.008	0.010	0.009	0.012	0.005	0.018	0.000
Cruise/Acceleration 25 to 50 Miles Per Hour	< 0	21	0.014	0.016	0.016	0.014	0.012	0.027	0.000
	0-3	22	0.266	0.327	0.290	0.214	0.037	0.074	0.058
	3-6	23	0.222	0.226	0.189	0.180	0.213	0.393	0.239
	6-9	24	0.006	0.010	0.006	0.007	0.051	0.120	0.003
	9-12	25	0.017	0.016	0.013	0.008	0.005	0.013	0.000
	12-18	27	0.016	0.019	0.014	0.013	0.001	0.004	0.000
	18-24	28	0.002	0.002	0.002	0.002	0.001	0.005	0.000
	24-30	29	0.001	0.001	0.000	0.000	0.001	0.008	0.000
	30+	30	0.001	0.001	0.001	0.001	0.001	0.009	0.000
Cruise/Acceleration 50+ Miles Per Hour	< 6	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6-12	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	12-18	37	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	18-24	38	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	24-30	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30+	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Speed (mph)			30	30	30	25	35	35	35

Emission Factors by Vehicle Activity

Emission rates for use with this analysis template can come from various models, including MOVES, EMFAC, or MOBILE6 Mexico, or from rates tabulated as part of this project. Emission rates representing the El Paso/Juarez port of entry are provided in the Task 3 technical support material (attached). Both approaches are discussed below. These approaches produce detailed emission rate information that will subsequently be combined into composite emission rates, through weighted averages. A discussion of the development of composite emission rates is in Section 4.0, which follows this section.

Using MOVES or Related Models to Develop Local Emission Rates

This section presents a discussion of background information and key underlying concepts for project-level emissions analysis using MOVES. The concepts and approaches are also applicable to MOBILE6 Mexico and EMFAC unless noted otherwise. Complete run specification and supporting files for the application of MOVES2010a to the El Paso/Juarez port of entry are provided as part of the electronic archive of supporting material for this white paper and analysis protocol.

The MOVES model represents a significant improvement compared to the MOBILE platform (EPA's previous highway vehicle emission factor model) by giving users the ability to account for variations in vehicle speed and acceleration as well as the vehicle operating mode (e.g., cruise, acceleration, braking, idling) when estimating highway vehicle emissions. Along with these enhanced capabilities comes the need for more detailed inputs, and thus for more underlying data to be collected. Unlike the MOBILE model, MOVES can be run at the project-level scale, which is the focus of this border crossing study. This level of analysis allows users to accurately model areas where travel activity does not follow typical driving patterns. This is the case for border crossings where vehicles typically idle for significant periods of time and also stop and start more frequently than in average traffic conditions.

Base emission rates within MOVES are defined by source bins which are organized by fuel type, regulatory class, age group, and operating mode. The regulatory class is used to define groups of model years that are all subject to the same emission standards and thus, use similar technologies to control emissions. The age groups are used to account for the effects of aging and deterioration of components of the emission control system over time. The MOVES model years associated with each regulatory class are based on U.S. Federal emission standards. However, Mexican emission standards are different from U.S. standards (they are based on a combination of U.S. and European standards). Therefore, using MOVES to estimate emission rates of Mexican vehicles emissions, it is essential to adjust the distribution of vehicles by model year group to account for the difference in U.S. and Mexican emissions standards.

In selecting border crossing data, attention was placed on the parameters that have the greatest influence on vehicle emissions in queuing and congested operating situations. Some of these key variables in MOVES are summarized below.

Vehicle Type

MOVES categorizes vehicles into 13 source types, which are subsets of 6 Highway Performance Monitoring System (HPMS) vehicle classes. Therefore, the characterization of border crossing vehicle data according to FHWA's HPMS classes was a critical step. To best represent the specific vehicle emission rates occurring at these crossings, local information on vehicle volumes by source type or HPMS class is needed. These data also are important in MOBILE6 Mexico and EMFAC.

Vehicle Age and Country of Registration

Vehicle age distributions by vehicle type are important when modeling emissions as these age groups are used to define the emission standards the vehicle was initially certified to meet as well as to account for the effects of deterioration of the emission control components over time. In addition, since vehicles operating in the U.S. and Mexico are subject to different emission standards, the country of registration is important. More detail is provided below on vehicle age and registration data when representing a mix of U.S. and Mexican domiciled vehicles in MOVES.

Within this border crossing analysis, a specific age distribution was developed for the following MOVES source types:

- Passenger cars;
- Passenger trucks;
- Light commercial trucks;
- Single unit short-haul trucks and combination short-haul trucks (assumed to have a similar distribution due to the lack of more detailed data and therefore were combined); and
- Buses.

Truck age distribution data were collected in detail for the El Paso/Juarez case study ports of entry, based on Texas Department of Safety (DPS) data[5] (applicability of this age distribution to other regions is available separately). These data included truck make, model year, VIN number, license plate, state or country of registration, and total border crossing count for 2010. These data were provided for the Bridge of the Americas (BOTA) and the Ysleta-Zaragoza Bridge. Although the vast majority of commercial vehicle border crossings are made by trucks registered in Mexico (98.6 percent), separate age distributions were initially developed for U.S. and Mexican trucks. Since the MOVES model incorporates U.S. emissions standards and uses vehicle age to determine which emission standard vehicles were certified to meet, it was important to distinguish trucks

[5] Personal communication between TranSystems and Captain Villarreal; data provided by e-mail, received on 03/21/2012.

complying with different emission standards. Age also is used by the model to estimate deterioration effects. Mexican truck age distributions need to be modified to account for the difference in emission standards between the U.S. and Mexican domiciled vehicles of the same model year. Mexican diesel engine emission standards were aligned with the U.S. EPA standards for the 1994 to 2003 model years. However, Mexico has not revised its emission standards to reflect recent U.S. standards, which require a significant reduction in NO_X for 2004-2007 engines and a further decrease in NO_X and particulate matter (PM) for 2007+ model-year engines. Essentially, pre-1994 and post-2004 Mexican trucks have higher emissions than American trucks with the same model year due to less stringent standards. For these age groups, the age distribution of Mexican trucks were shifted to make trucks "artificially older" and account for their higher emissions.

For case-study passenger vehicles, a combined age distribution was developed (that includes both Mexican and U.S. vehicles) by using a mix of 50 percent of U.S.-registered and 50 percent of Mexico-registered passenger vehicles.[6] Since no border crossing data were readily available, the El Paso County vehicle type age distribution developed by the Texas Council for Environmental Quality (TCEQ) for their On-Road Mobile Source MOVES Emissions Inventory was used. For passenger vehicles registered in Mexico, an age distribution was developed from model year data provided for the Mexico City passenger vehicle fleet, which was available from a 2004 International Sustainable Systems Research Center (ISSRC) study.[7] As described for trucks, since Mexican passenger car emission standards are different from U.S. emission standards, it was important to adjust the ISSR (Mexican passenger vehicle) age distribution to account for the differences in emission standards. The first emission standards for light-duty vehicles became effective in model year 1993 and were later strengthened, effective 2001. A mix of U.S. Tier 1/2 and Euro 3/4 standards is required since 2004. As was the case with heavy-duty vehicles, Mexico has not revised its light-duty emission standards to reflect Tier 2 U.S. standards which require a significant reduction in NO_X and PM. Therefore, the age distribution of Mexican cars for those age groups (pre-1993 and post-2007) was shifted to make them "artificially older" and account for higher emissions.

Operating Mode

MOVES includes operating mode bins that categorize vehicle operations by three key operating characteristics: 1) Mode (braking, idle, cruise, acceleration, and coasting), 2) Vehicle-Specific Power (VSP), and 3) Speed. Operating mode distributions, such as those tabulated in the preceding section, coupled with MOVES are the most accurate way of describing vehicle activity. Average speed can be used as a surrogate where alternate models such as MOBILE6 Mexico and EMFAC are being used.

---

[6] Personal communication between TranSystems and Said Larbi-Cherif, director of El Paso's International Bridge Division (03/19/2012); these numbers are also confirmed by a 1995 study of the El Paso Border Crossing by the El Paso MPO, which estimated that 47.3 percent of cars crossing the border were registered in the U.S. and 52.7 percent were registered in Mexico.

[7] International Sustainable Systems Research Center (2004); *Mexico City Vehicle Activity Study*.

Fuel Formulation and Supply

Fuel formulation defaults for all U.S. counties are available in the MOVES database but new formulations can be calculated with different fuel properties. A comparison of the El Paso fuel formulations and Mexican fuel standards indicated that sulfur contents in both gasoline and diesel are similar since 2007 (the El Paso defaults are again based on the TCEQ on-road MOVES Emissions Inventory). Additionally, the on-road diesel Material Safety Data Sheet provided by PEMEX (Petróleos Mexicanos) also indicated that diesel sold in Mexico is ultralow-sulfur with a maximum sulfur content of 15 parts per million (ppm). Therefore, the MOVES fuel inputs developed to model the El Paso border crossing did not include any differences in the sulfur content of U.S. and Mexican fuel. However, it is important to note that despite these Mexican standards and Safety Data Sheets, ultra-low-sulfur diesel (15 ppm sulfur) is still unavailable throughout most of Mexico. It is supposed to be available in the border region – a border wide swath of about 100 km on either side of the border – and in the three major cities: Mexico City, Monterrey and Guadalajara, but it is not clear that it is in fact available throughout the entire border region. The delays in providing ultra-low-sulfur diesel nationally may have a number of negative consequences including: impeding Mexico's opportunities for significant emissions reductions from diesel vehicles (since new emissions control systems such as DPFs require ultra-low-sulfur diesel to properly function); preventing improved public health; and reducing growth in the manufacture and sale of new clean vehicles within Mexico. Maximum savings through improved fuel efficiency may not be achieved and emissions standards comparable to those in place in the U.S., which would contribute to a smooth transition to long-haul cross-border trade, might not be implemented. Furthermore, U.S. 2007 model year and later trucks traveling into Mexico would be unable to be properly fueled, other than in the border region, Mexico City, Monterrey and Guadalajara, thus posing an additional obstacle to trade.

A comparison of the gasoline Reid vapor pressure (RVP) for U.S. and Mexican fuels showed a significant difference during summer months (aromatic content and benzene are also different). This RVP difference is important as a higher RVP in the Mexican fuel will lead to higher VOC emissions in the summer. Thus, a specific fuel formulation was created for Mexico in the MOVES emission factor modeling.

To properly model emissions, it is important to know how much U.S. and Mexican fuel is used; especially important for summer months, since fuel RVP is different in the two countries. For trucks, it was assumed that 78.1 percent of the fuel is purchased in Mexico. This number was based on a 2008 study from the Institute of Transportation Studies at the University of California, Davis.[8] This report provides information regarding the last fueling location of trucks registered in Mexico, which are the vast majority at the El Paso border crossings. Given that this information was not available for passenger vehicles, it was assumed that passenger vehicle owners purchase fuel in their respective country of

[8] Nicholas Lutsey (2008) Assessment of Out-Of-State Heavy-Duty Truck Activity Trends in California, Institute of Transportation Studies, University of California, Davis, UCD-ITS-RR-08-16.

registration. These are reasonable assumptions to apply for screening level analysis at most locations; however if location-specific data can be obtained it should be used.

As for the distribution of fuel technology (i.e., gasoline versus diesel vehicles), the 2005 Texas Transportation Institute (TTI) study[9] provided fuel information used to create a MOVES Alternative Vehicle Fuels and Technologies (AVFT) input for truck fuel fractions (an AVFT input can be developed to modify the MOVES default fuel fractions for the vehicles in the project area). According to the ISSRC study (2004 data collected in Mexico City), 0.6 percent of passenger vehicles were diesel. Based on the 0.6 percent value and the El Paso County light-duty diesel fraction, a MOVES AVFT input for passenger vehicle fuel fractions was created. This input can be replicated as a default across other POEs, but location-specific data is preferred.

Inspection and Maintenance (I/M) Program

The presence or absence of an I/M program significantly effects fleet-average emissions for vehicles subject to the program. In Texas, all gasoline-fueled vehicles between 2 and 24 years of age are required by law to be inspected annually if they are registered or operate primarily in participating counties. These include gasoline passenger vehicles, light-commercial trucks, and single-unit short-haul trucks.

In 2007, El Paso County implemented a two-speed idle (TSI) test and an on-board diagnostic (OBD) test. To develop the I/M program MOVES inputs, the El Paso County input which was developed by the TCEQ for their emissions inventory was used. The municipality of Juarez, Mexico also implemented an Inspection and Maintenance program starting in 1994. However, the compliance rate has been noticeably low with a historical average of about 20 percent and a 2010 compliance rate of 44.81 percent.[10] Vehicles in Juarez also are required by law to be inspected annually to verify that they meet the maximum emission levels stipulated in the Mexican norm NOM-041-SEMARNAT-2006. The inspection consists of a series of three tests:

- A visual inspection of exhaust smoke;
- A cruise test; and
- An idle test.

For model years 1996+, an OBD test is performed.

A "combined" I/M program was developed for passenger vehicles, which reflects both the U.S. and Mexican programs. To do so, inspection procedures and model-year applicability were compared. To create a combined I/M program input, the El Paso County input developed by the TCEQ and adjusted compliance ratios to account for a smaller

[9] Texas Transportation Institute (2005); Mexican Truck Idling Emissions at the El Paso-Ciudad Juarez Border Location (SWUTC/05/473700-00033-1).

[10] Ciudad Juárez (2011), Dirección General De Ecología Y Protección Civil, Programa de verificación vehicular de emisiones para el Municipio de Juárez 2011-2013.

participation of Mexican vehicles were used. For future years, the estimated compliance ratio for Mexican vehicles was adjusted since the Juarez Inspection and Maintenance program plan has a goal of reaching a 90 percent compliance rate by 2012. This exercise can be applied utilizing the MOVES or EMFAC models as needed for other POEs along the U.S./Mexican border.

Using Emission Rates Provided in Spreadsheet Tabulations

Spreadsheets containing detailed MOVES2010a emission rates for each of eight pollutants modeled for this analysis template specific to the El Paso/Juarez port of entry are provided with the supplementary electronic data accompanying this report. A separate spreadsheet was developed for each of the eight pollutants analyzed. These include:

- Carbon dioxide (CO_2) in "fhwa_border_crossing_emissions_study_emission_factors_CO2eq.xlsx;"
- Carbon Monoxide (CO) in "fhwa_border_crossing_emissions_study_emission_factors_CO.xlsx;"
- Coarse particulate matter (PM_{10}) in "fhwa_border_crossing_emissions_study_emission_factors_PM10.xlsx;"
- Fine particulate matter ($PM_{2.5}$) in "fhwa_border_crossing_emissions_study_emission_factors_PM2.5.xlsx;"
- Volatile Organic Compounds (VOC) in "fhwa_border_crossing_emissions_study_emission_factors_VOC.xlsx;"
- Sulfur dioxide (SO_2) in "fhwa_border_crossing_emissions_study_emission_factors_SO2.xlsx;"
- Oxides of Nitrogen (NO_X) in "fhwa_border_crossing_emissions_study_emission_factors_NOx.xlsx;" and
- Ammonia (NH_3) in "fhwa_border_crossing_emissions_study_emission_factors_NH3.xlsx."

Each of these spreadsheets includes emission rates for six different modes of travel activity, each of which is modeled on a separate tab. The six travel activity modes are defined as follows:

- **Uncongested Link Activity –** Emission rates that represents uncongested travel on the road network approaching the border crossing as well as at the border. Average speeds for this activity are generally around 30 mph.
- **Creeping Queues –** Emission rates that represents queued up lanes before those lanes are split up to feed individual booths or inspection processes. Average speeds for these creeping queues are generally about 5 mph but can be slow as 1 mph.

- **Stop-and-Go Queuing –** Emission rates that represent the storage lanes immediately in front of inspection booths or other similar processes. The length of the storage lanes is typically fairly short (i.e., less than 1,000 feet), and speeds are typically below 1 mph.

- **Idle –** Emission rates that represent idle activity are provided for all vehicle types and seasons covered by the tables. This type of idle activity reflects vehicles that are parked for brief periods and left running. It does not reflect the time spent when a vehicle was stopped in a stop-and-go queue. The stop-and-go queuing mode described above explicitly accounts for time spent at idle in the reported emission rates.

- **Extended Idle (Heavy Trucks) –** Extended idle is only applicable to heavy-duty combination trucks (i.e., those with a separate tractor and trailer or semitrailer, as opposed to single unit trucks). Emission rates represent the emissions associated running the engine to power auxiliary loads such as refrigeration units and air conditioning.

- **Vehicle Start-up –** Emission rates that represent the "puff" of additional pollution associated with turning a vehicle on. These additional emissions result from the need to enrich the fuel air mixture when the engine block is cold and catalysts have not reached their operating temperature. These emissions are a function of how long the vehicle has been parked prior to starting. It is also referred to as a prestart soak period.

The emission rates on each spreadsheet tab are further identified by fuel type (either gasoline or diesel powered vehicles), season (summer or winter operating conditions), and daily time period (a.m., midday, p.m., and overnight).

For privately-owned vehicles, separate emission rates are provided for northbound and southbound movements. SENTRI lanes are listed separately from general purpose POV lanes. For commercial vehicles, separate emission rates are provided for northbound laden trucks, northbound unladen trucks, northbound trucks using FAST program lanes, and southbound movements.

Note that the emission rate tables report zero emission rates where vehicle activity for a given situation is assumed not to exist. For example, buses are assumed to be diesel powered, so emission rates for gasoline powered buses report zero emissions.

Composite Emission Rates

Composite emission rates can be generated by taking weighted averages with respect to time of day, fuel type, and vehicle class.

Case-specific time-of-day activity profiles for vehicles crossing the Ysleta-Zaragoza port of entry are provided in Table 3.4. The day is broken up into morning and afternoon peak-periods, midday, and overnight. The bridge currently is open 24 hours per day for private vehicles and from 6 a.m. to midnight (Monday-Friday) for commercial vehicles. POE hours of operation are location specific and these data need to be estimated for application at other locations. The percentage of vehicle activity in each portion of the day is provided for the seven crossing types that are considered in this analysis template. Each column of data sums to 100 percent. Application of these weighting factors allows the study to focus on daily activity rather than period-specific activity. Some sensitivity regarding the length and delay is lost when using daily statistics rather than peak-period statistics for queue length and delay; therefore aggregating across the entire day needs to be considered on a case-by-case basis.

Diesel fractions for each vehicle class are provided in Table 3.5. These represent an equal weighting of U.S. and Mexican domiciled passenger vehicles and predominantly Mexican trucks (98.6 percent). Each row of data in the table sums to 100 percent. Intercity buses are assumed to be 100 percent diesel. Application of these weighting factors simplifies the analysis by allowing the study to focus on vehicle classes as a whole.

Table 3.4 Case-Specific Distribution of Activity by Time of Day for Calculating Composite Emission Rates

	Northbound FAST Trucks	Northbound Unladen Trucks	Northbound Laden Trucks	Southbound Trucks (All)	Northbound Passenger Vehicles	Northbound SENTRI Vehicles	Northbound Passenger Vehicles
6-9 a.m.	8%	20%	3%	8%	11%	11%	11%
9 a.m.-4 p.m.	44%	49%	42%	44%	38%	38%	38%
4-7 p.m.	23%	16%	26%	23%	16%	16%	16%
7 p.m.-6 a.m.	25%	16%	29%	25%	35%	35%	35%

Source: Supporting data collected from Customs and Border Protection (CBP), City of El Paso toll bridges, and traffic counts that were used to develop the Cambridge Systematics El Paso Regional Ports of Entry Operations Plan for the Texas Department of Transportation (2011).

Table 3.5 Case-Specific Diesel Fractions to Use for Calculating Composite Emission Rates

Vehicle Type	Gasoline Fraction	Diesel Fraction
Passenger Car[a]	99.51%	0.49%
Passenger Truck[a]	98.54%	1.46%
Light Commercial Truck[b]	89.47%	10.53%
Intercity Bus[c]	100.00%	0.00%
Single Unit Short-Haul Truck[d]	9.38%	90.63%
Combination Short-Haul Truck[d]	0.00%	100.00%

[a] Passenger car and passenger truck diesel fractions were calculated based on 50 percent of U.S. diesel fraction (default MOVES data) and 50 percent of Mexican diesel fraction (0.6 percent).[11]

[b] Light commercial trucks default MOVES diesel fractions were used.

[c] All buses are assumed to be diesel, which is the MOVES default and is consistent with Mexican trends.

[d] Single and combination unit truck diesel fractions were derived by fuel type data collected by a Texas Transportation Institute study (TTI)[12] and the ratio of single to combination unit trucks assumed by MOVES. All of the gasoline trucks from the TTI study were assumed to be single unit trucks.

Vehicle type distributions for privately owned vehicles and commercial vehicles are provided in Table 3.6. Application of these factors allows the analysis to focus on the type of lane/activity being analyzed, rather than replicating the calculations for individual vehicle classes. The values in Table 3.6 sum to 100 percent for privately owned vehicles, and sum to 100 percent for commercial vehicles.

[11] International Sustainable Systems Research Center. Mexico City Vehicle Activity Study (2004).

[12] Texas Transportation Institute. *Mexican Truck Idling Emissions at the El Paso-Ciudad Juarez Border Location*. (SWUTC/05/473700-00033-1) (2005).

Table 3.6 Case-Specific Vehicle Type Distribution for Calculating Composite Emission Rates

Crossing Type	Vehicle Type	Fraction
Privately Owned Vehicles[a]	Passenger Cars	79.6%
	Passenger Trucks	20.4%
Commercial Vehicles[b]	Light Commercial Truck	11.0%
	Single Unit Truck	30.3%
	Combination Unit Trucks	58.7%

[a] Derived from Texas Commission on Environmental Quality Data[13] and National Institute of Ecology in Mexico data.[14]

[b] Derived from data collected by a Texas Transportation Institute study (TTI).[15]

The case studies will walk through application of these weighting factors to produce composite emission rates.

3.2 Identify and Quantify Vehicle Activity

Ports of entry can be subdivided into four different types of activity: private vehicles (northbound, southbound), and commercial vehicles (northbound, southbound). At larger ports of entry these four activities may be at physically different locations, whereas lower volume facilities may combine aspects of the private and commercial vehicle crossings; where that's the case the process laid out below can be simplified somewhat.

Northbound Commercial Vehicle Activity

A key for organizing northbound commercial truck activity can be found in Table 3.7. There are three distinct jurisdictions that control different parts of the border crossing: the Mexican government to the south; the U.S. government to the north; and a Texas Department of public safety inspection area the commercial vehicles need to pass through

[13] Texas Commission on Environmental Quality. *Development and Production of Statewide, Nonlink-Based, On-Road Mobile Source MOVES Emissions Inventories*. Prepared by the Texas Transportation Institute (2011).

[14] National Institute of Ecology in Mexico. *Mobile Source Emission Estimates Using Remote Sensing Data from Mexican Cities* (2009).

[15] Texas Transportation Institute *Mexican Truck Idling Emissions at the El Paso-Ciudad Juarez Border Location.* SWUTC/05/473700-00033-1 (2005).

before they are released into the United States. Each jurisdiction operates a variety of processes that the commercial vehicles must pass through (i.e., entrance gates, cargo inspection, and exiting gates). Each of those processes include a mix of vehicle activity (i.e., creeping queues, stop-and-go queues, idle, engine restarts, etc.) associated with it.

Table 3.7 provides a matrix of these vehicle activities that can be associated with each process for the given jurisdictions, broken out by laden, unladen, and FAST trucks. Generally the matrix does not differ by truck type, but there are important differences in some cases. For example unladen trucks are typically not directed into the cargo inspection area operated by U.S. Customs and Border Protection; whereas laden trucks, that are not part of the FAST program, are all routed through cargo inspection.

When classifying activity associated with each process, consideration of both the physical layout and key relationships between different processes needs to be considered. Building on the example from the last paragraph, at the U.S. secondary inspection area laden trucks will experience creeping queues as they move within the facility, idle time as they wait for their designated cargo scan, and park/restart process to accommodate the scan itself. In contrast unladen and FAST trucks will simply creep to the exit booth (where the FMCSA safety inspection takes place.)

Northbound Private Vehicle Activity

Table 3.8 is the matrix of vehicle activity by process of jurisdiction for northbound privately owned vehicles. Activity needs to be quantified for each type of lane that will be included in the emissions analysis. For example SENTRI lanes need to be broken out from general purpose lanes. Buses tend to have a unique operating pattern; they approach the U.S. primary inspection point, passengers disembark and are cleared independently of the bus, and then board buses on the U.S. side of the border (often not the same bus). Once the bus crosses the border it picks up passengers who have been cleared for entry into the U.S., often these passengers would have arrived at the border on one of the preceding buses.

Table 3.7 Identifying Northbound Commercial Truck Activity

	Laden	Unladen	FAST
Mexican			
Toll Collection[a]	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
Mexican Export Customs Entrance	Creeping queue Idle	Creeping queue Idle	Creeping queue Idle
Mexican Export Inspection[b]	Creeping queue Park for one hour (if inspected)	Creeping queue Park for more than six minutes (if inspected)	Creeping queue
Mexican Customs Exit Inspection	Idle	Idle	Idle
U.S.			
U.S. Customs Primary Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
U.S. Secondary Inspection[c]	Creeping queue Idle Dist of park time and restart	Creeping queue	Creeping queue
U.S. Customs Exit Inspection	Idle	Idle	Idle
State of Texas			
Texas DOT Safety Inspection	Creeping queue Idle	Creeping queue Idle	Creeping queue Idle
Exit POE	Uncongested movement	Uncongested movement	Uncongested movement

[a] If no toll collection queues extend to next step in the border crossing process.

[b] Typically less than 10 percent of fleet, assume one hour park to physically inspect cargo.

[c] Unladen trucks are scanned as they exit the primary booth; FAST trucks assumed not to go to secondary; Laden trucks sent to secondary where the driver exits the vehicle: average park of less than 6 minutes for VACIS/Eagle Inspections (analogous to an x-ray) and 6-30 minutes for the Gantry scanner (analogous to a CAT scan).

Table 3.8 Identifying Northbound POV Activity

	General Purpose	SENTRI	Bus
Mexican			
Toll Collection	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
U.S.			
U.S. Customs Primary Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
U.S. Secondary Inspection	Park if inspected	N/A	N/A

Southbound Vehicle Activity

Table 3.9 provides a matrix of vehicle activity by process and jurisdiction for southbound commercial vehicles, and Table 3.10 is a matrix for southbound privately owned vehicles. Southbound commercial and private vehicle traffic may be combined until just prior to crossing the border, or all the way up to inbound cargo inspection for Mexico.

Table 3.9 Identifying Southbound Truck Activity

	All Trucks
U.S.	
Toll Collection	Uncongested movement Creeping queue Stop-and-go queue Idle
U.S. Customs Outbound Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle
Mexican	
Mexican Customs Primary Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle
Mexican Customs Secondary Inspection	Park if inspected
Mexican Customs Exit Inspection	Creeping queue Idle

Table 3.10 Identifying Southbound POV Activity

	General Purpose	Bus
U.S.		
U.S. Customs Outbound Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
Toll Collection[a]	Stop-and-go queue Idle	Stop-and-go queue Idle
Mexican		
Mexican Customs Primary Inspection	Uncongested movement Creeping queue Stop-and-go queue Idle	Uncongested movement Creeping queue Stop-and-go queue Idle
Mexican Customs Secondary Inspection	Park if inspected Idle	N/A

[a] If no toll collection queues extend to next step in the border crossing process.

3.3 Combine Data to Quantify Emissions

After the matrices of vehicle activity data and the composite emission factors are available it is a simple matter to multiply through all combinations of vehicle activity with the corresponding emission rates to produce the emissions inventory. Typically several emission inventories need to be developed, one for no-action scenario (or a baseline), and one for each of the management/policy/investment strategies to be analyzed. Once emission inventories are available they can be compared and contrasted to identify the emission impacts of the strategies being considered.

Results are often presented in a bar graph which allows the audience to visualize the differences and see relationships between strategies over time where multiple years are being analyzed.

4.0 Case Studies

This section provides specific examples of how the information presented in Section 3 can be applied to evaluate emissions at a specific border crossing, as well as ways to evaluate alternative control strategies or scenarios at the border crossing.

4.1 Characteristics of Border Crossing Used in Case Studies

Ysleta-Zaragoza (Zaragoza) is located in eastern El Paso. It connects to I-10 via State Highway 375 (North Americas Avenue). Southbound passenger vehicles are tolled at $2.50, commercial vehicles at $3.50 per axle, and pedestrians at $0.50. Northbound tolls are 23 pesos for passenger vehicles, 137 pesos for commercial vehicles (5 axles), and 5 pesos for pedestrians. A northbound dedicated commuter lane (DCL) booth is available at Zaragoza. Drivers pay 24 pesos per DCL crossing in addition to CBP's 5-year SENTRI enrollment fee. The bridge currently is open 24 hours per day for private vehicles and from 6 a.m. to midnight (Monday-Friday) for commercial vehicles.

Two case studies are presented:

- Case Study 1: Shift 1,000 privately owned vehicles into the SENTRI program to reduce the amount of VMT in creeping queues.
- Case Study 2: Combine U.S. and Mexican commercial vehicle inspections to reduce the number of vehicle starts and idle time.

To simplify the presentation the case studies focus on daily average conditions for summer in 2010. Two pollutants are considered, oxides of nitrogen (NO_x) and fine particulate matter ($PM_{2.5}$). Both strategies being analyzed consider northbound traffic only. In the following section, composite emission rates common to both case studies are developed. Subsequent sections then apply those rates to estimate emission inventories for a no-action alternative and for each case study strategy.

■ 4.2 Development of Composite Emission Rates

Composite emission rates for $PM_{2.5}$ are developed within this example, and corresponding calculations are available separately for NO_x. Subsequent portions of the case study then apply both sets of composite emission rates to quantify $PM_{2.5}$ and NO_x emissions. The starting point for developing composite emission factors are the MOVES emission rates estimated for the El Paso port of entry as part of this study (provided with the supplementary electronic data accompanying this report). Three weighted averages are applied:

- Time-of-day weighting factors (Table 3.4);
- Gasoline/diesel fractions (Table 3.5); and
- Vehicle class weighting factors (Table 3.6).

Weighted averages are applied in two steps to develop the composite emission factors. First, the time-of-day factors and gasoline/diesel fractions are applied; then the vehicle class weighting factors are applied to the results to produce composite $PM_{2.5}$ and NO_X emission rates for uncongested movements, creeping queues, stop-and-go queues, idle, and vehicle starts. The calculations are walked through separately for each process below.

Case-Specific Running Exhaust Composite Emission Factors

Time-of-day factors and gasoline/diesel fractions are applied to running exhaust emission rates in three tables:

- Table 4.1 Development of Case-Specific 2010 Daily Composite Uncongested Running Exhaust Emission Factors for $PM_{2.5}$;
- Table 4.2 Development of Case-Specific 2010 Daily Composite Creeping Queue Running Exhaust Emission Factors for $PM_{2.5}$; and
- Table 4.3 Development of Case-Specific 2010 Daily Composite Stop-and-Go Queue Running Exhaust Emission Factors for $PM_{2.5}$.

Only composite $PM_{2.5}$ emission rates are provided here. NO_X emission rates were generated via a similar process; tables are available separately.

There are five sections in each of these tables. The first four sections correspond to the four periods of the day (i.e., 6-9 a.m., 9 a.m.-4 p.m., 4-7 p.m., and 7 p.m.-6 a.m.). Time-of-day weighting factors from Table 3.4 are listed at the top of each section. Each of the four sections lists unadjusted emission rates separately for gasoline powered vehicles and diesel powered vehicles; the weighting factors from Table 3.5 are listed in the right most column. The last section of the table provides composite emission rates for each vehicle class. These represent typical daily emissions in units of grams per mile reflecting the application of the time-of-day weights and the gasoline/diesel weights.

Vehicle class weights are then applied (Table 3.6) to produce the final composite emission rates for privately owned vehicles (POV), buses, and commercial vehicles (COM). The resulting composite rates are combined as Table 4.4. Note that Table 4.4 incorporates both the $PM_{2.5}$ emission rates developed here, and the NO_x emissions rates developed separately.

Table 4.1 Development of Case-Specific 2010 Daily Composite Uncongested Running Exhaust Emission Factors for $PM_{2.5}$

	2010 Uncongested Movements $PM_{2.5}$ Running Exhaust Emission Factors (grams/mile)							
Running Exhaust Emission Factor (g/mile)	**NB FAST Trucks**	**NB Unladen Trucks**	**NB Laden Trucks**	**SB Trucks (All)**	**NB Autos**	**NB SENTRI Autos**	**SB Autos (All)**	**Gas or Diesel Fraction**
Percent of Daily Activity Summer AM Peak (6-9 a.m.)	8%	20%	3%	8%	11%	11%	11%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.009	0.013	0.009	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.011	0.015	0.010	98.5%
Light Commercial Truck	0.014	0.014	0.014	0.018	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.029	0.030	0.029	0.035	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.062	0.099	0.059	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.181	0.225	0.172	1.5%
Light Commercial Truck	0.243	0.250	0.242	0.290	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	0.880	N/A	0.880	100.0%
Single Unit Short-Haul Truck	0.679	0.724	0.653	0.733	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	0.852	0.923	0.823	0.908	N/A	N/A	N/A	100.0%
Percent of Daily Activity Summer Midday (9 a.m.-4 p.m.)	44%	49%	42%	44%	38%	38%	38%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.009	0.013	0.009	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.011	0.015	0.010	98.5%
Light Commercial Truck	0.014	0.014	0.014	0.018	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.029	0.030	0.029	0.035	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.062	0.099	0.059	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.181	0.225	0.172	1.5%
Light Commercial Truck	0.243	0.250	0.242	0.290	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	0.880	N/A	0.880	100.0%
Single Unit Short-Haul Truck	0.679	0.724	0.653	0.733	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	0.852	0.923	0.823	0.908	N/A	N/A	N/A	100.0%

Table 4.1 Development of Case-Specific 2010 Daily Composite Uncongested Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

Running Exhaust Emission Factor (g/mile)	2010 Uncongested Movements $PM_{2.5}$ Running Exhaust Emission Factors (grams/mile)							Gas or Diesel Fraction
	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)	
Percent of Daily Activity Summer PM Peak (4-7 p.m.)	23%	16%	26%	23%	16%	16%	16%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.009	0.013	0.009	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.011	0.015	0.010	98.5%
Light Commercial Truck	0.014	0.014	0.014	0.018	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.029	0.030	0.029	0.035	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.062	0.099	0.059	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.181	0.225	0.172	1.5%
Light Commercial Truck	0.243	0.250	0.242	0.290	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	0.880	N/A	0.880	100.0%
Single Unit Short-Haul Truck	0.679	0.724	0.653	0.733	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	0.852	0.923	0.823	0.908	N/A	N/A	N/A	100.0%
Percent of Daily Activity Summer night (7 p.m.-6 a.m.)	25%	16%	29%	25%	35%	35%	35%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.009	0.013	0.009	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.011	0.015	0.010	98.5%
Light Commercial Truck	0.014	0.014	0.014	0.018	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.029	0.030	0.029	0.035	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.062	0.099	0.059	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.181	0.225	0.172	1.5%
Light Commercial Truck	0.243	0.250	0.242	0.290	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	0.880	N/A	0.880	100.0%
Single Unit Short-Haul Truck	0.679	0.724	0.653	0.733	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	0.852	0.923	0.823	0.908	N/A	N/A	N/A	100.0%

Table 4.1 Development of Case-Specific 2010 Daily Composite Uncongested Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

	2010 Uncongested Movements $PM_{2.5}$ Running Exhaust Emission Factors (grams/mile)							
Running Exhaust Emission Factor (g/mile)	**NB FAST Trucks**	**NB Unladen Trucks**	**NB Laden Trucks**	**SB Trucks (All)**	**NB Autos**	**NB SENTRI Autos**	**SB Autos (All)**	**Gas or Diesel Fraction**
Percent of Daily Activity Occurring During Day	100%	100%	100%	100%	100%	100%	100%	
Summer Daily Composite								
Passenger Car	N/A	N/A	N/A	N/A	0.01	0.01	0.01	Combined
Passenger Truck	N/A	N/A	N/A	N/A	0.01	0.02	0.01	
Light Commercial Truck	0.04	0.04	0.04	0.05	N/A	N/A	N/A	
Intercity Bus	N/A	N/A	N/A	N/A	0.88	N/A	0.88	
Single Unit Short-Haul Truck	0.62	0.66	0.59	0.67	N/A	N/A	N/A	
Combination Short-Haul Truck	0.85	0.92	0.82	0.91	N/A	N/A	N/A	

Note: Composite rates are the product of emission rate, time-of-day fraction, and gas/diesel fraction summed by vehicle type.

Table 4.2 Development of Case-Specific 2010 Daily Composite Creeping Queue Running Exhaust Emission Factors for $PM_{2.5}$

	2010 Uncongested Movements $PM_{2.5}$							
Running Exhaust Emission Factor (g/mile)	**NB FAST Trucks**	**NB Unladen Trucks**	**NB Laden Trucks**	**SB Trucks (All)**	**NB Autos**	**NB SENTRI Autos**	**SB Autos (All)**	**Gas or Diesel Fraction**
Percent of Daily Activity Summer AM Peak (6-9 a.m.)	8%	20%	3%	8%	11%	11%	11%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.048	0.050	0.048	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.054	0.057	0.056	98.5%
Light Commercial Truck	0.048	0.049	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.133	0.134	0.133	0.133	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.442	0.461	0.448	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.061	1.080	1.053	1.5%
Light Commercial Truck	1.028	1.019	1.028	1.029	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.642	N/A	2.642	100.0%
Single Unit Short-Haul Truck	1.547	1.527	1.553	1.535	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.654	1.635	1.666	1.638	N/A	N/A	N/A	100.0%
Fraction of Daily Activity Summer Midday (9 a.m.-4 p.m.)	44%	49%	42%	44%	38%	38%	38%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.048	0.050	0.048	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.054	0.057	0.056	98.5%
Light Commercial Truck	0.048	0.049	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.133	0.134	0.133	0.133	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.442	0.461	0.448	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.061	1.080	1.053	1.5%
Light Commercial Truck	1.028	1.019	1.028	1.029	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.642	N/A	2.642	100.0%
Single Unit Short-Haul Truck	1.547	1.527	1.554	1.535	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.654	1.636	1.666	1.639	N/A	N/A	N/A	100.0%

Table 4.2 Development of Case-Specific 2010 Daily Composite Creeping Queue Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

Running Exhaust Emission Factor (g/mile)	2010 Uncongested Movements NO_x							Gas or Diesel Fraction
	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)	
Percent of Daily Activity Summer PM Peak (4-7 p.m.)	23%	16%	26%	23%	16%	16%	16%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.048	0.050	0.048	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.054	0.057	0.056	98.5%
Light Commercial Truck	0.048	0.049	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.133	0.134	0.133	0.133	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.442	0.461	0.448	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.061	1.080	1.053	1.5%
Light Commercial Truck	1.028	1.019	1.028	1.029	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.642	N/A	2.642	100.0%
Single Unit Short-Haul Truck	1.547	1.527	1.554	1.535	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.654	1.636	1.666	1.639	N/A	N/A	N/A	100.0%
Percent of Daily Activity Summer night (7 p.m.-6 a.m.)	25%	16%	29%	25%	35%	35%	35%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.048	0.050	0.048	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.054	0.057	0.056	98.5%
Light Commercial Truck	0.048	0.049	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.133	0.134	0.133	0.133	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.442	0.461	0.448	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.061	1.080	1.053	1.5%
Light Commercial Truck	1.028	1.019	1.028	1.029	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.642	N/A	2.642	100.0%
Single Unit Short-Haul Truck	1.547	1.527	1.553	1.535	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.654	1.635	1.666	1.638	N/A	N/A	N/A	100.0%

Table 4.2 Development of Case-Specific 2010 Daily Composite Creeping Queue Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

	2010 Uncongested Movements NO_x							
Running Exhaust Emission Factor (g/mile)	**NB FAST Trucks**	**NB Unladen Trucks**	**NB Laden Trucks**	**SB Trucks (All)**	**NB Autos**	**NB SENTRI Autos**	**SB Autos (All)**	**Gas or Diesel Fraction**
Percent of Daily Activity Occurring During Day	100%	100%	100%	100%	100%	100%	100%	
Summer Daily Composite								
Passenger Car	N/A	N/A	N/A	N/A	0.05	0.05	0.05	Combined
Passenger Truck	N/A	N/A	N/A	N/A	0.07	0.07	0.07	
Light Commercial Truck	0.15	0.15	0.15	0.15	N/A	N/A	N/A	
Intercity Bus	N/A	N/A	N/A	N/A	2.64	N/A	2.64	
Single Unit Short-Haul Truck	1.41	1.40	1.42	1.40	N/A	N/A	N/A	
Combination Short-Haul Truck	1.65	1.64	1.67	1.64	N/A	N/A	N/A	

Note: Composite rates are the product of emission rate, time-of-day fraction, and gas/diesel fraction summed by vehicle type.

Table 4.3 Development of Case-Specific 2010 Daily Composite Stop-and-Go Queue Running Exhaust Emission Factors for $PM_{2.5}$

	2010 Stop-and-Go Queue $PM_{2.5}$							
Running Exhaust Emission Factor (g/mile)	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)	Gas or Diesel Fraction
Percent of Daily Activity Summer AM Peak (6-9 a.m.)	8%	20%	3%	8%	11%	11%	11%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.089	0.090	0.090	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.095	0.098	0.099	98.5%
Light Commercial Truck	0.047	0.048	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.132	0.133	0.133	0.132	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.881	0.887	0.901	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.996	2.045	2.021	1.5%
Light Commercial Truck	1.046	1.031	1.057	1.040	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.658	N/A	2.658	100.0%
Single Unit Short-Haul Truck	1.517	1.463	1.521	1.504	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.605	1.540	1.614	1.592	N/A	N/A	N/A	100.0%
Fraction of Daily Activity Summer Midday (9 a.m.-4 p.m.)	44%	49%	42%	44%	38%	38%	38%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.089	0.090	0.090	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.095	0.098	0.099	98.5%
Light Commercial Truck	0.047	0.048	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.132	0.133	0.133	0.132	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel Summer Midday (9 a.m.-4 p.m.)								
Passenger Car	N/A	N/A	N/A	N/A	0.881	0.887	0.901	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.996	2.045	2.021	1.5%
Light Commercial Truck	1.046	1.031	1.057	1.040	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.658	N/A	2.658	100.0%
Single Unit Short-Haul Truck	1.517	1.463	1.521	1.504	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.605	1.540	1.614	1.592	N/A	N/A	N/A	100.0%

Table 4.3 Development of Case-Specific 2010 Daily Composite Stop-and-Go Queue Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

Running Exhaust Emission Factor (g/mile)	2010 Stop-and-Go Queue $PM_{2.5}$ NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)	Gas or Diesel Fraction
Percent of Daily Activity Summer PM Peak (4-7 p.m.)	23%	16%	26%	23%	16%	16%	16%	
Gasoline Summer								
Passenger Car	N/A	N/A	N/A	N/A	0.089	0.090	0.090	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.095	0.098	0.099	98.5%
Light Commercial Truck	0.047	0.048	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.132	0.133	0.133	0.132	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel Summer								
Passenger Car	N/A	N/A	N/A	N/A	0.881	0.887	0.901	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.996	2.045	2.021	1.5%
Light Commercial Truck	1.046	1.031	1.057	1.040	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.658	N/A	2.658	100.0%
Single Unit Short-Haul Truck	1.517	1.463	1.521	1.504	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.605	1.540	1.614	1.593	N/A	N/A	N/A	100.0%
Percent of Daily Activity Summer Overnight (7 p.m.-6 a.m.)	25%	16%	29%	25%	35%	35%	35%	
Gasoline								
Passenger Car	N/A	N/A	N/A	N/A	0.089	0.090	0.090	99.5%
Passenger Truck	N/A	N/A	N/A	N/A	0.095	0.098	0.099	98.5%
Light Commercial Truck	0.047	0.048	0.048	0.048	N/A	N/A	N/A	89.5%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Single Unit Short-Haul Truck	0.132	0.133	0.133	0.132	N/A	N/A	N/A	9.4%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%
Diesel								
Passenger Car	N/A	N/A	N/A	N/A	0.881	0.887	0.901	0.5%
Passenger Truck	N/A	N/A	N/A	N/A	1.996	2.045	2.021	1.5%
Light Commercial Truck	1.046	1.031	1.057	1.040	N/A	N/A	N/A	10.5%
Intercity Bus	N/A	N/A	N/A	N/A	2.658	N/A	2.658	100.0%
Single Unit Short-Haul Truck	1.517	1.463	1.521	1.504	N/A	N/A	N/A	90.6%
Combination Short-Haul Truck	1.605	1.540	1.614	1.592	N/A	N/A	N/A	100.0%

Table 4.3 Development of Case-Specific 2010 Daily Composite Stop-and-Go Queue Running Exhaust Emission Factors for $PM_{2.5}$ (continued)

Running Exhaust Emission Factor (g/mile)	2010 Stop-and-Go Queue $PM_{2.5}$							Gas or Diesel Fraction
	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)	
Percent of Daily Activity Occurring During Day	100%	100%	100%	100%	100%	100%	100%	
Summer Daily Composite								
Passenger Car	N/A	N/A	N/A	N/A	0.09	0.09	0.09	Combined
Passenger Truck	N/A	N/A	N/A	N/A	0.12	0.13	0.13	
Light Commercial Truck	0.15	0.15	0.15	0.15	N/A	N/A	N/A	
Intercity Bus	N/A	N/A	N/A	N/A	2.66	N/A	2.66	
Single Unit Short-Haul Truck	1.39	1.34	1.39	1.38	N/A	N/A	N/A	
Combination Short-Haul Truck	1.61	1.54	1.61	1.59	N/A	N/A	N/A	

Note: Composite rates are the product of emission rate, time-of-day fraction, and gas/diesel fraction summed by vehicle type.

Table 4.4 Case-Specific Running Exhaust Emission Rates Composited across Vehicle Classes
(g/mile)

	NB FAST Trucks	NB Unladen Trucks	NB Laden Trucks	SB Trucks (All)	NB Autos	NB SENTRI Autos	SB Autos (All)
Composite 2010 Daily Uncongested Movement Running Exhaust Emission Factors for $PM_{2.5}$							
POV	N/A	N/A	N/A	N/A	0.010	0.014	0.010
COM	0.692	0.746	0.668	0.741	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	0.880	N/A	0.880
Composite 2010 Daily Uncongested Movement Running Exhaust Emission Factors for NO_X							
POV	N/A	N/A	N/A	N/A	0.31	0.47	0.27
COM	9.48	10.09	9.05	10.04	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	8.61	N/A	8.61
Composite 2010 Daily Creeping Queue Running Exhaust Emission Factors for $PM_{2.5}$							
POV	N/A	N/A	N/A	N/A	0.054	0.056	0.054
COM	1.416	1.400	1.425	1.404	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	2.642	N/A	2.642
Composite 2010 Daily Creeping Queue Running Exhaust Emission Factors for NO_X							
POV	N/A	N/A	N/A	N/A	1.08	1.19	1.15
COM	19.27	19.28	19.27	18.85	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	26.86	N/A	26.86
Composite 2010 Daily Stop-and-Go Queue Running Exhaust Emission Factors for $PM_{2.5}$							
POV	N/A	N/A	N/A	N/A	0.099	0.100	0.100
COM	1.379	1.326	1.386	1.368	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	2.658	N/A	2.658
Composite 2010 Daily Stop-and-Go Queue Running Exhaust Emission Factors for NO_X							
POV	N/A	N/A	N/A	N/A	1.99	2.22	2.27
COM	17.89	17.65	17.69	17.95	N/A	N/A	N/A
BUS	N/A	N/A	N/A	N/A	26.86	N/A	26.86

Case-Specific Idle Exhaust Composite Emission Factors

Time-of-day factors and gasoline/diesel fractions are applied to idle exhaust emission rates in Table 4.5. The table has a similar format to those above, with five sections corresponding to the four periods of the day (i.e., 6-9 a.m., 9 a.m.-4 p.m., 4-7 p.m., and 7 p.m.-6 a.m.) and the daily composite rate in the fifth section. However, this table lists the time-of-day weighting factors in the right hand column to make better use of available space and the $PM_{2.5}$ and NO_X emission rates are both presented is this one table.

Vehicle class weights are then applied (Table 3.6) to produce the final composite emission rates for privately owned vehicles (POV), buses, and commercial vehicles (COM). The resulting composite rates are combined as Table 4.6.

Table 4.5 Development of Case-Specific 2010 Daily Composite Vehicle Idle Emission Factors for $PM_{2.5}$ and NO_X

Idling Emission Factor (g/hour)	2010 $PM_{2.5}$	2010 NO_X	Gas or Diesel Fraction	Fraction of Daily Activity Occurring During This Period
Summer AM Peak (6-9 a.m.)				
Gasoline				
Passenger Car	0.140	2.99	99.5%	11%
Passenger Truck	0.074	5.15	98.5%	11%
Light Commercial Truck	0.074	6.83	89.5%	3%
Intercity Bus	N/A	N/A	0.0%	11%
Single Unit Short-Haul Truck	0.106	13.70	9.4%	3%
Combination Short-Haul Truck	N/A	N/A	0.0%	3%
Diesel				
Passenger Car	2.656	37.70	0.5%	11%
Passenger Truck	5.060	113.12	1.5%	11%
Light Commercial Truck	6.147	124.93	10.5%	3%
Intercity Bus	6.680	53.92	100.0%	11%
Single Unit Short-Haul Truck	7.308	76.12	90.6%	3%
Combination Short-Haul Truck	6.894	87.44	100.0%	3%
Summer Midday (9 a.m.-4 p.m.)				
Gasoline				
Passenger Car	0.140	5.24	99.5%	38%
Passenger Truck	0.074	8.64	98.5%	38%
Light Commercial Truck	0.074	11.84	89.5%	42%
Intercity Bus	N/A	N/A	0.0%	38%
Single Unit Short-Haul Truck	0.106	13.99	9.4%	42%
Combination Short-Haul Truck	N/A	N/A	0.0%	42%
Diesel				
Passenger Car	2.657	67.25	0.5%	38%
Passenger Truck	5.061	199.68	1.5%	38%
Light Commercial Truck	6.147	221.67	10.5%	42%
Intercity Bus	6.681	54.72	100.0%	38%
Single Unit Short-Haul Truck	7.309	77.24	90.6%	42%
Combination Short-Haul Truck	6.894	88.73	100.0%	42%
Summer PM Peak (4-7 p.m.)				
Gasoline				
Passenger Car	0.074	4.85	99.5%	16%
Passenger Truck	0.074	8.04	98.5%	16%
Light Commercial Truck	N/A	10.98	89.5%	26%

Table 4.5 Development of Case-Specific 2010 Daily Composite Vehicle Idle Emission Factors for $PM_{2.5}$ and NO_X (continued)

Idling Emission Factor (g/hour)	2010 $PM_{2.5}$	2010 NO_X	Gas or Diesel Fraction	Fraction of Daily Activity Occurring During This Period
Intercity Bus	0.106	N/A	0.0%	16%
Single Unit Short-Haul Truck	N/A	13.95	9.4%	26%
Combination Short-Haul Truck	N/A	N/A	0.0%	26%
Diesel				
Passenger Car	2.657	62.18	0.5%	16%
Passenger Truck	5.061	184.83	1.5%	16%
Light Commercial Truck	6.147	205.07	10.5%	26%
Intercity Bus	6.680	54.59	100.0%	16%
Single Unit Short-Haul Truck	7.309	77.07	90.6%	26%
Combination Short-Haul Truck	6.894	88.53	100.0%	26%
Summer Overnight (7 p.m.-6 a.m.)				
Gasoline				
Passenger Car	0.140	3.66	99.5%	35%
Passenger Truck	0.074	6.19	98.5%	35%
Light Commercial Truck	0.074	8.32	89.5%	29%
Intercity Bus	N/A	N/A	0.0%	35%
Single Unit Short-Haul Truck	0.106	13.84	9.4%	29%
Combination Short-Haul Truck	N/A	N/A	0.0%	29%
Diesel				
Passenger Car	2.656	46.43	0.5%	35%
Passenger Truck	5.060	138.72	1.5%	35%
Light Commercial Truck	6.147	153.53	10.5%	29%
Intercity Bus	6.680	54.30	100.0%	35%
Single Unit Short-Haul Truck	7.308	76.65	90.6%	29%
Combination Short-Haul Truck	6.894	88.06	100.0%	29%
Summer Daily Composite				
Passenger Car	0.142	4.63	Combined	100%
Passenger Truck	0.147	9.63		
Light Commercial Truck	0.696	29.87		
Intercity Bus	6.680	54.46		
Single Unit Short-Haul Truck	6.631	71.08		
Combination Short-Haul Truck	6.894	88.45		

Note: Fraction of daily activity for trucks is based on northbound laden truck activity.

Table 4.6 Case-Specific Idle Exhaust Emission Rates Composited Across Vehicle Classes
(g/hour)

Idling Emission Factor (g/hour)	2010 $PM_{2.5}$	2010 NO_X
Composite 2010 daily vehicle idle emission factors for $PM_{2.5}$ and NO_X		
POV	0.14	5.65
COM	6.13	76.74
BUS	6.68	54.46

Case Specific Vehicle Start/Re-Start Exhaust Composite Emission Factors

Time-of-day factors and gasoline/diesel fractions are applied to idle exhaust emission rates via the following table:

- Table 4.7 Development of Case-Specific 2010 Daily Composite Vehicle Start Emission Factors for $PM_{2.5}$.

Only composite $PM_{2.5}$ emission rates are provided here. NO_X emission rates were generated via a similar process; the table is included available separately.

The table has a similar format to those above, with five sections corresponding to the four periods of the day (i.e., 6-9 a.m., 9 a.m.-4 p.m., 4-7 p.m., and 7 p.m.-6 a.m.) and the daily composite rate in the fifth section. Each of the four sections that correspond to the period of the day list unadjusted emission rates separately for gasoline powered vehicles and diesel powered vehicles. The gasoline/diesel weighting factors from Table 3.5 and time-of-day weighting factors from Table 3.4 are listed on the right. The last section of the table provides composite emission rates for each vehicle class.

Vehicle class weighting factors are then applied (Table 3.6) to produce the final composite emission rates for privately-owned vehicles (POV), buses, and commercial vehicles (COM). The resulting composite rates are combined as Table 4.8.

Table 4.7 Development of Case-Specific 2010 Daily Composite Vehicle Start Emission Factors for $PM_{2.5}$

	2010 $PM_{2.5}$ Start Emission Factor by Pre-Start Soak Time (g/start)									
Pre-Start Soak Time (minutes)	**<6**	**6 to 30**	**30 to 60**	**60 to 90**	**90 to 120**	**120 to 360**	**360 to 720**	**> 720**	**Gas or Diesel Fraction**	**Fraction of Daily Activity Occurring During This Period**
Summer AM Peak (6 a.m.-9 a.m.)										
Gasoline										
Passenger Car	0.022	0.025	0.030	0.035	0.036	0.038	0.032	0.037	99.5%	11%
Passenger Truck	0.034	0.038	0.048	0.054	0.056	0.060	0.059	0.051	98.5%	11%
Light Commercial Truck	0.028	0.031	0.039	0.044	0.046	0.049	0.047	0.042	89.5%	3%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	11%
Single Unit Short-Haul Truck	0.029	0.031	0.043	0.049	0.052	0.058	0.056	0.063	9.4%	3%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	3%
Diesel										
Passenger Car	0.894	1.098	1.160	1.229	1.259	1.331	1.068	1.186	0.5%	11%
Passenger Truck	0.177	0.201	0.224	0.234	0.243	0.257	0.260	0.245	1.5%	11%
Light Commercial Truck	0.202	0.232	0.259	0.272	0.283	0.300	0.305	0.290	10.5%	3%
Intercity Bus	0.038	0.039	0.043	0.047	0.052	0.059	0.101	0.142	100.0%	11%
Single Unit Short-Haul Truck	0.034	0.035	0.039	0.044	0.050	0.056	0.085	0.148	90.6%	3%
Combination Short-Haul Truck	0.034	0.035	0.039	0.045	0.050	0.053	0.100	0.136	100.0%	3%
Summer Midday (9 a.m.-4 p.m.)										
Gasoline										
Passenger Car	0.013	0.015	0.021	0.025	0.027	0.026	0.034	0.034	99.5%	38%
Passenger Truck	0.019	0.020	0.031	0.038	0.040	0.041	0.051	0.053	98.5%	38%
Light Commercial Truck	0.015	0.017	0.025	0.031	0.033	0.033	0.042	0.043	89.5%	42%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	38%
Single Unit Short-Haul Truck	0.013	0.016	0.029	0.037	0.039	0.043	0.052	0.056	9.4%	42%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	42%
Diesel										
Passenger Car	0.709	0.833	0.955	1.041	1.079	1.053	1.231	1.204	0.5%	38%
Passenger Truck	0.105	0.115	0.146	0.162	0.172	0.175	0.226	0.261	1.5%	38%

Table 4.7 Development of Case-Specific 2010 Daily Composite Vehicle Start Emission Factors for $PM_{2.5}$ (continued)

	2010 $PM_{2.5}$ Start Emission Factor by Pre-Start Soak Time (g/start)									
Pre-Start Soak Time (minutes)	**<6**	**6 to 30**	**30 to 60**	**60 to 90**	**90 to 120**	**120 to 360**	**360 to 720**	**> 720**	**Gas or Diesel Fraction**	**Fraction of Daily Activity Occurring During This Period**
Light Commercial Truck	0.116	0.129	0.166	0.184	0.196	0.201	0.262	0.305	10.5%	42%
Intercity Bus	0.011	0.012	0.015	0.021	0.026	0.026	0.077	0.143	100.0%	38%
Single Unit Short-Haul Truck	0.002	0.002	0.007	0.013	0.018	0.024	0.068	0.134	90.6%	42%
Combination Short-Haul Truck	0.015	0.016	0.020	0.025	0.032	0.036	0.081	0.134	100.0%	42%
Summer PM Peak (4 p.m.-7 p.m.)										
Gasoline										
Passenger Car	0.014	0.017	0.022	0.025	0.028	0.028	0.033	0.037	99.5%	16%
Passenger Truck	0.023	0.027	0.036	0.041	0.045	0.045	0.051	0.057	98.5%	16%
Light Commercial Truck	0.019	0.022	0.029	0.034	0.036	0.036	0.042	0.046	89.5%	26%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	16%
Single Unit Short-Haul Truck	0.018	0.013	0.033	0.040	0.039	0.046	0.054	0.058	9.4%	26%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	26%
Diesel										
Passenger Car	0.746	0.875	0.987	1.025	1.095	1.085	1.186	1.269	0.5%	16%
Passenger Truck	0.118	0.141	0.162	0.172	0.186	0.187	0.220	0.272	1.5%	16%
Light Commercial Truck	0.131	0.160	0.184	0.197	0.214	0.216	0.257	0.319	10.5%	26%
Intercity Bus	0.046	0.047	0.052	0.058	0.061	0.066	0.104	0.145	100.0%	16%
Single Unit Short-Haul Truck	0.003	0.003	0.008	0.014	0.018	0.025	0.069	0.134	90.6%	26%
Combination Short-Haul Truck	0.006	0.006	0.011	0.016	0.021	0.026	0.072	0.137	100.0%	26%
Summer Overnight (7 p.m.-6 a.m.)										
Gasoline										
Passenger Car	0.013	0.017	0.021	0.025	0.028	0.026	0.032	0.037	99.5%	35%
Passenger Truck	0.013	0.019	0.028	0.035	0.036	0.038	0.046	0.051	98.5%	35%
Light Commercial Truck	0.010	0.015	0.023	0.028	0.029	0.031	0.037	0.042	89.5%	29%
Intercity Bus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	35%

Table 4.7 Development of Case-Specific 2010 Daily Composite Vehicle Start Emission Factors for $PM_{2.5}$ (continued)

	2010 $PM_{2.5}$ Start Emission Factor by Pre-Start Soak Time (g/start)									
Pre–Start Soak Time (minutes)	**<6**	**6 to 30**	**30 to 60**	**60 to 90**	**90 to 120**	**120 to 360**	**360 to 720**	**> 720**	**Gas or Diesel Fraction**	**Fraction of Daily Activity Occurring During This Period**
Single Unit Short-Haul Truck	0.006	0.010	0.020	0.027	0.029	0.034	0.042	0.046	9.4%	29%
Combination Short-Haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0%	29%
Diesel Summer										
Passenger Car	0.697	0.905	0.931	1.020	1.102	1.021	1.178	1.271	0.5%	35%
Passenger Truck	0.073	0.115	0.137	0.150	0.153	0.161	0.203	0.254	1.5%	35%
Light Commercial Truck	0.078	0.127	0.153	0.168	0.172	0.183	0.234	0.296	10.5%	29%
Intercity Bus	0.075	0.076	0.080	0.086	0.092	0.098	0.133	0.141	100.0%	35%
Single Unit Short-Haul Truck	N/A	0.001	0.006	0.011	0.017	0.022	0.066	0.132	90.6%	29%
Combination Short-Haul Truck	0.066	0.067	0.071	0.077	0.082	0.088	0.066	0.198	100.0%	29%
Summer Daily Composite										
Passenger Car	0.018	0.021	0.027	0.031	0.034	0.033	0.039	0.042	Combined	100%
Passenger Truck	0.020	0.024	0.034	0.041	0.043	0.045	0.053	0.056		
Light Commercial Truck	0.025	0.031	0.041	0.047	0.050	0.052	0.063	0.071		
Intercity Bus	0.042	0.043	0.047	0.053	0.058	0.061	0.104	0.143		
Single Unit Short-Haul Truck	0.003	0.004	0.010	0.015	0.020	0.026	0.066	0.126		
Combination Short-Haul Truck	0.028	0.029	0.033	0.038	0.044	0.049	0.075	0.153		

Note: Fraction of daily activity for trucks is based on northbound laden truck activity.

Table 4.8 Case-Specific Stat Exhaust Emission Rates Composited Across Vehicle Classes
(g/start)

	<6	6 to 30	30 to 60	60 to 90	90 to 120	120 to 360	360 to 720
Composite 2010 daily vehicle start emission factors for $PM_{2.5}$							
POV	0.02	0.02	0.03	0.03	0.04	0.04	0.04
COM	0.02	0.02	0.03	0.03	0.04	0.04	0.07
BUS	0.04	0.04	0.05	0.05	0.06	0.06	0.10
Composite 2010 daily vehicle start emission factors for NO_X							
POV	1.07	1.46	2.05	2.30	2.35	2.15	2.16
COM	0.36	0.48	0.78	0.86	0.85	0.82	0.81
BUS	N/A	N/A	N/A	N/A	N/A	N/A	N/A

4.3 Case Study No-Action Alternative

The northbound passenger vehicle process at the Ysleta-Zaragoza bridge is shown in Figure 4.1 and Figure 4.2. Northbound passenger vehicles traveling into the United States from Mexico must first pay a toll on the Mexican side of the border (PN 1). Following toll collection, vehicles cross the bridge into the United States. Here, passenger vehicles are divided into one of three lane types: Standard, SENTRI, or Ready Lane. Vehicles then enter CBP primary inspection booths (PN 2). Following primary inspection processing, vehicles are either directed to exit the POE or to enter secondary inspection (PN 3). Secondary inspections include more detailed reviews of both drivers and the vehicle. Following secondary inspections at both crossing, vehicles are directed to exit the facility and are free to travel to their destination in the United States.

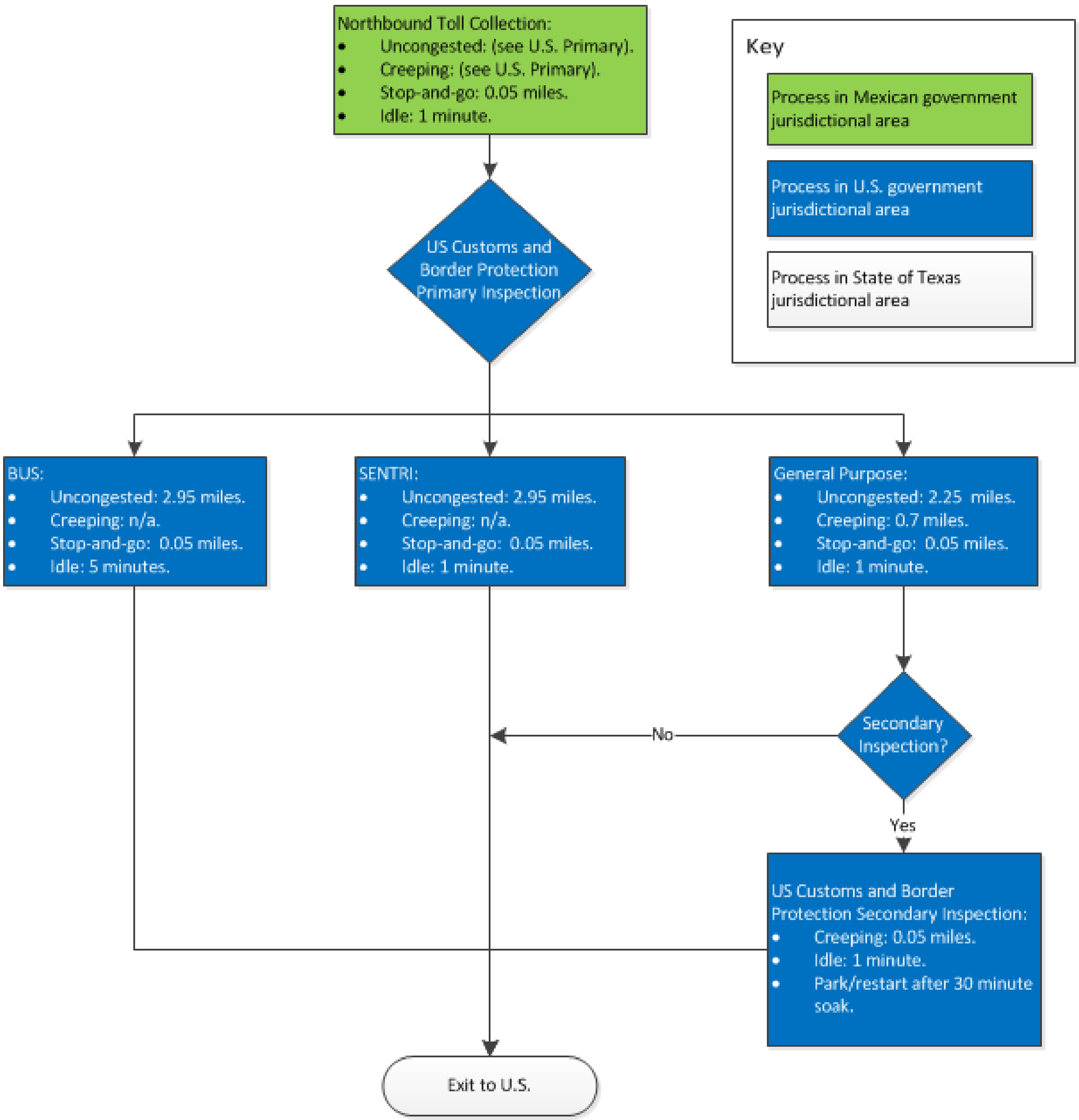
The northbound process for commercial vehicle movements at the Yselta-Zaragoza border crossings is shown in the Figure 4.3 aerial and Figure 4.4 flow chart. As commercial vehicles travel northbound approaching the border on the Mexican side at the Ysleta-Zaragoza crossing they must first pay a toll (CN 1). The next step is processing by Mexican customs (CN 2). Prior to processing by Mexican customs, U.S. and Mexican brokers prepare and file the Mexican Pedimento and the U.S. Inward Cargo Manifest. Transfer of these documents to the commercial vehicle operators usually occurs at a broker office in the immediate vicinity of the border crossing, on a roadside prior to the Mexican export compound, or while the truck is waiting in a queue to cross the border.

The processing by Mexican customs (CN 2) includes the verification of all documentation. Once this is complete, the commercial vehicle either is routed to the inspection facility (CN 3) or directed to bypass this and drive through the inspection area and to the exit (CN 4). Less than 10 percent of vehicles are randomly selected and are sent from the booths (CN 2) to export inspections (CN 3). The main purpose of these inspections is to ensure that all applicable export duties and taxes are paid. Export inspections may involve the partial or complete unloading of a trailer and can take anywhere from 30 minutes to several hours. Commercial vehicles arrive at the exit of Mexican Customs either directly from the entry booths or following the inspection (CN 4).

Figure 4.1 Northbound Passenger Processes Aerial

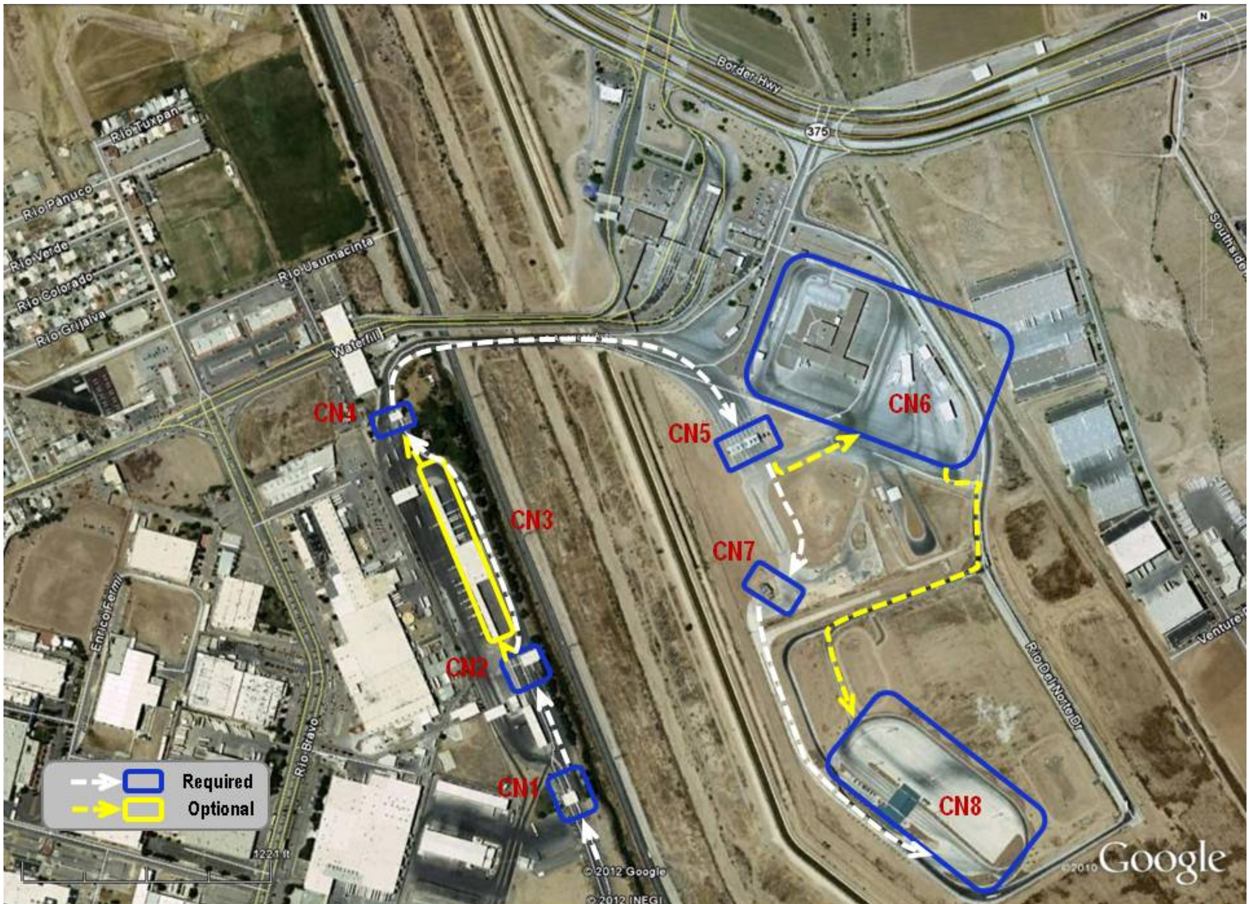
Source: Cambridge Systematics, Inc., © 2012 Google, and INEGI (INSTITUTO NACIONAL DE ESTADÍSTICA Y GEOGRAFÍA).

Figure 4.2 Northbound Passenger Processes Flowchart



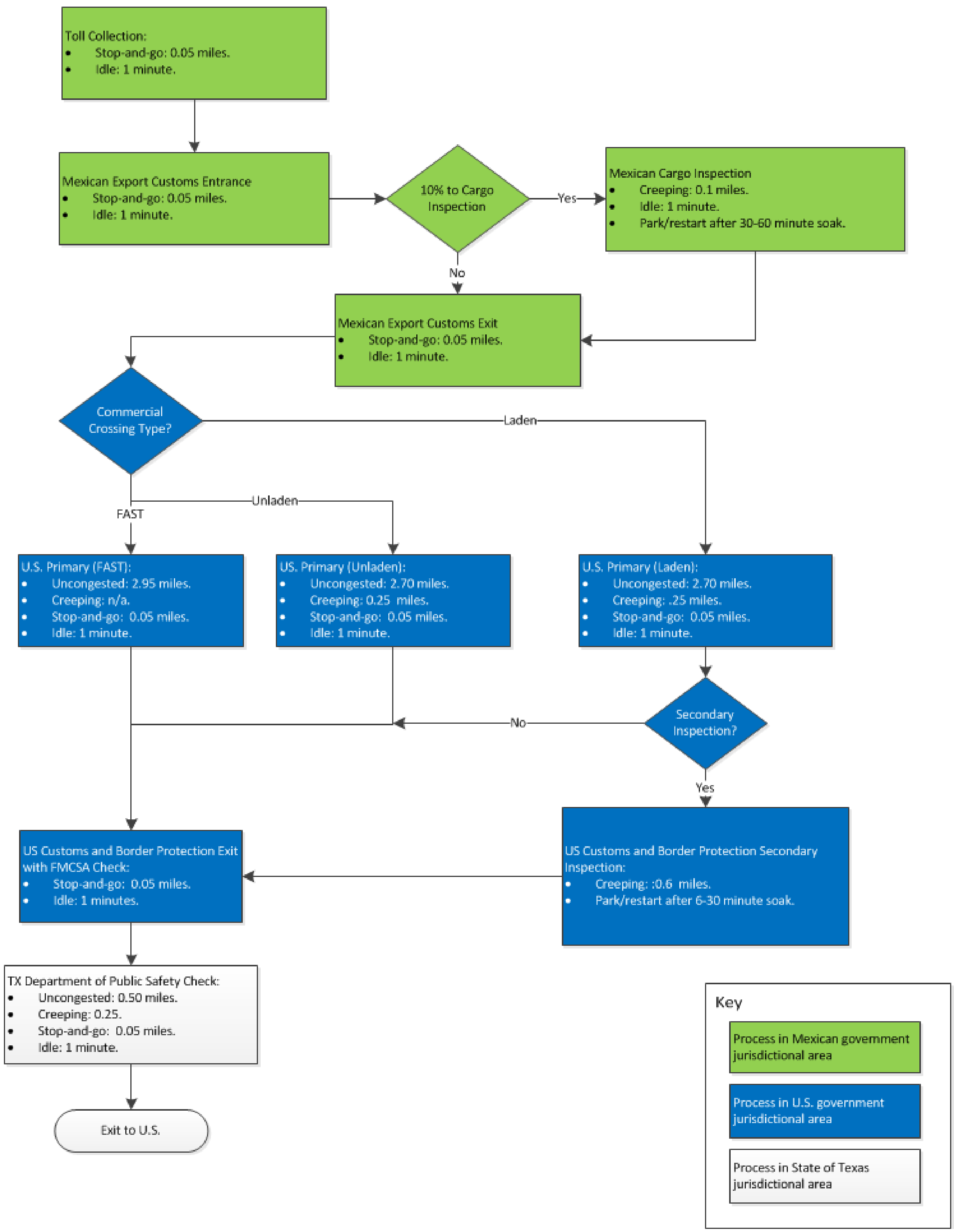
Source: Cambridge Systematics, Inc.

Figure 4.3 Northbound Commercial Processes Aerial



Source: Cambridge Systematics, Inc., © 2012 Google, and INEGI (INSTITUTO NACIONAL DE ESTADÍSTICA Y GEOGRAFÍA).

Figure 4.4 Northbound Commercial Processes Flowchart



Source: Cambridge Systematics, Inc.

Upon exiting the Mexican Customs processes, vehicles cross the bridge and enter the United States facilities. U.S. Customs and Border Protection (CBP) primary inspection occurs at booths for designated FAST lanes, empties, or standard trucks (CN 5). FAST lanes are the two most western lanes at Ysleta-Zaragoza, with the lane adjacent to the FAST lanes primarily for empties. There is an x-ray machine right after the booth that checks the trailers while the driver drives through, getting activated by the space between the car and trailer. From the booths, the trucks are either sent to the exit (CN 7), or get directed to one of many secondary inspections (CN 6). Secondary inspections include Pylon (for FAST vehicles), VACIS, Gantry, or Eagle inspections. The VACIS inspection and Eagle inspection operate similarly. Trucks line up in a queue, drivers exit the vehicle, and a mobile x-ray unit drives along the length of the vehicles, scanning them. The Gantry is a building that trucks drive into, the driver exits, and the truck is scanned. If something is detected or the CBP officer wants to take a closer look, they are sent to the dock for further inspection. Following secondary inspection, vehicles are directed to the U.S. exit inspection (CN 7), where documentation is verified to ensure the vehicle went through all the necessary processes before being released. Additionally, U.S. DOT/ Federal Motor Carrier Safety Administration (FMCSA) conduct inspections on certain vehicles following primary inspections and prior to a vehicle exiting.

Upon exiting the facility (CN 7), vehicles head to the TxDOT Border Safety Inspection Facility (BSIF) (CN 8). At the BSIF, the Texas Department of Public Safety (DPS) inspects trucks crossing into the United States using various procedures, usually starting with visual safety inspection and then proceeding to a detailed truck safety inspection if violations are found. The BSIFs incorporate ITS technologies to minimize delay at these locations, including dynamic message signs, static and weigh-in-motion scales, dimensioning in motion, and flow managers.

Northbound 2010 Activity Levels

Table 4.9 provides a summary of aggregate volume and delay data for the Ysleta-Zaragoza port of entry. The example queue length calculation results for the northbound direction in 2011 for both border crossings. Additional information was taken from Google Earth as follows:

- The approach to the border was assumed to start three miles from the U.S. Primary inspection booth for both privately owned vehicles and commercial traffic. The distance that vehicles travel in uncongested traffic was then estimated by subtracting the creeping queue and stop-and-go queue lengths from the three-mile approach distance.

- The creeping queue length within the cargo inspection area is estimated to be 0.6 miles long based on aerials.

- Creeping distance from FMCSA to Texas DPS is estimated at 0.25 miles, followed by a further 0.5 miles of uncongested travel to exit the facility.

Table 4.9 Northbound Queue and Delay Data Used for 2010

	Ysleta-Zaragoza			
	POV	SENTRI	Trucks	FAST
Daily Traffic Volumes[a]	6,760	836	1,022 (681 Laden, 341 Unladen)	350
Length of Booth Approach Lanes	275	275	275	275
Number of Bridge Lanes	2	1	2	2
Average Daily				
Open Inspection Booths	7	2	4	1
Estimated Vehicles in Queue	200	N/A	52	20
Estimated delay			25 min	
Calculated Queue Length (feet)[b]	1,813	N/A	1,415	788
Observed Queue Length (feet)	2,000			

Source: Supporting data collected from Customs and Border Protection (CBP), City of El Paso toll bridges, and traffic counts that were used to develop the Cambridge Systematics (2011) El Paso Regional Ports of Entry Operations Plan for the Texas Department of Transportation.

[a]Average during hours of operation.

[b]Assume average POV length + spacing = 25 feet, average truck length + spacing = 65 feet.

Calculations

A calculation summary is presented in Table 4.10, below. Inputs to the calculations include:

- Activity levels identified through the flowcharts in Figure 4.2 (POV port of entry) and Figure 4.4 (commercial port of entry);
- Volume and queuing estimates from Table 4.9;
- Running exhaust composite emission factors from Table 4.4;
- Idle exhaust composite emission factors from Table 4.6; and
- Vehicle start composite emission factors from Table 4.8.

Table 4.10 No-Action Alternative Activity and Emissions Tabulation

Process	Activity Description	Quantity	Units	Volume	NO_x Rate	$PM_{2.5}$ Rate	Units	NO_x Lbs./Day	$PM_{2.5}$ Lbs./Day
Northbound Private Vehicle Port of Entry (Mexican Jurisdiction)									
Toll collection	Stop-and-Go Queue	0.05	miles	7,025	1.99	0.099	g/mile	1.54	0.08
	Idle	1	minute	7,025	5.65	0.140	g/hour	1.46	0.04
Northbound Private Vehicle Port of Entry (U.S. Jurisdiction)									
U.S. Primary, Buses[a]	Uncongested	2.95	miles	N/A	8.61	0.880	g/mile	N/A	N/A
	Creeping Queue	0	miles	N/A	26.86	2.642	g/mile	N/A	N/A
	Stop-and-Go Queue	0.05	miles	N/A	26.86	2.658	g/mile	N/A	N/A
	Idle	5	minutes	N/A	54.46	6.680	g/hour	N/A	N/A
U.S. Primary, SENTRI	Uncongested	2.95	miles	275	0.47	0.014	g/mile	0.84	0.03
	Creeping Queue	0	miles	275	1.19	0.056	g/mile	N/A	N/A
	Stop-and-Go Queue	0.05	miles	275	2.22	0.100	g/mile	0.07	0.00
	Idle	1	minute	275	5.65	0.140	g/hour	0.06	0.00
U.S. Primary, General	Uncongested	2.25	miles	6,750	0.31	0.010	g/mile	10.38	0.33
	Creeping Queue	0.7	miles	6,750	1.08	0.054	g/mile	11.25	0.56
	Stop-and-Go Queue	0.05	miles	6,750	1.99	0.099	g/mile	1.48	0.07
	Idle	1	minute	6,750	5.65	0.140	g/hour	1.40	0.03
U.S. Secondary[b]	Creeping Queue	0.05	miles	338	1.08	0.054	g/mile	0.04	0.00
	Restart (6-30 minute soak)	N/A		338	1.46	0.020	g/start	1.09	0.01
	Subtotal (Northbound Private Vehicle Port of Entry)							29.60	1.16
Northbound Commercial Vehicle Port of Entry (Mexican Jurisdiction)									
Toll collection	Stop-and-Go Queue (FAST)	0.05	miles	350	17.89	1.379	g/mile	0.69	0.05
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.65	1.326	g/mile	0.66	0.05
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Export Customs Entrance	Stop-and-Go Queue (FAST)	0.05	miles	350	17.89	1.379	g/mile	0.69	0.05
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.65	1.326	g/mile	0.66	0.05
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31

Table 4.10 No-Action Alternative Activity and Emissions Tabulation (continued)

Process	Activity Description	Quantity	Units	Volume	NO_x Rate	$PM_{2.5}$ Rate	Units	NO_x Lbs./Day	$PM_{2.5}$ Lbs./Day
Export Cargo Inspection	Creeping Queue (FAST)	0.05	miles	350	19.27	1.416	g/mile	0.74	0.05
	Creeping Queue (Unladen)	0.05	miles	341	19.28	1.400	g/mile	0.72	0.05
	Creeping Queue (Laden)	0.05	miles	681	19.27	1.425	g/mile	1.45	0.11
	Restart (30-60 min soak)	N/A		1,372	0.78	0.030	g/start	2.36	0.09
Export Customs Exit	Stop-and-Go Queue (FAST)	0.05	miles	350	17.89	1.379	g/mile	0.69	0.05
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.65	1.326	g/mile	0.66	0.05
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Northbound Commercial Vehicle Port of Entry (U.S. Jurisdiction)									
U.S. Primary	Uncongested (FAST)	2.95	miles	350	9.480	0.69	g/mile	21.58	1.58
	Creeping Queue (FAST)	0	miles	350	19.270	1.42	g/mile	N/A	N/A
	Stop-and-Go Queue (FAST)	0.05	miles	350	17.890	1.38	g/mile	0.69	0.05
	Uncongested (Unladen)	2.7	miles	341	10.090	0.75	g/mile	20.48	1.51
	Creeping Queue (Unladen)	0.25	miles	341	19.280	1.40	g/mile	3.62	0.26
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.650	1.33	g/mile	0.66	0.05
	Uncongested (Laden)	2.7	miles	681	9.050	0.67	g/mile	36.69	2.71
	Creeping Queue (Laden)	0.25	miles	681	19.270	1.425	g/mile	7.23	0.53
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
U.S. Secondary	Creeping Queue (Laden)	0.6	miles	681	19.280	1.40	g/mile	17.37	1.26
	Restart (6-30 min soak)	N/A		681	0.48	0.020	g/start	0.72	0.03
U.S. Customs Exit	Stop-and-Go Queue (FAST)	0.05	miles	1,372	17.89	1.379	g/mile	2.71	0.21
	Stop-and-Go Queue (Unladen)	0.05	miles	1,372	17.65	1.326	g/mile	2.67	0.20
	Stop-and-Go Queue (Laden)	0.05	miles	1,372	17.69	1.386	g/mile	2.68	0.21
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31

Table 4.10 No-Action Alternative Activity and Emissions Tabulation (continued)

Process	Activity Description	Quantity	Units	Volume	NO_x Rate	$PM_{2.5}$ Rate	Units	NO_x Lbs./Day	$PM_{2.5}$ Lbs./Day
Northbound Commercial Vehicle Port of Entry (State of Texas Jurisdiction)									
Texas DPS Inspection	Uncongested (FAST)	0.5	miles	350	9.480	0.69	g/mile	3.66	0.27
	Creeping Queue (FAST)	0.25	miles	350	19.270	1.42	g/mile	3.72	0.27
	Stop-and-Go Queue (FAST)	0.05	miles	350	17.890	1.38	g/mile	0.69	0.05
	Uncongested (Unladen)	0.5	miles	341	10.090	0.75	g/mile	3.79	0.28
	Creeping Queue (Unladen)	0.25	miles	341	19.280	1.40	g/mile	3.62	0.26
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.650	1.33	g/mile	0.66	0.05
	Uncongested (Laden)	0.5	miles	681	9.050	0.67	g/mile	6.79	0.50
	Creeping Queue (Laden)	0.25	miles	681	19.270	1.425	g/mile	7.23	0.53
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Subtotal (Northbound Commercial Vehicle Port of Entry)								186.45	13.82
Northbound Port of Entry Total								**216.06**	**14.98**

[a] No transit buses utilize Ysleta-Zaragoza.

[b] Assumed to be 5% of general volume.

As a point of reference, the emissions also can be estimated for the same volume of traffic and assuming no border crossing delay by assuming three miles of uncongested VMT (Table 4.11). The resulting estimate assumes no toll collection or inspections of any type occur, and establishes an estimate of the floor below which no operational strategies or infrastructure investment could reduce emissions.

Table 4.11 Hypothetical Emissions Without Any Delay

Activity Description	Quantity	Units	Volume	NO_x Rate	$PM_{2.5}$ Rate	Units	NOx Lbs./Day	$PM_{2.5}$ Lbs./Day
POV (SENTRI)	3	miles	275	0.47	0.140	g/mile	0.85	0.25
POV (General)	3	miles	6,752	0.31	0.010	g/mile	13.84	0.45
Commercial (FAST)	3	miles	350	9.48	0.69	g/mile	21.94	1.60
Commercial (Unladen)	3	miles	341	10.09	0.75	g/mile	22.76	1.68
Commercial (Laden)	3	miles	681	9.05	0.67	g/mile	40.76	3.01
Hypothetical Emissions Without Any Delay							100.16	6.99

■ 4.4 Case Study 1 Calculation

This strategy shifts 1,000 privately owned vehicles into the SENTRI program to reduce the amount of VMT in creeping queues. Because new border crossing capacity is constructed, it is assumed that general purpose lanes will be converted to SENTRI lanes for a portion of the day, and daily average queue lengths do not change relative to the no-action alternative.

Calculations

A calculation summary is presented in Table 4.12 below. Inputs to the calculations include:

- Activity levels identified through the flowcharts in Figure 4.2 (POV port of entry) and Figure 4.4 (commercial port of entry);
- Volume and queuing estimates from Table 4.9;
- Running exhaust composite emission factors from Table 4.4;
- Idle exhaust composite emission factors from Table 4.6; and
- Vehicle start composite emission factors from Table 4.8.

The commercial vehicle portion of the calculation table is identical to the no-action scenario. The presentation of commercial vehicle results is simplified in this example to highlight the portions of the calculations impacted by the case study strategy.

Table 4.12 POV Strategy Activity and Emissions Tabulation

Process	Activity Description	Quantity	Units	Volume	NO_x Rate	$PM_{2.5}$ Rate	Units	NO_x Lbs./Day	$PM_{2.5}$ Lbs./Day
Northbound Private Vehicle Port of Entry (Mexican Jurisdiction)									
Toll collection	Stop-and-Go Queue	0.05	miles	7,025	1.99	0.099	g/mile	1.54	0.08
	Idle	1	minute	7,025	5.65	0.140	g/hour	1.46	0.04
Northbound Private Vehicle Port of Entry (U.S. Jurisdiction)									
U.S. Primary, Buses[a]	Uncongested	2.95	miles	N/A	8.61	0.880	g/mile	N/A	N/A
	Creeping Queue	0	miles	N/A	26.86	2.642	g/mile	N/A	N/A
	Stop-and-Go Queue	0.05	miles	N/A	26.86	2.658	g/mile	N/A	N/A
	Idle	5	minutes	N/A	54.46	6.680	g/hour	N/A	N/A
U.S. Primary, SENTRI	Uncongested	2.95	miles	1,275	0.47	0.014	g/mile	3.90	0.12
	Creeping Queue	0	miles	1,275	1.19	0.056	g/mile	N/A	N/A
	Stop-and-Go Queue	0.05	miles	1,275	2.22	0.100	g/mile	0.31	0.01
	Idle	1	minute	1,275	5.65	0.140	g/hour	0.26	0.01
U.S. Primary, General	Uncongested	2.25	miles	5,750	0.31	0.010	g/mile	8.84	0.29
	Creeping Queue	0.7	miles	5,750	1.08	0.054	g/mile	9.58	0.48
	Stop-and-Go Queue	0.05	miles	5,750	1.99	0.099	g/mile	1.26	0.06
	Idle	1	minute	5,750	5.65	0.140	g/hour	1.19	0.03
U.S. Secondary[b]	Creeping Queue	0.05	miles	338	1.08	0.054	g/mile	0.04	0.00
	Restart (6-30 min soak)	N/A		338	1.46	0.020	g/start	1.09	0.01
Subtotal (Northbound Private Vehicle Port of Entry)								29.48	1.12
Subtotal (Northbound Commercial Vehicle Port of Entry from No-Action Alternative)								186.45	13.82
Northbound Port of Entry Total								**215.93**	**14.94**

[a] No transit buses utilize Ysleta-Zaragoza.

[b] Assumed to be five percent of general volume.

4.5 Case Study 2 Calculations

This strategy would combine the Mexican and U.S. cargo inspection procedures at a single facility. Such a strategy is an extension of pilot programs starting in Fall 2012 where North American imports arriving at ports in Montreal and Prince Rupert, British Columbia would be cleared for entrance into the United States without the need for a second round of inspection at the border. A modified process flow chart is provided as Figure 4.5. After the toll collection at the entrance to the border crossing, trucks would proceed to a common cargo inspection area that would operate similarly to the existing U.S. cargo screening area.

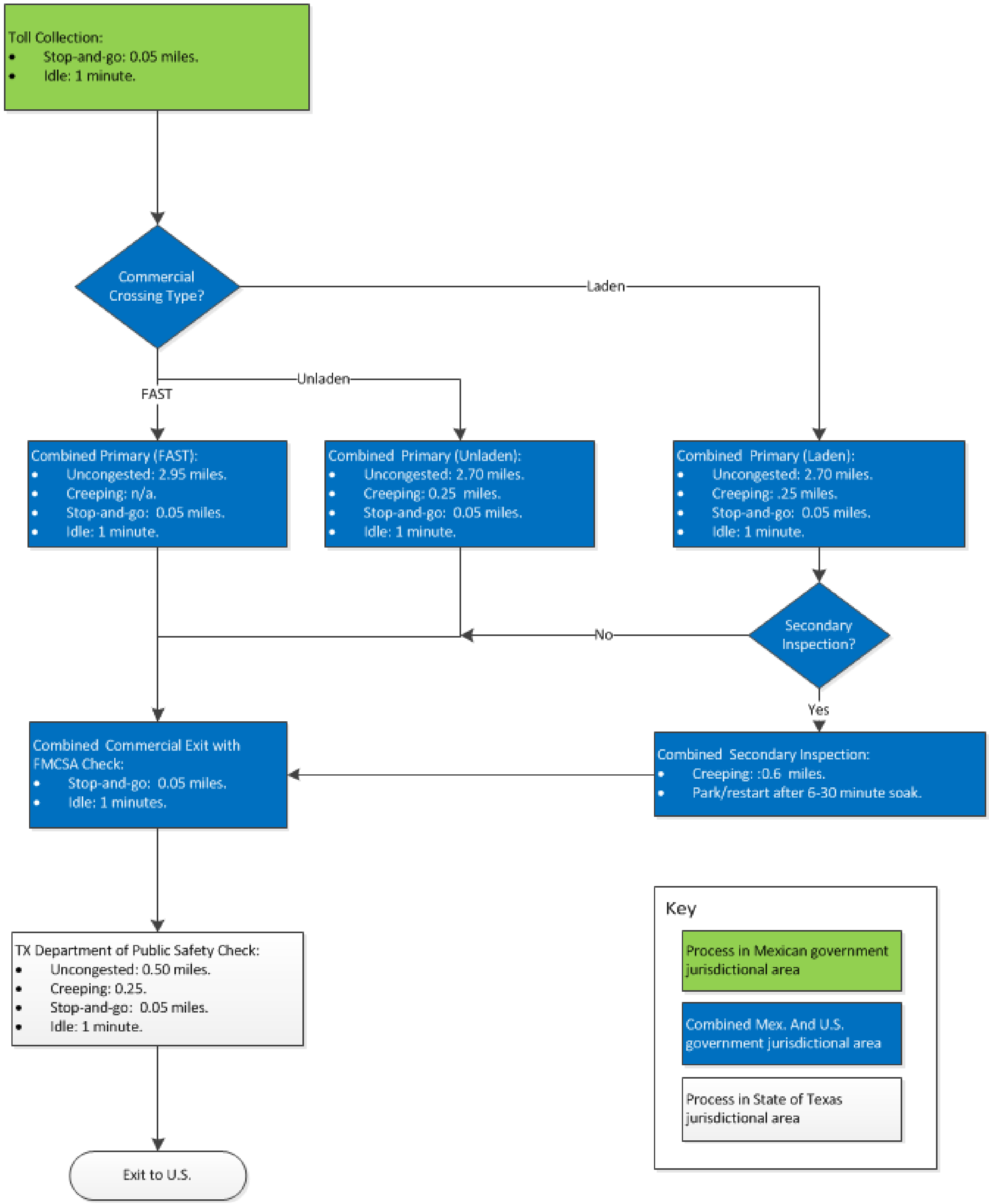
Calculations

A calculation summary is presented in Table 4.13 below. Inputs to the calculations include:

- Activity levels identified through the flowcharts in Figure 4.2 (POV port of entry) and Figure 4.4 (commercial port of entry);
- Volume and queuing estimates from Table 4.9;
- Running exhaust composite emission factors from Table 4.4;
- Idle exhaust composite emission factors from Table 4.6; and
- Vehicle start composite emission factors from Table 4.8.

The privately owned (passenger) vehicle portion of the calculation table is identical to the no-action scenario. The presentation of passenger vehicle results is simplified in this example to highlight the portions of the calculations impacted by the case study strategy.

Figure 4.5 Northbound Commercial Processes Flowchart *Case Study 2*



Source: Cambridge Systematics, Inc.

Table 4.13 Commercial Vehicle Strategy Activity and Emissions Tabulation

Process	Activity Description	Quantity	Units	Volume	NOx Rate	$PM_{2.5}$ Rate	Units	NOx Lbs./Day	$PM_{2.5}$ Lbs./Day
Subtotal (Northbound Private Vehicle Port of Entry from No-Action Alternative)								29.60	1.16
Northbound Commercial Vehicle Port of Entry (Mexican Jurisdiction)									
Toll collection	Stop-and-Go Queue (FAST)	0.05	miles	350	17.89	1.379	g/mile	0.69	0.05
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.65	1.326	g/mile	0.66	0.05
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Northbound Commercial Vehicle Port of Entry (Combined Mexican and U.S. Jurisdiction)									
Combined Primary	Uncongested (FAST)	2.95	miles	350	9.480	0.69	g/mile	21.58	1.58
	Creeping Queue (FAST)	0	miles	350	19.270	1.42	g/mile	N/A	N/A
	Stop-and-Go Queue (FAST)	0.05	miles	350	17.890	1.38	g/mile	0.69	0.05
	Uncongested (Unladen)	2.7	miles	341	10.090	0.75	g/mile	20.48	1.51
	Creeping Queue (Unladen)	0.25	miles	341	19.280	1.40	g/mile	3.62	0.26
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.650	1.33	g/mile	0.66	0.05
	Uncongested (Laden)	2.7	miles	681	9.050	0.67	g/mile	36.69	2.71
	Creeping Queue (Laden)	0.25	miles	681	19.270	1.425	g/mile	7.23	0.53
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Combined Secondary	Creeping Queue (Laden)	0.6	miles	681	19.280	1.40	g/mile	17.37	1.26
	Restart (6-30 min soak)	N/A		681	0.48	0.020	g/start	0.72	0.03
Combined Customs Exit	Stop-and-Go Queue (FAST)	0.05	miles	1,372	17.89	1.379	g/mile	2.71	0.21
	Stop-and-Go Queue (Unladen)	0.05	miles	1,372	17.65	1.326	g/mile	2.67	0.20
	Stop-and-Go Queue (Laden)	0.05	miles	1,372	17.69	1.386	g/mile	2.68	0.21
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31

Table 4.13 Commercial Vehicle Strategy Activity and Emissions Tabulation (continued)

Process	Activity Description	Quantity	Units	Volume	NOx Rate	$PM_{2.5}$ Rate	Units	NOx Lbs./Day	$PM_{2.5}$ Lbs./Day
Northbound Commercial Vehicle Port of Entry (State of Texas Jurisdiction)									
Texas DPS Inspection	Uncongested (FAST)	0.5	miles	350	9.480	0.69	g/mile	3.66	0.27
	Creeping Queue (FAST)	0.25	miles	350	19.270	1.42	g/mile	3.72	0.27
	Stop-and-Go Queue (FAST)	0.05	miles	350	17.890	1.38	g/mile	0.69	0.05
	Uncongested (Unladen)	0.5	miles	341	10.090	0.75	g/mile	3.79	0.28
	Creeping Queue (Unladen)	0.25	miles	341	19.280	1.40	g/mile	3.62	0.26
	Stop-and-Go Queue (Unladen)	0.05	miles	341	17.650	1.33	g/mile	0.66	0.05
	Uncongested (Laden)	0.5	miles	681	9.050	0.67	g/mile	6.79	0.50
	Creeping Queue (Laden)	0.25	miles	681	19.270	1.425	g/mile	7.23	0.53
	Stop-and-Go Queue (Laden)	0.05	miles	681	17.69	1.386	g/mile	1.33	0.10
	Idle	1	minute	1,372	76.74	6.130	g/hour	3.87	0.31
Subtotal (Northbound Commercial Vehicle Port of Entry)								168.08	12.48
Northbound Port of Entry Total								197.68	13.65

5.0 Interpretation of Findings

Graphics summarizing and comparing the case study results are presented below in Table 5.1, Figure 5.1 for $PM_{2.5}$, and Figure 5.2 for NO_x.

Emissions from commercial vehicles are significantly larger than those from the privately owned vehicles even though there are substantially more privately owned vehicles crossing the border at Ysleta-Zaragoza. Commercial vehicles make up only about 15 percent of the volume in this case study, but have on the order of 11 times the $PM_{2.5}$ emissions and six times the NO_x emissions than privately owned vehicles.

Delay and queuing account for approximately half of the emissions associated with traffic crossing the border at port of entry. While this is an approximate estimate, it has important implications for the maximum level of emission reductions that can be achieved by strategies focused on the port of entry itself.

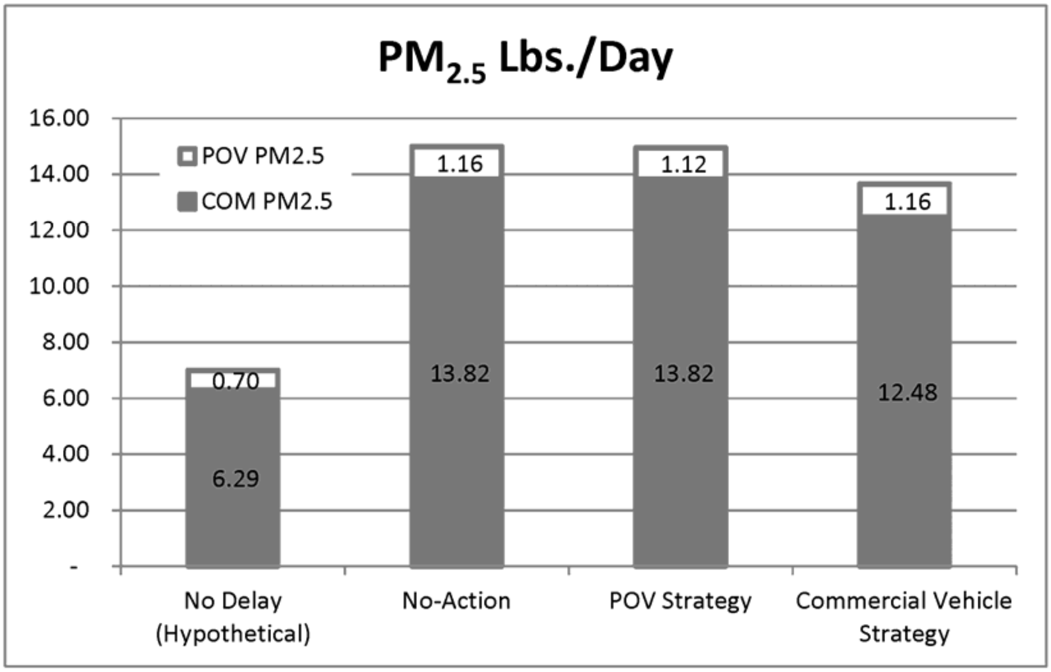
Table 5.1 Summary of 2010 Daily Summertime $PM_{2.5}$ and NO_x Emissions at Ysleta-Zaragoza Port of Entry

	Commercial Vehicle $PM_{2.5}$	Privately Owned Vehicle $PM_{2.5}$	Commercial Vehicle NO_x	Privately Owned Vehicle NO_x
No Delay (Hypothetical)	6.29	0.70	85.46	14.70
No-Action	13.82	1.16	186.45	29.60
POV Strategy	13.82	1.12	186.45	29.48
Commercial Vehicle Strategy	12.48	1.16	168.08	29.60

These results are estimated based on daily average conditions for northbound traffic in 2010. One finding is that southbound travel information, in terms of typical delay in queue length, is extremely limited. There also is little agreement among stakeholders over the quality of the southbound data that are available. The same issues crop up with traffic forecasts because there are often multiple jurisdictions preparing estimates of future conditions for a variety of purposes. Because these are case studies designed to illustrate the application of the analysis template, this work focused on 2010 northbound travel, rather than attempting to resolve some of those data concerns.

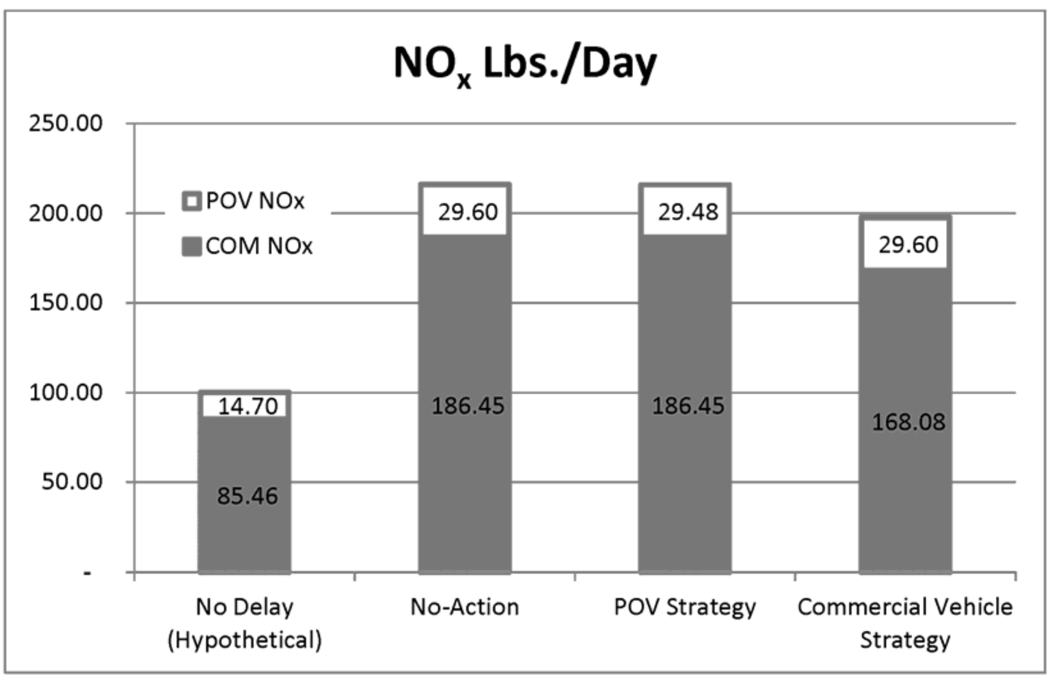
The template also is designed to be relatively straightforward to apply as improved travel data becomes available. Therefore we encourage results to be updated as appropriate.

Figure 5.1 2010 Ysleta-Zaragoza Northbound Daily $PM_{2.5}$ Emissions



Source: Cambridge Systematics, Inc.

Figure 5.2 2010 Ysleta-Zaragoza Northbound Daily NO_x Emissions



Source: Cambridge Systematics, Inc.

5.1 Candidate Best Management Practices

All recommendations for best management practices focus on minimizing queue delay and congestion at the border. Another important consideration is that commercial traffic contributes proportionately much more pollution than passenger vehicle traffic.

- Minimize the number of booths and combine inspections. Each point where a vehicle needs to stop for a specific check has stop-and-go queuing leading up to the booth and idling at the booth itself. Emissions from each of these processes may be as much as 5 percent of the controllable emissions at the port of entry.

- Minimize queue vehicle miles of travel (VMT) and/or minimize delay. For queued vehicles, gram-per-mile emission rates are generally on the order of two times the emission rate for uncongested VMT. Minimizing delay is analogues to minimizing queue VMT; but time spent parked should not be included in the tabulation of delay.

- Park rather than stack vehicles. Some new border crossing designs include a storage parking lot where vehicles can be parked rather than idle/creep while waiting for cargo inspections. For commercial vehicles, the amount of creeping VMT inside of the cargo inspection areas may be similar to the queue lengths approaching the border.

- Combining redundant cargo and vehicle inspections (i.e., Mexican-, U.S.-, and state-level cargo inspections and safety checks).

Examples of strategies that would be compatible with these best management practices would be: consolidating toll and inspection booths; appointment systems; and preclearance of more vehicles and vehicle occupants through programs such as SENTRI, FAST, and the use of Ready Lanes.

5.2 Candidate Performance Measures

Candidate performance measures include:

- Emissions in terms of grams per vehicle processed through the port of entry;

- The total mass of pollutants emitted at the port of entry, or process within the port of entry;

- The amount of VMT in creeping queues and stop-and-go queues;

- Tracking the number of booths that a vehicle must pass through; and

- Tracking the amount of non-parked delay.

All of the above metrics should be minimized.

■ 5.3 Application of the Analysis Template to Other Regions

This section supports decision-making about the transferability of estimation protocols for emissions and delay. More detailed information can be found in the Task 3 technical reports included as an attachment to this white paper and analysis template. Parameter categories examined generally include:

- Activity Information (vehicle volumes, types, and payloads);
- Infrastructure Information (traffic and lane conditions);
- Combustion conditions due to ambient temperature and humidity;
- Engine power adjustments for road grade and elevation;
- Off-network traffic activity;
- Additional vehicle profile detail (age, registration, model); and
- Directional similarity or difference (northbound versus southbound).

In reviewing the data collected, the El Paso POE Group has been identified as having the following characteristics: truck volumes exceeding 700,000 in 2010, and comprising 7 percent of total vehicle counts; and passenger vehicle counts nearing 10 million and bus counts exceeding 22,000 in 2010. The El Paso POE Group carries high volumes of truck traffic coupled with high passenger and bus traffic. Approximately half of El Paso NB truck crossings are laden, and truck counts are relatively constant by season (as is the percent of trucks that are laden). Examining proxies for relative levels of congestion and delay, the El Paso POE Group carries 55,000 trucks per commercial lane annually, and 4,600 trucks per lane per daily hour of operation – and El Paso crossings are open 12 or 16 hours per day for commercial traffic.

Noting these characteristics, the most similar POE Groups to El Paso appear to include: Laredo, Texas; Hidalgo, Texas; Calexico East, California; Nogales Arizona; Brownsville, Texas; and Otay Mesa, California. For all of these crossings, relatively high truck and passenger vehicle volumes are present. At Brownsville and Calexico East, the percentage of NB laden trucks is consistent with El Paso, though Laredo, Otay Mesa, Hidalgo and Nogales do have higher proportions of laden trucks (it is important to note that trucks maybe laden when traveling NB, but unladen upon return, so these proportions may balance out when both NB and SB traffic are considered). In terms of lane configurations, these crossings all have several commercial truck lanes, and the presence of a FAST lane. In terms of relative volume and congestion, Brownsville, Hidalgo, Laredo, Nogales, Otay Mesa, and Calexico East all have at least 50,000 trucks per commercial lane, or over 3,500 trucks per lane-hour. Hours of operation at each of these POEs are typically between 12 and 16 hours, though Hidalgo operates for fewer hours. Additionally, grade is relatively consistent among these crossings (0-1.99 percent), although grade at Otay Mesa is higher (it is important to note that actual grade at crossing may differ from topography, due to presence of bridges or other infrastructure with differing grade). Temperature and humidity profiles do differ at Brownsville and Hidalgo, though Laredo, Nogales, and Calexico East profiles are similar to El Paso.

For these conditions, the dominant ports that are unlike El Paso are Lukeville, Sasabe, Naco, Roma, Columbus, and Presidio. For all of these POE Groups, truck volumes are relatively low (less than 10,000 per year) and there are only 0-2 dedicated commercial truck lanes present – and no FAST lanes. In terms of relative volume and congestion, these POEs have less than 10,000 trucks per lane per year, and have roughly 1,000 or less trucks per lane per hour of operation. Lukeville, Sasabe, Columbus, and Presidio are identified as being in regions with high grade compared to the major crossings. However, all of these crossings do have similar temperature and humidity profiles when compared to El Paso (with the exception of Roma).

The above analysis is a first-order consideration of POE location variables and examine their applicability as inputs for the MOVEs model along the entire U.S.-Mexico border as a whole. In addition to the size, use, and influence of each specific POE, other site-specific variables can be analyzed in more detail for a better understanding of emissions related to each POE.

6.0 Glossary of Port of Entry Terms

Many of definitions in this section have been adapted from the abbreviated U.S. Land Port of Entry Design Guide.[16]

Aduanas – The customs agency for Mexico.

Border Station – Also known as "Port" or "Land Port of Entry."

Bus Inspection – Drop-off and lobby area for inspection of passengers and luggage transported by commercial bus line**.**

Bus Plaza – The area where buses off-load passengers for inspection.

Bus Lobby – The area where bus passengers go through a primary inspection turnstile and a secondary inspection.

Christmas Tree – The branch-like arrangement of lanes often used in the secondary inspection area.

Commercial – Vehicular traffic carrying merchandise for resale.

Commercial Building – Also known as Cargo Building – A building within the commercial inspection area to house staff and operations.

Commercial Dock – A raised platform, typically enclosed or protected by a canopy depending on the climate, where trucks unload their cargo for physical inspection.

Commercial Inspection – Inspection of commercial vehicles for control of material goods, collection of duties and confiscation of contraband.

Commercial Lot – The area in a port for secondary inspection of commercial vehicles.

Commercial Primary Inspection Area – The area that performs the initial screening inspection of commercial vehicular traffic (primarily trucks) entering the U.S.

Commercial Secondary Inspection Area – Areas including the commercial lot, commercial dock, commercial building, truck scale, empty vehicle inspection, truck radiographic inspection, bulk material inspection, and APHIS PPQ and APHIS VS facilities for more thorough examination of the contents of commercial vehicles.

---

[16] GSA (2000) U.S. Land Port of Entry Design Guide.

Customs and Border Protection (CBP) – The Department of Homeland Security agency responsible for securing the borders of the United States while simultaneously facilitating the flow of legitimate trade and travel.

Customs Brokers – Brokers assist importers with the processing of commercial shipments. Acting as agents for the shipper, they coordinate the preparation of documents, make fee payments, and unload goods for inspection.

Dedicated Commuter Lanes (DCL) – A program providing expedited inspection and clearance through primary inspection for enrollees.

Egal – Commercial inspection that produces x-ray type images of tankers, commercial trucks, sea and air containers, and other vehicles.

Exit Control Booth – A booth at the exit point from the commercial inspection area where inspectors ensure that vehicles leaving the area have passed inspection.

FAST Lane – Free and Secure Trade program lane which requires the driver, vehicle, and cargo be precleared for entry into the United States through the Free and Secure Trade program.

FMCSA – Federal Motor Carrier Safety Administration.

Gantry – Commercial inspection that employs gamma ray technology to produce x-ray type images of tankers, commercial trucks, sea and air containers, and other vehicles.

Impoundment Lot – A fenced lot for storing vehicles and other large items that have been seized by Customs Agents and CBP Inspectors.

Inbound Traffic – Traffic entering the United States from a foreign country.

Land Port of Entry – A Land Port of Entry is the facility that provides for the controlled entry into or departure from the United States for persons and materials arriving as commercial, noncommercial, pedestrian, or rail traffic.

LPR – License Place Readers.

Non-Commercial – Passenger and bus vehicle traffic not carrying merchandise for resale or use in manufacturing.

Non-Commercial Primary Vehicle Inspection Area – The area that performs the initial screening inspection of non-commercial vehicular traffic (primarily automobiles) entering the U.S.

Non-Commercial Secondary Vehicle Inspection Area – The area provided to allow for more detailed and thorough inspection of traffic which did not clear the primary inspection area.

Outbound Inspection – CBP program for inspecting and controlling the export of high-technology goods, firearms, licensable commodities, currency, and stolen vehicles.

Pedestrians – Individuals walking into the United States. There is significantly more volume of pedestrian traffic on the U.S.-Mexico border than on the U.S.-Canada border.

Pedestrian Primary Inspection – The turnstile and counter area where the initial screening inspection of pedestrians is performed.

Pedestrian Secondary Inspection – The area where a more thorough inspection of pedestrians and their belongings is performed.

Port or **Port of Entry (POE) –** *(See Land Port of Entry.)*

Pre-Access Commuter Entry (PACE) – A sticker-based DCL providing expedited entry and clearance through primary inspection.

Pre-Arrival Processing (PAP) – A USCS commercial vehicle pre-inspection program that allows for presubmittal of manifest and invoices which can be preclassified and directly recalled by computer systems at the primary inspection.

Primary Inspection – The initial encounter and screening at a Port, either of non-commercial (vehicular primary), pedestrian, commercial, or bus traffic.

Pylon Scanner – Commercial inspection to produce x-ray type images of tankers, commercial trucks, sea and air containers, and other vehicles for contraband.

Ready Lane – A POV entry lane to the United States for vehicles whose occupants have WHTI-compliant, RFID-enabled cards approved by the Department of Homeland Security compliant documents.

Referral Parking – Parking by the main building to accommodate foreign visitors who have business to conduct at the port, but do not intend to enter the U.S.

Secondary Building – A small building located in the secondary inspection area that provides office space and separate restroom facilities for staff and visitors.

Secretariat of Communication and Transportation (SCT) – Mexican national level department of transportation.

Secondary Inspection – A more thorough inspection, often including a search of the person and/or vehicle. Determination for the inspection can be based upon suspicion or simply a random sampling of individuals.

Secretaria De Medio Ambiente Y Recursos Naturales (Semarnat) – Mexico's national environmental protection agency.

Secured Electronic Network for Travelers Rapid Inspection (SENTRI) – Transponder-based DCL program providing expedited inspection and clearance through primary inspection.

USDA – United States Department of Agriculture.

VACIS – Commercial inspection that employs gamma ray technology to produce x-ray type images of tankers, commercial trucks, sea and air containers, and other vehicles.

U.S.Department of Transportation
Federal Highway Administration

U.S Department of Transportation
Federal Highway Administration
Office of Planning, Environment, and Realty
1200 New Jersey Ave, SE
Washington, DC 20590

FHWA-HEP-13-004

November 2012