Final Report

Impacts of Border Delays at California-Baja California Land Ports of Entry

Volume 3: Emissions Impact Analysis Report

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In Coordination with T. Kear Transportation Planning and Management, Inc.

Border Glossary and Acronyms

Aduanas	Administración General de Aduanas: Mexican customs agency.
APCD	Air Pollution Control District, regional agencies responsible for regional air quality planning and regulation in California.
BMPs	Best Management Practice: (strategies, policies, or projects) to reduce POE delay and emissions.
CARB	California Air Resources Board: State of California air pollution planning and regulatory agency.
CBP	United States (U.S.) Customs and Border Protection: the U.S. customs agency.
CO	Carbon monoxide.
CO_2	Carbon dioxide.
Commercial vehicle STP	Scaled tractive power is the power delivered to the axel of a commercial vehicle normalized by an average weight for vehicles in that class. This parameter is closely related to passenger vehicle VSP.
Design day	Used to represent either worst case or average environmental and congestions conditions, for which emissions are to be quantified.
Diurnal emissions	Evaporative emissions from parked vehicles that are driven by the diurnal (daily) increase in temperature. Related to resting losses.
DPM	Diesel particulate matter.
Eagle scanner	A non-intrusive cargo inspection based on x-ray and/or gamma- ray imaging, similar to the VACIS.
EMFAC	The California Air Resources Board’s emission factor model for on-road motor vehicles. EMFAC2017 is the latest version approved by the U.S. Environmental Protection Agency.
Emission control	Emission control is any device intended to limit the amount of pollution emitted by a vehicle, and, include both after treatment devices such as exhaust catalysts and the computer systems that manage the combustion process.

FAST	Fast and Secure Trade, a trusted traveler/trusted shipper program allows expedited processing for commercial vehicles. This program is managed by the U.S. Customs and Border Protection.
FHWA	U.S. Federal Highway Administration: part of the U.S. Federal Department of Transportation.
FMM	Forma Migratoria Múltiple: A document issued by Mexico's Instituto Nacional de Migración which allows U.S. and Canadian residents to travel beyond the 35-km border zone in Mexico.
Gantry	A non-intrusive cargo inspection based on x-ray and/or gamma- ray imaging which is more sophisticated than the VACIS and Eagle inspections.
GSA	U.S. General Services Administration.
ICTC	Imperial County Transportation Commission, which serves as the regional transportation planning agency for Imperial County, California.
I/M	Inspection and Maintenance (Smog Check) program.
INDAABIN	Instituto de Administración y Avalúos de Bienes Nacionales: Mexico's federal agency, which is responsible for the administration of federal property, similar to the General Services Administration (GSA) in the U.S.
LPOE	Land Port of Entry.
MOVES	USEPA on-road emission factor model (MOtor Vehicle Emission Simulator), MOVES2014a is the latest version.
NOx	Oxides of nitrogen.
Passenger vehicle VSP	Vehicle specific power is the power that a vehicle delivers to the road/divided by vehicle mass and represents instantaneous vehicle engine power. This parameter is closely related to commercial vehicle STP.
PM2.5	Particulate matter with diameter less than or equal to 2.5 micrometers.
PM10	Particulate matter with diameter less than or equal to 10 micrometers.

POE	See LPOE.
POV	Privately-owned vehicles (generally passenger vehicles).
Resting losses	Evaporative emissions that occur when a vehicle is parked, largely as a result of permeation of fuels and lubricants through vehicle components and off-gassing of vehicle components. Resting loss emissions are defined as only occurring when temperatures are declining. Related to diurnal emissions.
Running emissions	Running emissions include both exhaust and evaporative emissions that occur when a vehicle is in use.
ROG	Reactive Organic Gases.
SANDAG	San Diego Association of Governments, which serves as the regional planning agency for San Diego County, California.
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales, Mexico's federal agency responsible for environmental regulation.
SIDUE	Secretaría de Infraestructura y Desarrollo Urbano del Estado, Baja California agency responsible for transportation.
Soak time	Soak time is the length of time that a vehicle sits once it has been turned off, before it is restarted. It is important in determining starting emissions, resting losses, and diurnal emissions.
SPA	Secretaría de Protección al Ambiente de Baja California, which is the Baja California agency responsible for environmental regulation.
Starting Emissions	Starting emissions are additional emissions resulting whenever a vehicle is started. They vary based on the temperature of the engine and operating state of the vehicle's emission control system, which in term can be characterized based on "soak time".
STP	See commercial vehicle STP.
USEPA	U.S. Environmental Protection Agency.
VACIS	Vehicle and Cargo Inspection System: A non-intrusive cargo inspection based on x-ray and/or gamma-ray imaging, similar to the Eagle scanner.

Vehicle Activity Data	Quantifies the amount that a vehicle spends in different modes of operation and the distance traveled in each mode. Typically quantified as vehicle miles of travel (VMT), vehicle hours of travel (VHT), or soak time.
VMT	Vehicle miles of travel.
VHT	Vehicle hours of travel.
VSP	See passenger vehicle VSP.

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(OME 5x5) ....CalEastPOV25_BL+AAC (OME 5x5).xlsx

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Transit and Active

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(OME 5x5 and 10x10) .... CalEastPOV35_BL+AAC (OME 5x5 & 10x10).xlsx

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Calexico East Commercial – 2016
Baseline Analysis ....CalEastCOM16_BL.xlsx

Calexico East Commercial – 2025
Baseline Analysis ....CalEastCOM25_BL.xlsx

Calexico East Commercial – 2025
Baseline with "All American Canal
Enhancements" at Calexico East
Analysis (OME 5x5) ....CalEastCOM25_BL+AAC (OME 5x5).xlsx

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Baseline with "All American Canal
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1 Executive Summary

This volume of the Economic and Air Quality/Climate Impacts of Delays at the Border study report quantifies emissions at the California-Baja California land ports-of-entry (POEs). Six pollutants are covered for privately owned vehicles (POVs) and commercial vehicles:

- Carbon dioxide (CO_2);
- Reactive Organic Gases (ROG);
- Oxides of Nitrogen (NOx);
- Particulate matter smaller than 10 microns in aerodynamic diameter (PM10);
- Particulate matter smaller than 2.5 microns in aerodynamic diameter (PM2.5); and
- Carbon Monoxide (CO).

Results are presented separately for San Diego County and Imperial County, across five scenarios spanning several strategies and analysis years (Table 1).

Table 1. Overview of Analysis Scenarios

2016 Analysis	2025 Analyses	2035 Analyses
Baseline 2016	Baseline 2025	
	Baseline 2025 plus Capacity Enhancements, Transit, and Active Transportation (Otay Mesa East 5x5)	Baseline 2035 plus Capacity Enhancements, Transit, and Active Transportation (Otay Mesa East 5x5)
		Baseline 2035 plus Capacity Enhancements, Transit, and Active Transportation (Otay Mesa East 10x10)

Note: "5x5" and "10x10" refers to the number of privately owned vehicle and commercial vehicle primary booths at the proposed Otay Mesa East Port of Entry.

These scenarios are detailed in Section 3 of this volume. Broadly, the 2025 baseline and 2035 baseline include projects that are either completed, funded or are anticipated to receive funding. For example, construction of the Phase 3 improvements at the San Ysidro POE, and Phase 1 of the Calexico West POE improvements are assumed to be built in the future baseline scenarios. The capacity enhancement scenario and capacity enhancement plus transit and active transportation scenarios looked at the effect of projects that are still being planned, such as the Otay Mesa East (OME) POE, an expanded bridge over the All-American Canal at Calexico East, and proposed transit improvements.

The basic framework for land POE emissions analyses leveraged approaches developed for the U.S. Federal Highway Administration (FHWA) and the U.S. – Mexico Joint Working Committee on Transportation Planning in the United States-Mexico land POEs Emissions and Border Wait-Time Analysis Template (JWC template)[1]. That process (see Figure 6 under Section 2 of this volume), utilizes queue models to study each process at the POE, along with estimated demand for each lane type, to estimate how much delay and queuing POVs and commercial vehicles

[1] FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.

experience as they cross the border. The resulting estimates of vehicle activity are coupled with emission rates from the California Air Resources Board (CARB) EMFAC model. The EMFAC2017 version 1.02 was used to generate emission rates for use in this analysis.

Policy, strategy, and project recommendations are considered within an overall hierarchy of emission reduction strategies pyramid (Figure1)[2]. The base of the pyramid (cleaner, more efficient vehicles and better fuels) includes strategies that are already being implemented at regional, state and national scales. Such as increasingly stringent emission certification and fuel economy standards for new vehicles.[3]

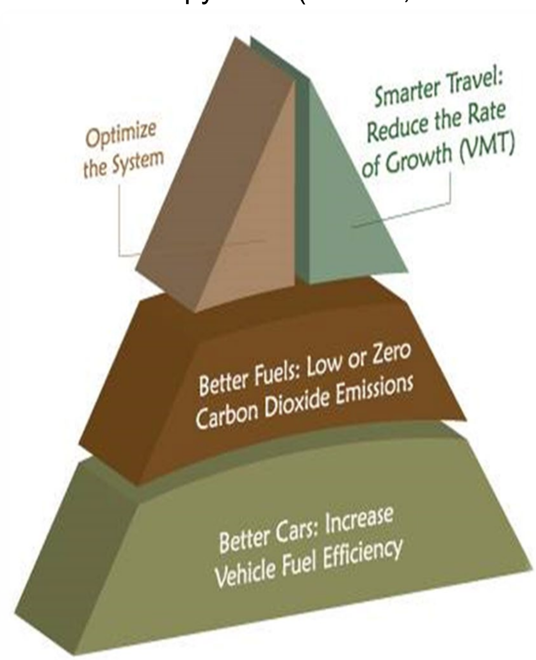

Figure 1. Emission Reduction Strategy Pyramid

Results for a typical weekly average day during the summer for POVs and commercial vehicles are show in Figure 2 through Figure 5 below. These figures report the CO_2, ROG, and NOX emissions, pollutants whose significance lies in their contribution to pollution concerns on a county-wide scale. POE specific results for the remaining pollutants, and winter season emissions, are in the body of this report volume. Emissions estimates are presented per 1,000 vehicles crossing the border so that the trends can be illustrated independently of growth in volume of border crossers. The results shown in Figure 2 through Figure 5 illustrate these trends in ongoing emission reductions through planned improvements at the POEs and the phase in of cleaner, more efficient, vehicles. By 2035, however, emissions reductions for some pollutants at the busier POEs can be seen bottoming out. This suggests the need for additional vehicle technology improvements and capacity enhancements to maintain the downward trajectory of emissions past 2035.

The analysis shows that the planned infrastructure improvements and policies to expand capacity are needed by 2025 and 2035 so that growing delay and queuing do not overwhelm emission reductions derived from the lower polluting, more efficient vehicles and fuels. These infrastructure improvements are strategies that optimize the system, which is at the top of the emission reduction strategy pyramid.

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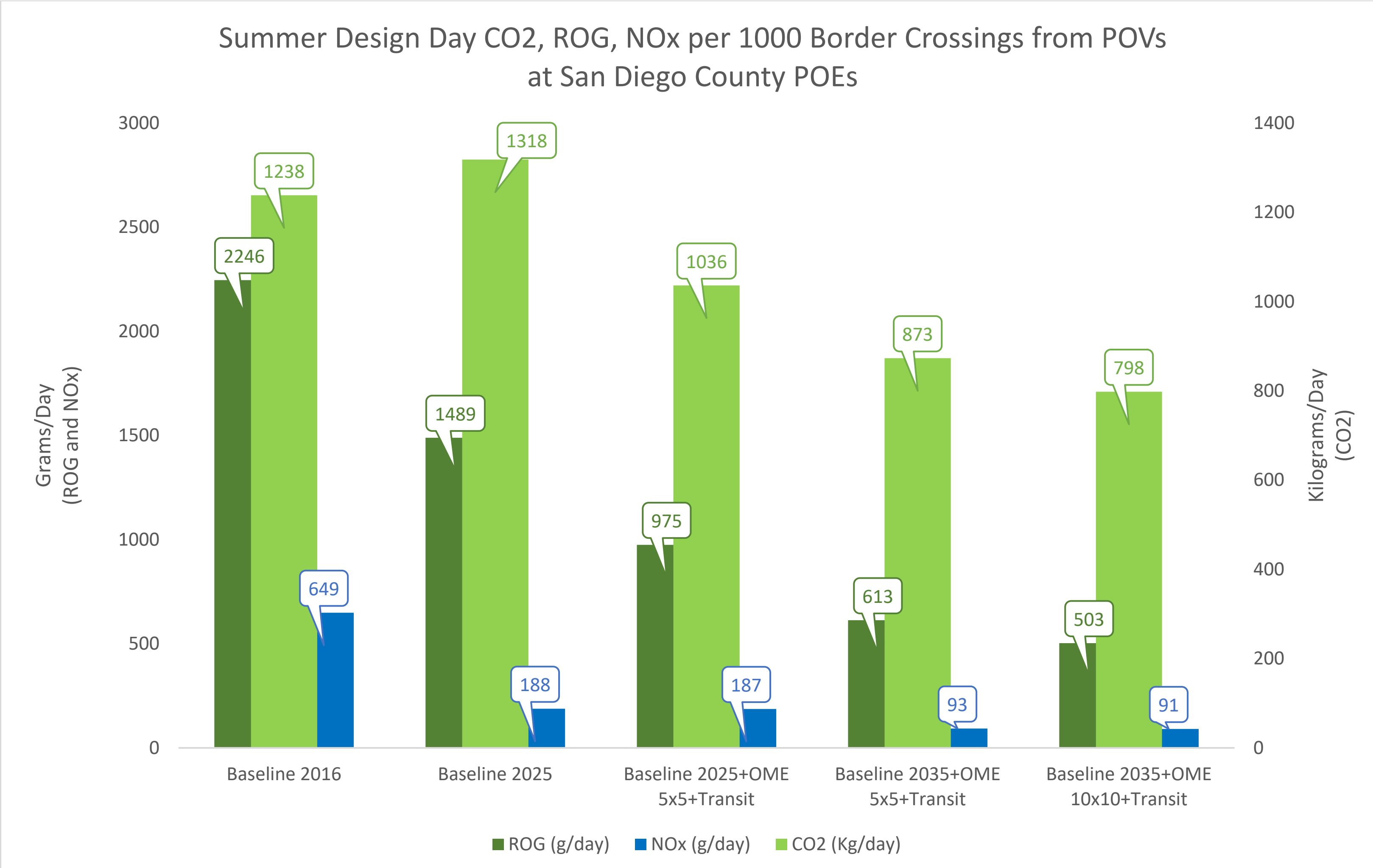
[2] CEC (2016) Reducing Air Pollution at Land Ports-of-Entry: Recommendations for Canada, Mexico and the United States, Montreal, Canada: Commission for Environmental Cooperation.
[3] The Governor's recent executive order, EO N-79-20, has goals for the State of California for sales of new passenger cars and trucks and for drayage trucks to be zero-emission by 2035. For medium- and heavy-duty vehicles the goal for zero-emission is by 2045 for all operations where feasible. CARB is tasked to develop regulations. https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf. This analysis does not account for the anticipated but unquantified benefits of EO N-79-20.

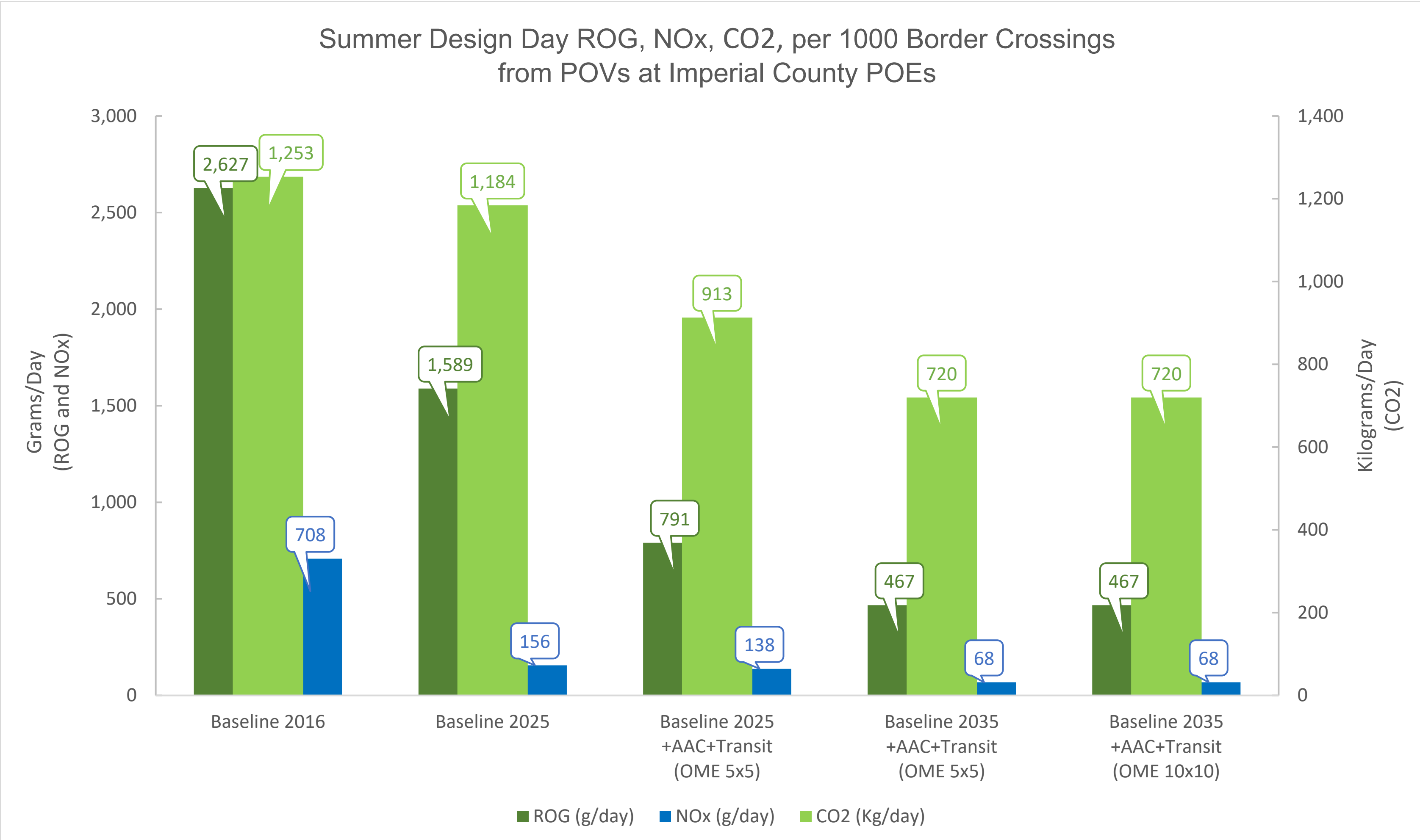
Specific recommendations that could potentially help reduce emissions by managing demand, minimizing delay, and promoting lower polluting, more efficient vehicles can be found in Table 2 through Table 6 and are also discussed in Section 8 of the report.

Figure 2. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at San Diego County POEs



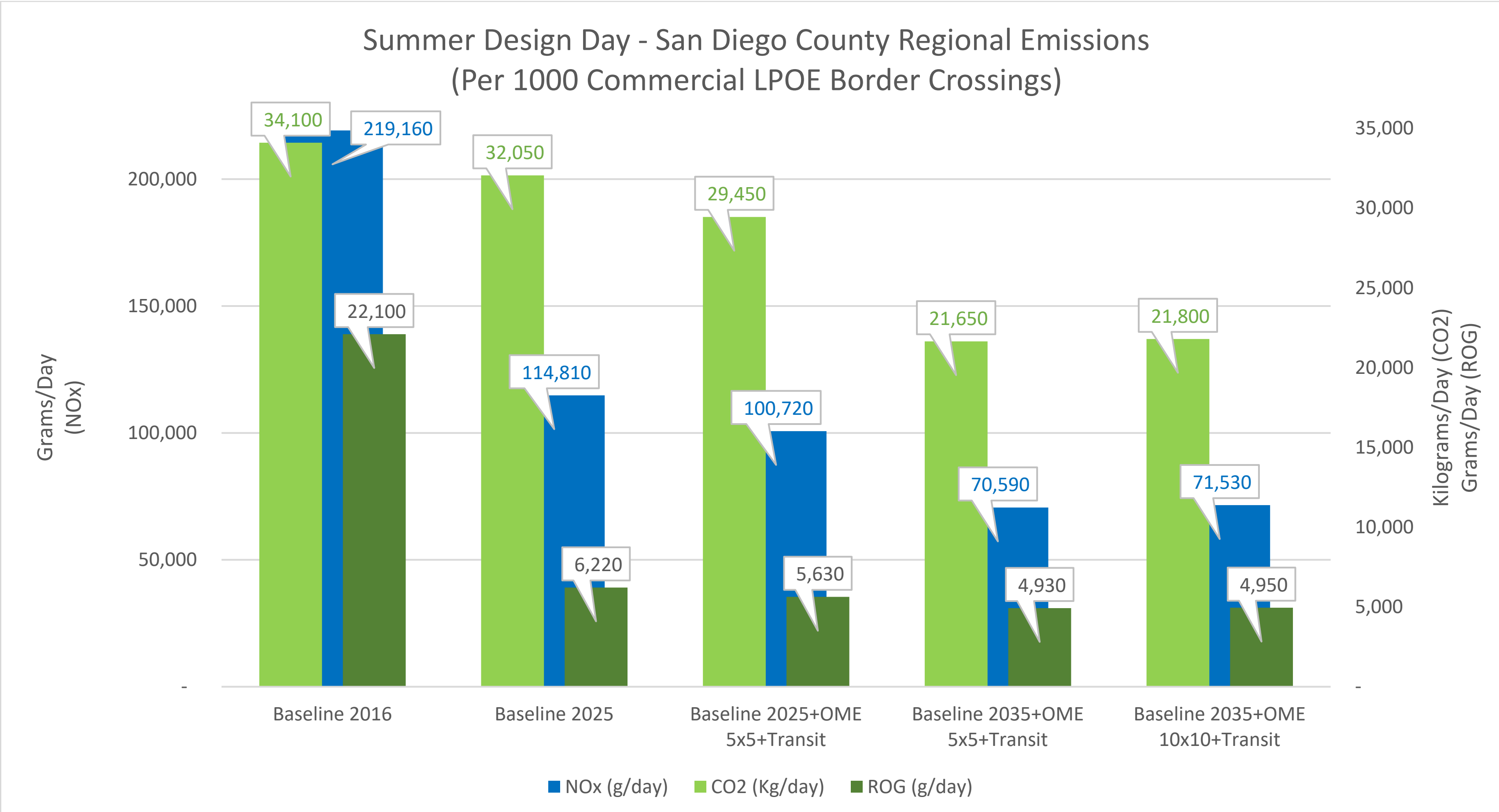
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 3. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at Imperial County POEs



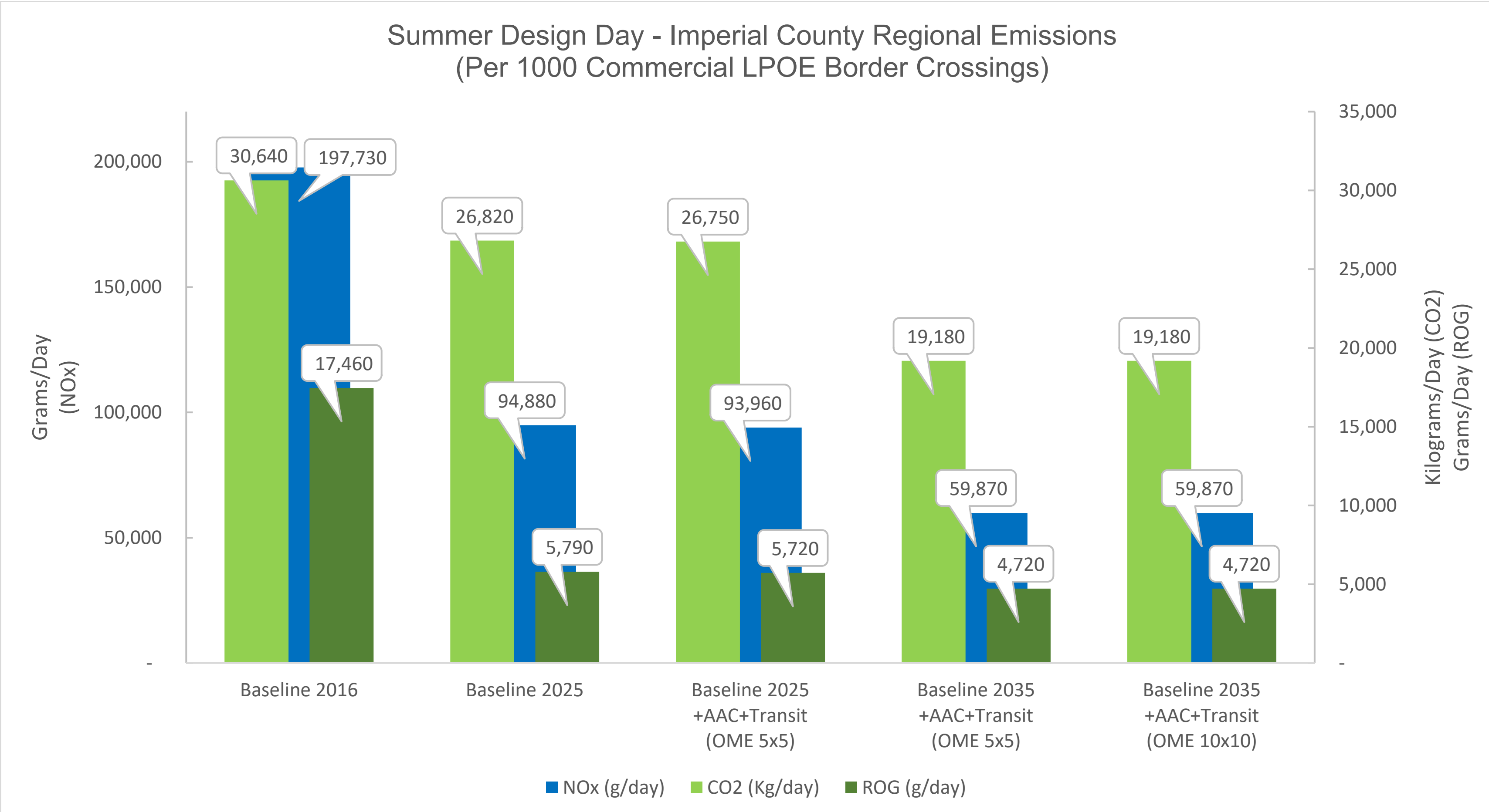
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 4. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at San Diego County POEs



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 5. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at Imperial County POEs



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

The Project Team developed several recommendations to improve conditions at the border. The recommended strategies may have significant impacts on border crossers and businesses that utilize crossings in the California-Baja California border region. Potential impacts include reductions in delays, changes in modal split, and air quality improvement. Broadly, the types of recommended improvements can be summarized in the following categories:

- Expansions of Physical Capacity at the land POEs;
- Improved Operations at the land POEs;
- Improved Access to POEs;
- Corridor-Wide Improvements for Corridors that include a POE; and
- Long-Term Strategies.

Specific improvements considered under each category are listed in Table 2 through Table 6, as well as the impact they are anticipated to have in either border-crossing wait times/delay or modal splits between motorized vehicles and pedestrians.

In terms of capacity expansions at POEs, the Project Team recommends that additional lanes and booths be added for motorized vehicles. These improvements are expected to reduce delays for motorized crossers in the binational region, saving time and money of individual crossers (see Table 2).

Table 2. Expansion of Physical Capacity at POEs

Improvement	Impact on Wait-Times	Impact on Modal Split
Additional lanes and booths for motorized vehicles • Phase 3 Improvements at San Ysidro (complete)[4] • Phase 1 (complete) and Phase 2 Improvements at Calexico West[5] • Bridge Expansion over All-American Canal at Calexico East[6] • Otay Mesa Commercial Modernization[7]	Reduces wait-times for motorized crossers in binational region	Minimal, but may increase share of motorized crossers
Additional lanes and booths for pedestrian crossers • Phase 2 Improvements at Calexico West • Otay Mesa Pedestrian Modernization[8]	Reduces wait-times for pedestrian crossers in binational region	Minimal, but may increase share of pedestrian users
New POE facilities • **Otay Mesa East** Port of Entry	Reduces wait-times for motorized crossers across San Diego-Tijuana region	Minimal, but may increase share of motorized crossers

There are several improvements recommended under the Improved Operations at POEs category, more than half of which are related to truck crossings. In particular, interchangeable lanes, reversible lanes, and other innovative lane management operations are recommended to reduce delays for all POE crossers; however, this may also increase the share of motorized personal trips (see Table 3).

[4] Phase 3 improvements at San Ysidro include the addition of 10 southbound POV lanes with additional southbound primary inspection booths and 8 northbound POV lanes with 15 additional northbound inspection booths. This project was completed in 2019. *Source:* *General Services Administration*

[5] Phase 1 improvements at Calexico West include the addition of 5 southbound POV lanes and a southbound bridge over the New River as well as 10 northbound POV lanes. This project was completed in 2018. *Source: General Services Administration.* Phase 2 improvements at Calexico West include a new pedestrian processing facility, 5 additional southbound POV lanes and 6 additional northbound POV lanes. This phase is currently unfunded but expected to be constructed by the corresponding analysis year (2025). *Source: General Services Administration.*

[6] "Expanded bridge over the All-American Canal" is part of proposed improvements to increase capacity at the Calexico East POE. Envisioned expansion comprises 2 additional northbound POV lanes and 2 additional northbound commercial lanes. The bridge expansion component is proposed to address the current bottleneck observed over this section of the approach road. These improvements are expected to be constructed before 2025. *Source: California Transportation Commission*

[7] Otay Mesa Commercial Modernization refers to a General Services Administration (GSA) led effort to renovate and expand commercial facilities at the Otay Mesa POE, including 6 additional commercial processing booths and other related improvements. *Source: General Services Administration*

[8] Otay Mesa Pedestrian Modernization refers to a GSA led effort to renovate and expand pedestrian facilities at the Otay Mesa POE. The construction is expected to include 6 additional pedestrian processing lanes and other related improvements. *Source: General Services Administration*

Table 3. Improved Operations at POEs

Improvement	Impact on Wait Times	Impact on Modal Split
Southbound Electronic Commercial Clearance (Aduanas PITA program)	Marginal, but reduces total crossing and idling time for truck crossers at POE	-
Unified Cargo Processing	Marginal, but potentially reduces total crossing and idling time for truck crossers at POE	-
Joint Inspection Facility	Marginal, but reduces total crossing and idling time for truck crossers at POE	-
Interchangeable Lanes	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Reversible Lanes	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Lane Management	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Appointment Time for Truck Crossers	Potential to reduce wait-times for truck crossers at POE	-
Extended Hours of Operations	Potential to reduce wait-times for crossers at POE	-
Variable tolls at OME	Potential to reduce wait-times for truck crossers at Otay Mesa	-

Strategies to improve access to POEs include improved bike and pedestrian access to POEs, enhanced transit services at the border, the deployment of an advanced traffic management and traveler information system and the prioritization of zero / near-zero emission trucks, with their different impacts are listed in Table 4. There are several improvements being advanced by border agencies. For example, Caltrans and SANDAG are pursuing a border wait time measurement system using Intelligent Transportation Systems (ITS) technologies. The system completed a successful pilot phase for southbound POV wait time measurements at San Ysidro, and the agencies are advancing the system at all ports of entry and in both the northbound and southbound directions. This effort corresponds to the Advanced Traffic Management and Advanced Traveler Information System and Regional Border Management System improvement concepts mentioned in Table 4.

Table 4. Improved Access to POEs

Improvement	Impact on Wait Times	Impact on Modal Split
Bike and pedestrian access improvements	-	Potential shift to pedestrian mode from motorized mode
Enhanced transit services (including: Tijuana BRT and higher frequency of transit service at San Ysidro and Otay Mesa), completion of Calexico West Intermodal Transit Center, and completion of Transit Center/Cell Phone Lot at Calexico East.	-	Potential shift to pedestrian mode from motorized mode
Advanced Traffic Management and Advanced Traveler Information System, including RFID and Wi-Fi readers on Mexico's northbound lanes to capture commercial and POV vehicle wait-time data	Potential reduction in NB wait times for trucks and POVs due to planning and routing to faster POE	-
Zero/Near-Zero Emission Truck Prioritization at POEs	Potential to reduce wait times for truck crossers at POE (and reduce emissions from using zero/near-zero emission trucks)	-

A recommendation for corridor-wide improvements consisted of the deployment of a Regional Border Management System (RBMS) and subcomponents. The individual components have the potential to reduce northbound and southbound delays for commercial and passenger vehicles due to efficient re-routing with advanced travel information (see Table 5).

Table 5. Corridor-Wide Improvements for Corridors that Include a POE

Improvement	Impact on Wait Times	Impact on Modal Split
Regional Border Management System (RBMS) and Subcomponents - • Southbound Congestion Management and ITS Infrastructure Improvements • Freight Advanced Traveler Information System (FRATIS), including Information Dissemination Process • Integrated Corridor Management (ICM) and Active Traffic Management (ATM)	Potential reduction in NB and SB wait-times due to improved POE choice and trip routing could be realized for commercial and passenger vehicles with advanced travel information	Minimal, but may increase share of motorized crossers

A final recommendation (see Table 6) is that local planning agencies support binational planning processes and foster collaboration efforts for POE operations and transportation infrastructure. This cooperation is essential for the successful implementation of several of the recommended strategies identified above.

Table 6. Other Improvements and Long-Term Strategies

Improvement or Strategy	Impact on Wait Times	Impact on Modal Split
Support Binational Planning Process for POEs and Transportation Infrastructure	Potential reductions to NB and SB wait-times	Potential shift to pedestrian mode from motorized mode

These recommendations also align with state of California goals and objectives noted in existing planning documents and efforts currently underway. Key examples of planning efforts that include border improvement strategies, projects and policies include the 2016 California Sustainable Freight Action Plan (CSFAP), which includes a work plan to implement pilot projects for "Advanced Technology Corridors at Border Ports of Entry". The series of pilot projects are currently being implemented and include elements such as deployment of technology to dynamically manage border infrastructure to reduce wait times. Currently, Caltrans is developing the 2020 California Freight Mobility Plan (CFMP) which is anticipated to include many of the same border improvement elements.[9]

Another example of planning work aligned with the study recommendations is the 2021 California-Baja California Border Master Plan (BMP) effort. This ongoing effort involves participation from more than 30 U.S. and Mexican agencies at the local, state and federal levels to coordinate on border infrastructure projects and improvement strategies. As part of the 2021 BMP, a comprehensive list of innovative border improvement strategies documents various approaches to help manage the binational transportation system in the California-Baja California region. The goal of developing innovative strategies is to optimize the use of existing infrastructure and projects under development with a focus on innovative and multimodal strategies and to leverage technology where possible. Some of the objectives in the 2021 BMP innovative strategies that overlap with the improvement categories listed above include:

- Promote a mode shift from single occupant vehicles (SOV) to active transportation and transit;
- Provide safe and secure processing at the border and reduce wait times for all modes of border crossings;
- Improve the air quality in and around the border region;
- Coordinate binational operations and shared data;
- Provide accurate and timely information to the traveling public; and
- Provide high-speed connections to and from the border.

[9] https://dot.ca.gov/programs/transportation-planning/freight-planning/strategic-planning

2 Methodological Framework

Details of the air quality analysis methods, border crossing process, existing POE configurations, and the peer review process undertaken to refine the analysis, are discussed in Section 2 below.

2.1 Air Quality Analysis Methodology

The basic framework for land Port of Entry (POE) emissions analysis leveraged approaches developed for the U.S. Federal Highway Administration (FHWA) and the U.S. – Mexico Joint Working Committee on Transportation Planning in the United States-Mexico Land POE Emissions and Border Wait-Time Analysis Template (JWC template)[10]. A flowchart of the approach is provided as Figure 6. The process involves developing representative emission rates and then combining those rates with vehicle activity data for all the scenarios being analyzed. Differences between scenarios can then be quantified by contrasting the results from the emissions analysis.

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 compositing those emission rates into a form that can be applied directly to the border activity.

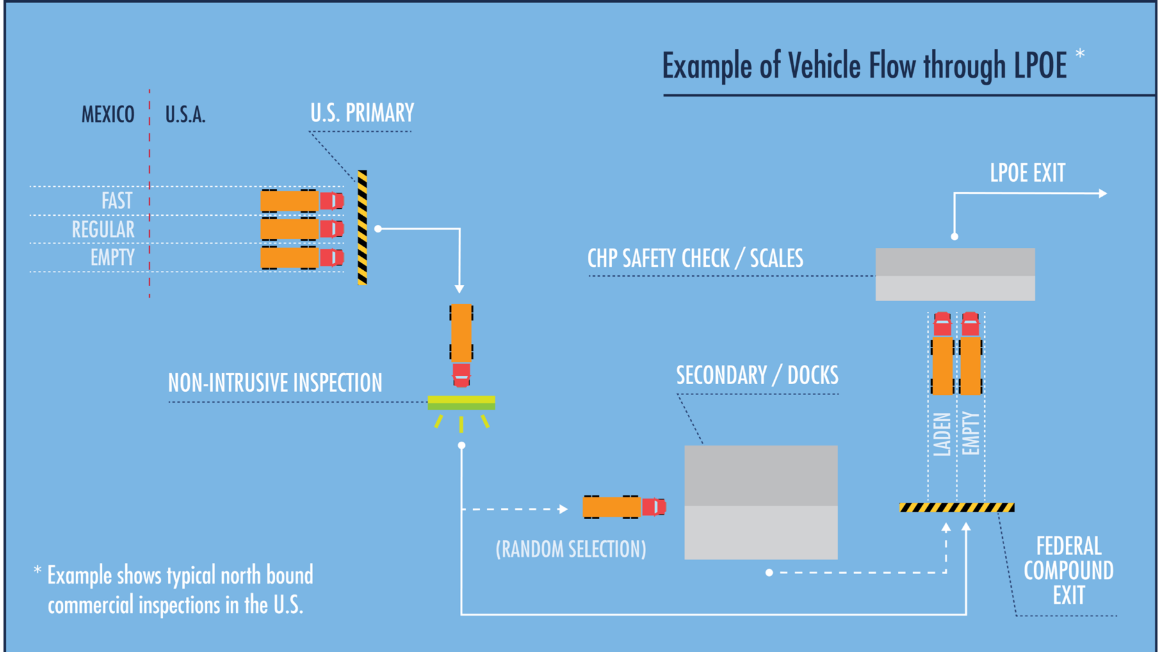
DEFINING VEHICLE BEHAVIOR AT PORTS-OF-ENTRY

The JWC template utilized detailed analysis of vehicle behavior through the use of a VISSIM[11] microsimulation model for both Bridge of the Americas and Ysleta-Zaragoza ports-of-entry in El Paso. Vehicle behavior was generated and aggregated in a manner intended to make it applicable to all U.S. – Mexico POEs. The analysis identified the difference between various 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. The JWC template parameterization of vehicle behavior was used in this study, no new VISSIM analysis was conducted.

[10] FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.
[11] VISSIM is a software package from PTV Group that enables the development and application of detailed traffic microsimulation models. Specific rules can be defined to mimic the distribution of time required for primary and secondary inspections of different types of vehicles and to mimic interactions between vehicles and vehicle-environment interactions.

Figure 6. Overview JWC Template Methodology

Emission Estimate Methodology Example for Land Port-of-Entry (LPOE)



EMISSIONS BY LANE TYPE = VEHICLE FLOW x EMISSION FACTORS x WEIGHTING FACTORS

VEHICLE FLOW

SPECIFIC TO INSPECTION STOPS			BETWEEN INSPECTIONS
Identifying lane types specific to each LPOE, which may include: COMMERCIAL: • FAST • Regular • Empty POV: • Regular • Ready • SENTRI	Identifying inspection stops specific to each LPOE, which may include: • Inspections within Aduanas • U.S. Primary • Non-intrusive inspection • Secondary inspection/docks • CHP safety check/scales • Future toll collection	Based on volumes and processing rates, identify and quantify vehicle behaviors associated with each individual inspection stop: • Stop and start queue • Creeping queue • Extended idle • Soak and restart • Free-flow driving	Identifying vehicle behaviors on roads between inspection stops, and identify queue spill-back with potential to block upcoming inspection stop(s).

EMISSION FACTORS

Obtain applicable emission factors specific to each **vehicle class**, **lane type**, **process**, **vehicle age**, **fuel type**, **inspection and maintenance programs**, etc., from MOVES, MOVES Mexico, and/or EMFAC.

WEIGHTING FACTORS

Weighting factors specific to each LPOE such as **lane type**, **processes**, **vehicle age**, **fuel type**, **time of day**, etc., derived from surveys, observations, and secondary sources.

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 used in development of the JWC Template, this activity was identified as travel on the links located at, or immediately upstream of, the primary inspection booths where the average speed over a five-minute period was below 10 miles per hour on both ends of the link. In practice, simulated speeds on links tagged as having stop-and-go queuing average less than 1 mile per hour.
- **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 used in development of the JWC Template, this activity was identified as travel on links where the average speed over a five-minute period was below 10 miles per hour on both ends of the link. 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 used in development of the JWC Template, this activity was identified as occurring on links where the average speed over a five-minute period was greater than 10 miles per hour on both ends of the link. 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 7 through Table 9 summarize representative vehicle speeds for use with the California Air Resources Board (CARB) EMFAC model and the U.S. Environmental Protection Agency (USEPA) MOVES model. Passenger vehicle-specific power (VSP) and commercial vehicle scaled tractive power (STP) profiles are detailed for use with the MOVES model. 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). EMFAC2017, which is utilized for this study, utilizes the average speed data at the bottom of each table. EMFAC2017, the emissions model used in this analysis, uses speed rather than VSP or STP to account for modal activity differences. Eight types of lanes are represented in the vehicle activity characterizations:

Table 7. Stop-and-Go Queue VSP Profiles

	VSP STP	Bin	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
1 to 25 mph	< 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
25 to 50 mph	< 0	21	–	–	–	–	0.000	–	–
	0-3	22	–	–	–	–	0.000	–	0.000
	3-6	23	–	–	–	0.000	0.000	–	0.000
	6-9	24	–	–	–	–	0.000	–	0.000
	9-12	25	–	–	–	–	–	–	–
	12-18	27	–	–	–	0.000	–	–	–
	18-24	28	–	–	0.000	–	0.000	–	–
	24-30	29	–	–	–	–	0.000	0.000	0.000
	30+	30	–	–	0.000	0.000	0.000	0.000	0.000
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			1	1	1	1	1	1	1

Source: FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.

Table 8. Creeping Queue VSP Profiles

	VSP STP	Bin	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
1 to 25 mph	< 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
25 to 50 mph	< 0	21	0.000	0.000	0.000	0.000	0.000	0.000	–
	0-3	22	–	0.000	–	–	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	–
	12-18	27	0.000	0.000	0.000	0.000	0.000	0.000	–
	18-24	28	–	0.000	0.000	0.000	0.000	0.000	–
	24-30	29	0.000	–	0.000	0.000	0.000	0.001	–
	30+	30	0.000	0.000	0.000	0.000	0.000	0.000	–
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			5	5	5	5	5	5	5

Source: FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.

Table 9. Uncongested Movement VSP Profiles

	VSP STP	Bin	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
1 to 25 mph	< 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
25 to 50 mph	< 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
50 + mph	< 6	33	–	–	–	–	–	–	–
	6-12	35	–	–	–	–	–	–	–
	12-18	37	–	–	–	–	–	–	–
	18-24	38	–	–	–	–	–	–	–
	24-30	39	–	–	–	–	–	–	–
	30+	40	–	–	–	–	–	–	–
Average Speed			30	30	30	25	35	35	35

Source: FHWA, United States-Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template. 2012.

1) Northbound FAST[12] commercial vehicles (laden),
2) Northbound unladen commercial vehicles,
3) Northbound laden commercial vehicles,
4) Southbound commercial vehicles (all types),
5) Northbound Regular lane passenger vehicles,
6) Northbound SENTRI[13] passenger vehicles,
7) Northbound Ready Lane passenger vehicles (represented by SENTRI), and
8) Southbound autos (all types)

Note that data for VSP distributions and average speeds for SENTRI lanes are assumed to represent the Ready Lane[14] VSP distributions and average speeds. This assumption has been used in multiple studies because both Ready Lanes and SENTRI lanes cater to regular border crossers, and vehicle activity data has never been parameterized for Ready Lane traffic.

Additional types of vehicle behavior that need to be quantified for the analysis consist of information about vehicles which are parked, idling, extended idling[15] or starting, when those activities do not occur on the roadway segments. In the case of most U.S. - Mexico border crossings, commercial vehicles stopping and restarting for inspections need to be accounted for outside of the queue and uncongested flow described above. As was the case for running emissions, off-network emissions estimates are developed as emission rates (start emissions in grams/start and extended idling in grams per hour) and are specific to soak times (i.e., specific start emission rates are developed for each specific soak). The soak times considered by EMFAC 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.

Within the context of border analysis, all soak periods are considered to be between six minutes and thirty minutes.

EMISSION FACTORS BY VEHICLE ACTIVITY

Emission rates for use with this analysis template are based on EMFAC2017. EMFAC produces detailed emission rate information that is subsequently combined into composite emission rates,

[12] Free and Secure Trade (FAST) program where drivers, vehicles, and cargo are pre-cleared for entry into the U.S.
[13] 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.
[14] Ready Lanes provide a dedicated lane for privately-owned vehicles entering the U.S. for vehicles whose occupants have Western Hemisphere Travel Initiative or WHTI-compliant, RFID-enabled cards approved by the Department of Homeland Security.
[15] Extended idle is used to power accessory loads such as air conditioning when a vehicle is parked.

through weighted averages. This section presents a discussion of background information and key underlying concepts for project-level emissions analysis. The parameters that have the greatest influence on vehicle emissions in queuing and congested operating situations are summarized below.

Vehicle Type

Vehicle classes based on EMFAC2017 classification systems, which are subsets of six Highway Performance Monitoring System (HPMS) vehicle classes, are used in this analysis. Characterization of border crossing vehicle data according to FHWA's HPMS classes is 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 come from the intercept surveys and visual observations performed by the consultant team at each POE. Data are aggregated into six vehicle classes that can readily be classified visually in the field.

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 EMFAC2017.

Specific age distributions were developed for the following classes:

- Passenger cars;
- Light duty trucks[16];
- Light commercial vehicles[17];
- Single unit short-haul commercial vehicles and combination short-haul commercial vehicles[18]; and
- Buses.

The EMFAC2017 model is designed for vehicles certified to California and U.S. emissions standards and uses vehicle age to determine which standard vehicles were certified to. Historically it has been important to distinguish between U.S. and Mexico certified vehicles and either map the Mexican vehicles to "technology groups" used by EMFAC, or make off-model adjustments to account for these Mexican fuel and fleet. Because California requires all commercial vehicles to comply with California standards for the same model year, this was only an issue for privately-owned vehicles. At California – Baja California POEs, the majority of Mexican domiciled vehicles were originally sold as new in the United States. Starting with EMFAC2017, the CARB no longer adjusts for Mexican certified vehicles. This analysis follows this new CARB practice and models all passenger vehicles as though they were certified to

[16] Including the EMFAC2017 LDT1 and LDT2 vehicle classes.
[17] Including the following EMFAC2017 vehicle classes: MDV, LHDT1, LHDT2, and MHDT.
[18] EMFAC2017 HHDT vehicle class.

California emission standards. However, Mexican gasoline is refined to a different standard than US and California reformulated fuel. Its higher aromatic compound content and higher Reid vapor pressure during the summer need to be accounted for. This has previously been done in related projects and a set of adjustments derived for application to the Mexican fuel and fleet (Table 10), which provides a multiplicative correction factor for the use of gasoline purchased in Baja California.

Table 10. Effect of Fuel Supply on Emissions

	Winter	Summer
Hydrocarbons (VOC or ROG)	1.6	2.5

Source: ICAPCD (2015) Vehicle Idling Emissions Study at Calexico East and Calexico West Ports-of-Entry, www.imperialctc.org/media/managed/pdf/Idling_Vehicle_Study_Calexico_POEs_Final_20151030_Study_only.pdf

Operating Mode

The JWC template provides for speed bins to be used to characterize the operating modes of vehicles. Detailed modal data and corresponding average speeds were presented in Table 7 through Table 9 above.

Fuel Formulation and Supply

A fuel correction was previously estimated (Table 10) for the formulation of Mexican gasoline. The adjustment was derived in MOVES, using fuel data from the San Diego and Tijuana[19] regions that had been developed for a related study. The corrections reflect the ratio of emissions calculated using the default EMFAC2014 (which assumed the same fuel characteristics as EMFAC2017) fuel formulation for San Diego; and a Tijuana fuel formulation based on data from the Alliance of Automobile Manufacturers North American Fuel Survey[20] . The fuel correction varies by season. Because of reduced Reid vapor pressure of California's reformulated summertime fuels, the relative difference between California and Mexico sourced fuel is much greater during the summer than during the winter. The percentage of fuel last purchased in each country were obtained from the at-border surveys for use with the adjustment factors in Table 10 above.

Inspection and Maintenance (I/M) Program

An adjustment for the Mexicali and Tijuana I/M programs was derived from EMFAC2014 and EMFAC2017. Baja California has phased in an I/M program that is as stringent or more stringent than the Enhanced California I/M program in San Diego, and much more stringent than the change of ownership I/M program for Imperial County. However, compliance rates are not yet known for the Baja California program. Therefore the Mexican inspection and maintenance program is assumed to yield similar benefits to the programs in neighboring U.S. counties.

[19] Tijuana and Mexicali fuel characteristics should be similar because both regions utilize fuel delivered through Ensenada; San Diego and Calexico both utilize California reformulated gasoline and are expected to have similar fuel characteristics,
[20] Alliance of Automobile Manufacturers, (07/2013, 01/2013, 01/2014, 07/2014) Alliance of Automobile Manufacturers North American Fuel Survey. 2014: http://www.autoalliance.org/index.cfm?objectid=6E64B9C0-40B5-11E3-8898000C296BA163.

COMPOSITE EMISSION RATES

Composite emission rates were generated by taking weighted averages with respect to time of day, fuel type, and vehicle class. This analysis performs emission calculations by hour and lane type. The vehicle class distribution and age distribution data discussed above are used to generate emission rates covering multi-hour periods (AM, midday, PM and overnight) for each lane type and activity type, at each POE.

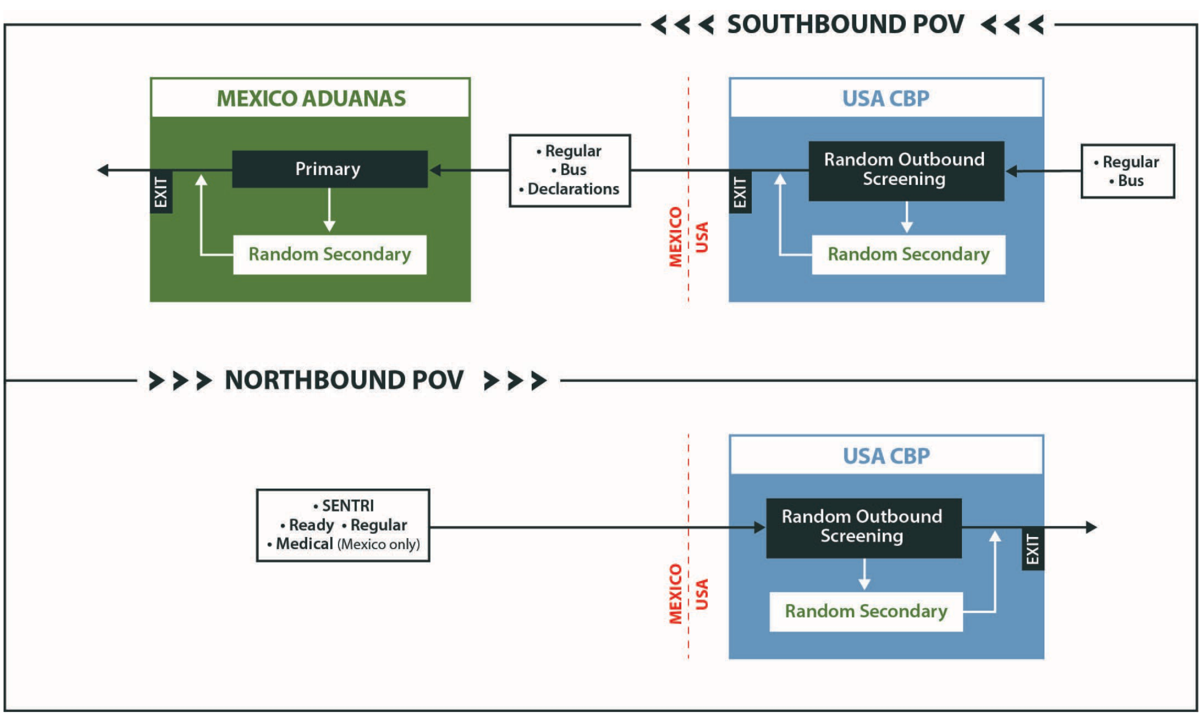
2.2 Port of Entry Crossing Process

This section provides a step by step overview of the process that commercial vehicles, privately-owned vehicles, and busses go through for northbound and southbound border crossings. The description helps identify the location and type of vehicle activity that must be analyzed to estimate emissions from the POE. These processes are adapted to fit the unique characteristics of each POE.

Privately Owned Vehicle Processes

The process for privately owned vehicles is much more streamlined than what is required of commercial shipments (discussed in the next section). Figure 7 provides a process flow chart for northbound and southbound privately-owned vehicles crossing the border, discussion follows the figure.

Figure 7. Northbound and Southbound Privately-owned Vehicle Crossing Process



NORTHBOUND PRIVATELY-OWNED VEHICLES

Northbound vehicles traveling from Mexico to the United States are not required to submit to inspection processes on the Mexican side. They queue to enter the CBP primary inspection booths. A secondary inspection area is located after the primary booths; only a fraction of vehicles is required to divert to the secondary area. As with commercial traffic, there are specific lane designations up to and in most cases through the primary booths:

- The Secure Electronic Network for Travelers Rapid Inspection (SENTRI) is a CBP program that allows expedited clearance for pre-approved, low-risk travelers upon arrival in the United States. It requires pre-screening and certification of the driver, vehicle, and any passengers, and all occupants must be in possession of their SENTRI cards at the time of entry into the United States. Applicants for the program undergo a rigorous background check and in-person interview before enrollment. SENTRI lanes typically offer the shortest border crossing lines and fastest processing times.
- READY Lane usage requires that all travelers have Western Hemisphere Travel Initiative (WHTI) compliant identification documents (such as a U.S. passport card; enhanced driver's license; enhanced tribal card; Trusted Traveler cards (NEXUS, SENTRI, Global Entry and FAST cards); the new enhanced permanent resident card, or new border crossing card). The WHTI-compliant identification allows for electronic identification of all passengers before the vehicle arrives at the CBP primary inspection booth, and thus faster processing. The type of lane that the medical lane merges with may limit eligibility (see description below).
- Regular lanes are applicable to all other vehicles. When the vehicle arrives at the CBP primary inspection booth an officer documents and screens all travelers.
- Medical lane “Fast Lane” program is a special lane for tourists and medical tourism for the exclusive use of visitors to Mexico that have patronized a participating business. This lane allows travelers to enter the border line at a designated entrance with a Fast Pass, cutting off a significant portion of the border line. A Mexican police officer will take the Fast Pass where the medical lane is entered. Because CBP does not recognize medical lanes, the lanes end just prior to crossing into the U.S. and vehicles are merged into other traffic lanes.

SOUTHBOUND PRIVATELY-OWNED VEHICLES.

As passenger vehicles head southbound into Mexico they are subject to outbound inspections by CBP at the entrance of the passenger vehicle portion of the POE. The enforcement times and percentage of vehicles inspected varies as the southbound inspections use a “pulse and surge” technique for outbound traffic [21, 22]. This procedure allows for immediate stand-down of outbound inspections to manage traffic flow departing the port of entry[23]. There are currently no designated “specialty” lanes in the U.S. approaching the border, and all lanes are considered regular lanes.

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[21] “Pulse and surge” operations are short durations that involve periodic outbound inspections followed by periods without inspections.
[22] Testimony of Commissioner Alan Bersin, U.S. Customs and Border Protection, in Senate Caucus on International Narcotics Control, "Money Laundering and Bulk Cash Smuggling Along the Southwest Border". 2011, CBP: http://www.dhs.gov/news/2011/03/09/testimony-commissioner-alan-bersin-us-customs-and-border-protection-senate-caucus.
[23] CBP, National Southwest Border Counter narcotics Strategy Implementation Update. 2010: White House: available at http://www.whitehouse.gov/sites/default/files/ondcp/policy-and-research/swb_implementation10_0.pdf.

As vehicles enter Mexico, they are subject to inspected by Mexican Aduanas. Aduanas operates two separate lanes types:

- Declaration lanes for travelers that need to obtain a Forma Migratoria Múltiple (FMM) tourist card, declare items being imported to Mexico, or any other interaction with Aduanas. Travelers using the declaration lanes park and enter the administration building to conduct their business.
- Non-declaration lanes for POVs that do not require tourist cards and are importing personal goods valued below a de minimis threshold. Vehicles approach automated booths and are given either a green light allowing them to pass or a red light directing them to a secondary inspection area.

Depending on the primary inspection, vehicles are either directed to exit the facility, or are sent to secondary inspection. Vehicles that are selected for a secondary inspection are identified both randomly and based on weight and vehicle characteristics collected at the automated inspection booth. The secondary inspections include more detailed reviews of both drivers and the vehicle. Upon completion of secondary inspection, these vehicles are then allowed to leave the facility.

Commercial Vehicle Processes

Because of the economic and regulatory setting for commercial traffic, cross border commercial trucking between California and Baja California is principally a drayage operation. Most Mexican domiciled tractors are restricted to circulation in the United States to a narrow commercial zone extending out to 20 miles from the border and are restricted from hauling anything but international cargo. Those constraints do not bind all commercial vehicles; for example, those with dual registration in both the U.S. and Mexico or U.S. owned and domiciled commercial vehicles. However, since commercial border crossings take several hours and require specialized experience to efficiently navigate Mexican Aduanas and U.S. Customs requirements, almost all commercial trucking is done as drayage. For example, during the three-year (October 2011-October 2014) FHWA/ Federal Motor Carrier Safety Administration (FMCSA) pilot program allowing certain Mexican carriers to operate farther into the United States, the busiest POE was Otay Mesa, where the pilot program amounted to less than 1% of border traffic[24]. Commercial truck shipments between the United States and Mexico use drayage tractors that pick up a trailer from a yard on one side of the border and then haul it over the border to another yard for transfer to a domestic carrier.

NORTHBOUND COMMERCIAL CROSSING

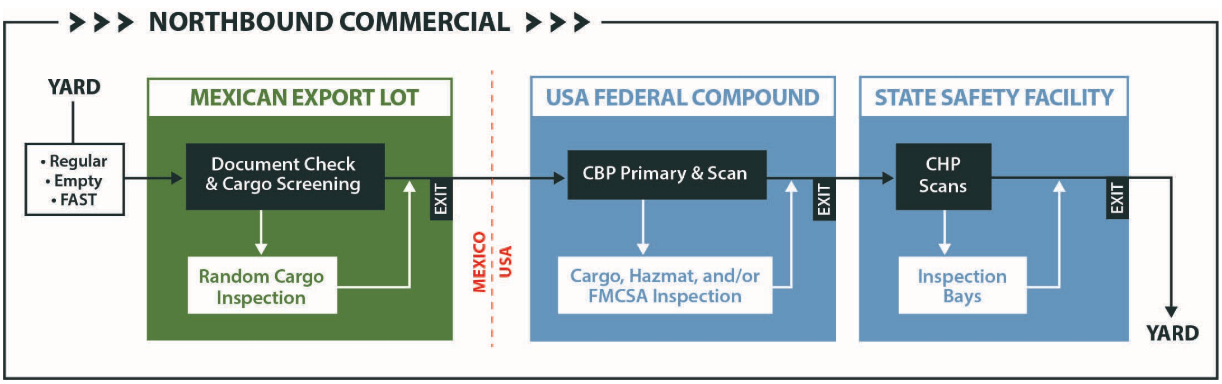
The typical northbound border-crossing process requires a shipper in Mexico to file shipment data with both Mexican and U.S. Federal agencies, prepare both paper and electronic forms, and use a drayage or transfer tractor to move the goods from Mexico to the United States. Once

[24] FMCSA (2015) United States-Mexico Cross-Border Long-Haul Trucking Pilot Program Report to Congress, https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/US-Mexico%20Cross-Border%20Long-Haul%20Trucking%20Pilot%20Program%20Report%20FINAL%20January%202015.pdf

the shipment is at the border with the drayage or transfer tractor and an authorized driver, the process flows through three main inspection areas (Figure 8)[25]:

- Mexican export lot,
- U.S. Federal compound, and,
- State of California inspection facility.

Figure 8. Northbound Commercial Crossing Process



At the Mexican export lot, an inbound gate screens drivers for the required documentation and directs a portion of the commercial truck traffic into the Mexican Customs (Aduanas) cargo inspection area. Aduanas does a random audit which can include nonintrusive inspection and/or physical inspection of the cargo. Commercial vehicles not selected for audit proceed to the exit gate and onto the border and the U.S. Federal compound. The inbound gate often differentiates between regular, empty, and “Free and Secure Trade” (FAST) vehicles and there may be approach lanes and/or booths dedicated to each.

Designating specific lanes to regular, empty, and FAST vehicles recognizes the differing levels of scrutiny and processing time required for each. The FAST program is a trusted traveler/trusted shipper program allowing expedited processing for commercial carriers who have completed background checks and fulfill certain eligibility requirements. Participation in FAST requires that every link in the supply chain, from manufacturer to carrier to driver to importer, is certified under the Customs-Trade Partnership Against Terrorism program. FAST lanes typically have a much higher through-put than the regular lanes. Similarly, empty commercial vehicles take less time to inspect and with nothing to declare can be processed through customs faster. For both northbound crossing and southbound crossings, empty commercial vehicles typically lock their rear doors open so that both Customs and Border Protection (CBP) and Aduanas officers easily verify that there is no cargo onboard.

Several U.S. agencies operate within the U.S. Federal Compound. At the CBP primary inspection booth, identification and shipment documentation is presented to the processing agent. The vehicle is also scanned by non-intrusive pylon mounted scanners as it passes through the primary inspection booth. The CBP inspector at the primary inspection booth uses a

[25] Adapted from FHWA (2012) Border-Wide Assessment of Intelligent Transportation Systems (ITS)Technology – Current and Future Concepts, Report FHWA-HOP-12-015.

computer terminal to crosscheck the information about the driver, vehicle, and cargo with information sent previously by the carrier via the CBP's Automated Cargo Environment (ACE) electronic manifest (e-Manifest). The CBP inspector then makes a decision to refer the commercial truck, driver, or cargo for a more detailed secondary inspection of any or all these elements, or alternatively releases the commercial truck to the exit gate. Loaded, empty, and FAST vehicles are differentiated and there are typically approach lanes and/or booths dedicated to each. The average processing time through the primary inspection booth and the cargo inspection area differs between the FAST, regular, and empty lanes.

Cargo inspection includes any inspection that the driver, cargo, or conveyance undergoes between the primary inspection and the exit gate of the U.S. Federal compound. These may include one or more non-intrusive scanners, or physical inspection of cargo and checks with other agencies staffing the U.S. Federal compound, including the U.S. Department of Agriculture (USDA), Food and Drug Administration (FDA), and the Federal Motor Carrier Safety Administration (FMCSA). Non-intrusive inspections include Pylon (for FAST vehicles), VACIS, Gantry, or Eagle inspections, all of which utilize some form of x-ray, gamma-ray, or similar scanning technology. VACIS inspections and Eagle inspections operate similarly. Commercial vehicles 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 commercial vehicles drive into, the driver exits, and the commercial 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. After the cargo inspection, commercial traffic then passes through an exit gate before proceeding to the State of California inspection facility. Shipments that include hazardous materials (HAZMAT) also undergo a HAZMAT inspection within the U.S. Federal compound.

The state of California inspection facility is located adjacent to the federal compound and is primarily operated by the California Highway Patrol (CHP). Officers weigh and inspect commercial vehicles to determine whether they comply with state standards and regulations. If their initial visual inspection finds any violation, they direct the commercial truck to proceed to a more detailed inspection at a special facility. The CARB randomly inspects and tests a portion of the commercial traffic to ensure that the vehicles comply with California's emission control regulations. The engine of any commercial truck operating in California must be certified to the same emissions criteria as a California registered commercial truck and emissions controls must be maintained and functioning.

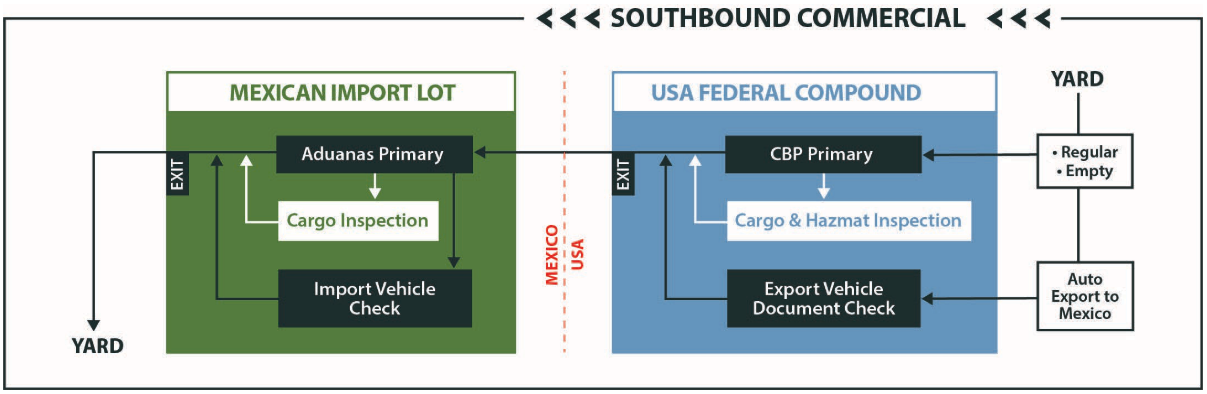
SOUTHBOUND COMMERCIAL CROSSING

No comprehensive description of the southbound commercial crossing process is publicly available. The best available data are the discussions of southbound commercial traffic from the technical appendices of the Joint Working Committee analysis template[26]. That discussion is not directly applicable to California. Additional input from Aduanas de Tijuana, gathered during a March 6, 2017 meeting at their Mesa de Otay POE augmented the prior literature to complete this description.

[26] FHWA (2012) United States – Mexico Land Ports-of-Entry Emissions and Border Wait-Time White Paper and Analysis Template: Task 3b Border Traffic characteristics.

Southbound commercial crossing processes are similar to the northbound crossings, but do not involve state safety inspections. The Aduanas process, within the Mexican import lot, is more involved than the Aduanas export process for northbound crossings. The typical southbound border-crossing requires a shipper to file shipment data with both U.S. and Mexican Federal agencies, and use a drayage or transfer tractor to move the goods from the United States to Mexico. Once the shipment is at the border with the drayage or transfer tractor and an authorized driver, the process involves clearance through both the U.S. Federal compound and the Mexican import lot (Figure 9):

Figure 9. Southbound Commercial Crossing Process



At the U.S. Federal compound, export shipments are routed into either the CBP cargo inspection area or to the exit gate and onto the Mexican import lot. The CBP export cargo inspection facilities have loading docks for the physical inspection of cargo, including HAZMAT. All commercial vehicles are subject to southbound inspections by CBP, though the majority of southbound shipments are cleared for export electronically before they arrive at the border and proceed directly to the exit gate from the U.S. federal compound. Empty and loaded commercial vehicles often have designated approach lanes and booths and can be subject to differing levels of scrutiny. Since 2009 CBP has had a more prevalent southbound inspection program to curb the flow of illegal weapons and money from the United States into Mexico. All shipments that include hazardous materials are subject to an additional inspection step to inventory the material and ensure that it's appropriately documented.

After exiting the U.S. facility, commercial vehicles enter the Mexican Secretariat of Communication and Transportation (SCT) and Aduanas facilities in the Mexican import lot. All commercial vehicles with HAZMAT and/or agricultural/biological cargo are subject to an initial inspection prior to the Aduanas entrance booth. At the entrance booth invoice papers are reviewed and stamped if the commercial truck destination is beyond the border commercial zone. Commercial vehicles are then subject to cargo inspection which includes a review of paperwork where the Mexican Import Pedimentos are checked against the versions filed electronically by the Mexican customs broker. For commercial vehicles for which paperwork is in order, a large majority (> 90 percent) proceed directly to the exit gate, while the remaining commercial vehicles are randomly selected for a more thorough physical inspection.

Used passenger vehicles are exported from the United States and imported to Mexico through the Calexico East and Otay Mesa commercial ports-of-entry. The process typically involves the use of both Mexican and U.S. customs brokers. Each vehicle from the U.S. must be exported from the U.S. before it is imported to Mexico, which requires the services of a customs broker on the U.S. side. Before the passenger vehicle arrives at the U.S. export cargo inspection area it needs to already have had CBP confirm its title and approve the export, otherwise the passenger vehicle will be held in the cargo inspection area while CBP verifies the vehicle title and ensures it is eligible for export, a process that can take a week or longer. Once cleared by CBP, the U.S. title for the vehicle is stamped as “EXPORTED” by CBP and the passenger vehicle proceeds to the Mexican import lot, where the vehicle’s eligibility for import is verified[27]. The Mexican customs broker will then pay import duties based on the type and age of the vehicle, as well as other taxes. It can take more than a day to complete this process, so there are areas to store passenger vehicles within the Aduanas cargo inspection area. In practice, vehicles being exported from the U.S. and imported to Mexico are batched together and processed on specific days. Both CBP and Aduanas designate specific lanes and booths through the Otay Mesa commercial port of entry for processing these passenger vehicles.

2.3 Port of Entry Layout

Figures for each port of entry, which identify the base year layout and document the number of available lanes, booths, and inspection areas are provided below along with a summary of each POE’s key attributes from the perspective of emissions modeling. The ports of entry are discussed in geographical order from San Ysidro in the west to Andrade in the east.

San Ysidro/Puerta México

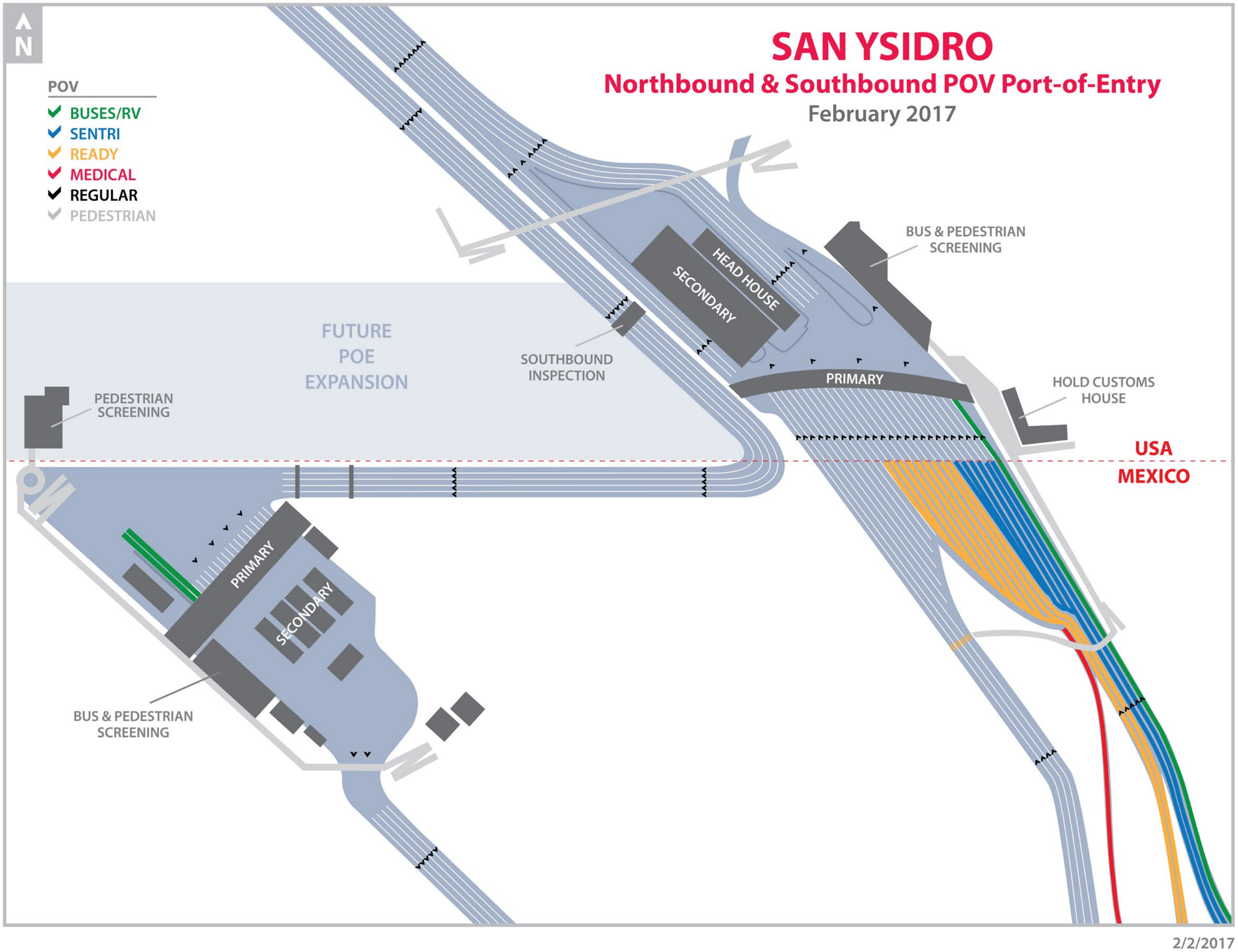
The San Ysidro/Puerta México POE forms the primary border crossing for privately-owned vehicles (POVs) and pedestrians traveling between San Diego, California and Tijuana, Baja California. San Ysidro/Virginia Avenue is the northbound border crossing located in the United States. Puerta México/El Chaparral is the southbound border crossing located in Mexico. Figure 10 provides a schematic representation of the two facilities, detailing the number and type of lanes approaching and crossing the border. In the base year, the San Ysidro POE layout had the following attributes:

- Up to 25 northbound privately-owned vehicle lanes, all but three of which have double stacked primary inspection booths;
- Up to 15 northbound pedestrian booths on the eastern edge of the port of entry and up to 14 northbound pedestrian booths on the west side of the port of entry;
- Up to 22 southbound inspection lanes, two of which are typically dedicated to declarations;
- NB buses utilize the right-most lane. Passengers must exit the bus at the border and be cleared for entry into the U.S. within the pedestrian facility, then re-board the bus in the

[27] There are specific rules based on vehicle age and country of origin (manufacture) limiting the import of used vehicles to Mexico, in addition the vehicle must comply with all safety and emissions control regulations from both the U.S. and Mexico, as well as having a current smog check.

United States. Vehicle scanners are available for buses entering the United States. The Aduanas secondary inspection area also includes vehicle scanners;

Figure 10. San Ysidro/Puerta México-Virginia Avenue/El Chaparral Port of Entry Layout



The specific number of vehicle lanes and booths that are open and dedicated SENTRI, Ready Lane, or regular traffic, changes continuously to manage security and inspection needs. The U.S. General Services Administration (GSA) oversaw a project to reconfigure and expand the San Ysidro POE which added additional northbound lanes and reconfigure the southbound approach within the United States. That decade long project was completed in 2019.

Otay Mesa/Mesa de Otay

The Otay Mesa/Mesa de Otay POE forms the primary border crossing for commercial traffic traveling between San Diego, California and Tijuana, Baja California, as well as additional capacity for privately-owned vehicles and pedestrians to cross the border. Figure 11 shows the northbound commercial port of entry facilities in Mexico and the U.S. Figure 12 provides the same information for the southbound commercial ports-of-entry and the privately-owned vehicle ports-of-entry. The lane geometry, location of primary, secondary, and cargo inspection facilities are all shown. Otay Mesa includes:

- Up to six northbound commercial lanes through the Mexican export lot feeding up to ten primary commercial inspection booths in the United States;
- Up to 13 northbound privately-owned vehicle lanes with one inspection booth per lane;
- Up to six northbound pedestrian booths on the eastern edge of the privately-owned vehicle port of entry;
- Up to four southbound commercial lanes exiting the United States, plus an additional lane (not shown) that is dedicated to the export of used vehicles from the United States to Mexico;
- Up to two southbound privately-owned vehicle lanes on the U.S. side of the border feeding approximately 15 primary inspection lanes in Mexico, one or two of which would be for declarations;
- Southbound pedestrians located on the western edge of the port of entry in Mexico and up to14 northbound pedestrian booths on the east side of the port of entry in the U.S.

The figure for each port of entry depicts typical lane configurations (e.g., FAST, SENTRI, Ready, regular, empty), but the actual configuration at any time will be set to best manage the security and inspection needs at those ports-of-entry.

Because of space limitations, the California commercial vehicle inspection facility (CVEF) is located about a half mile to the east of the commercial portion of the U.S. Federal Compound. Both the commercial portion of the U.S. Federal compound and State of California inspection facility are designed with a “race track” layout, designed for commercial vehicles to circulate near the perimeter of the facilities, with key infrastructure (i.e. scales, inspection bays and scanners) located in the center of the track.

Figure 11. Otay Mesa-Mesa de Otay Port of Entry Layout

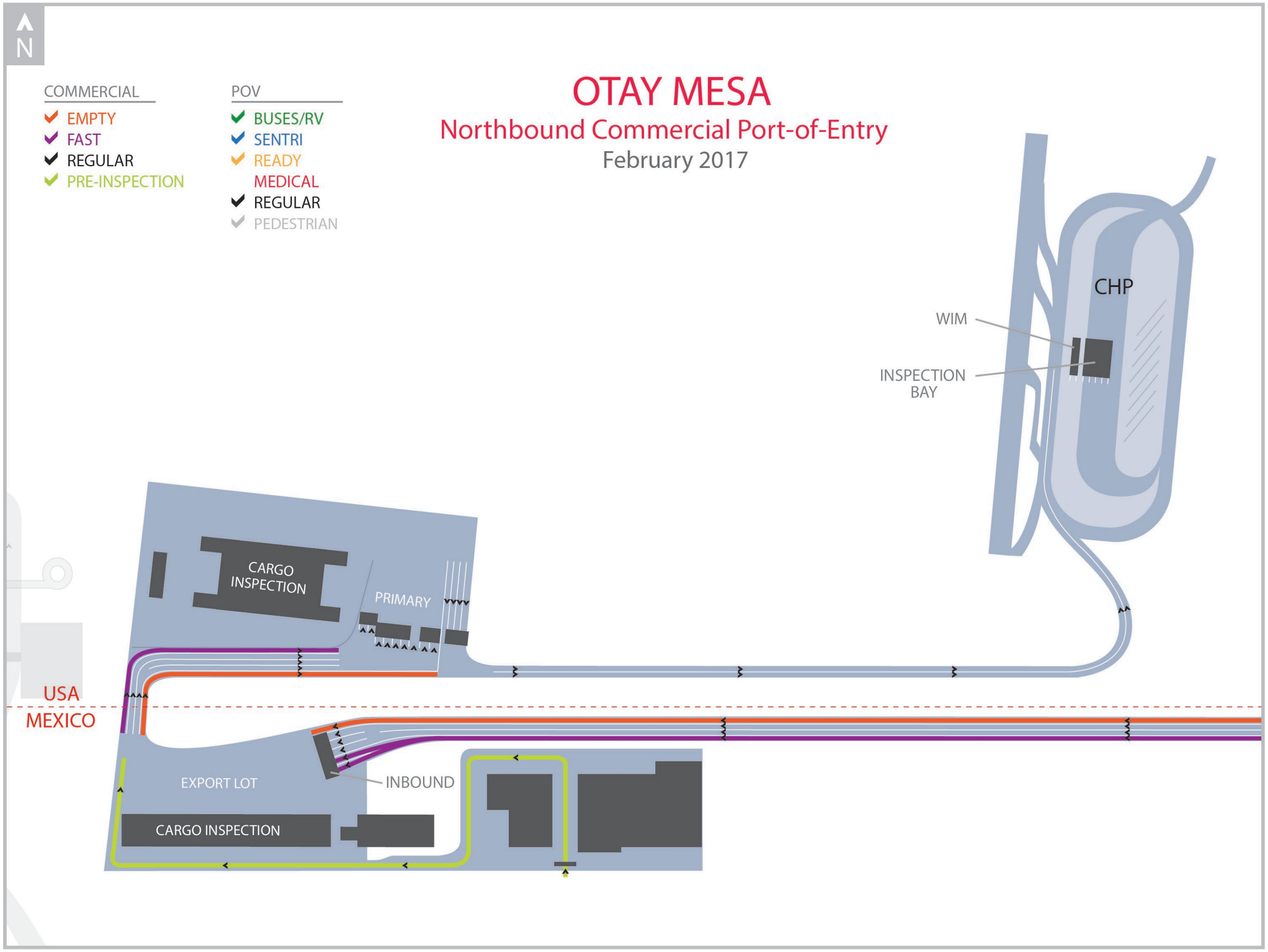
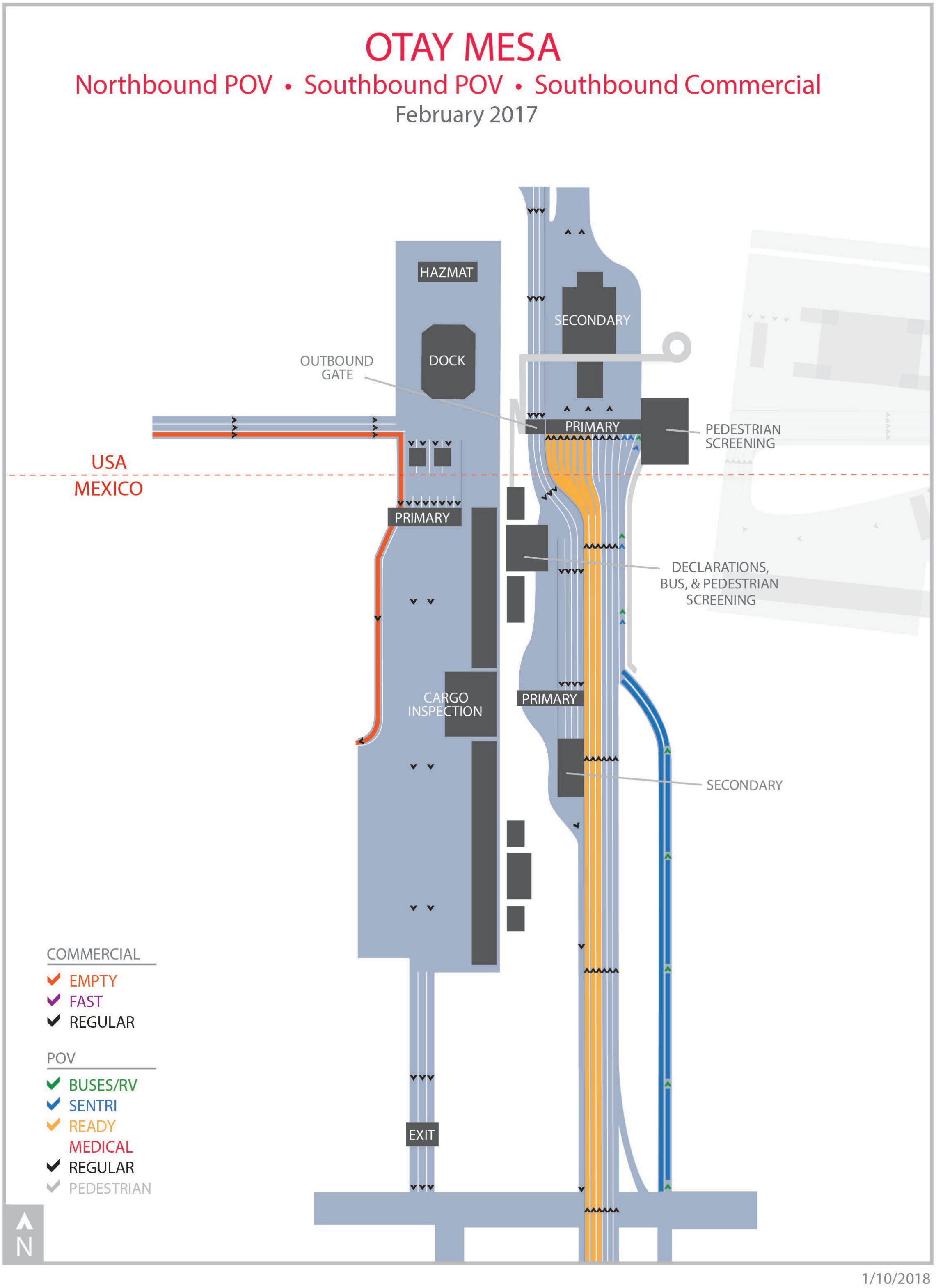


Figure 12. Otay Mesa/Mesa de Otay Port of Entry Layout



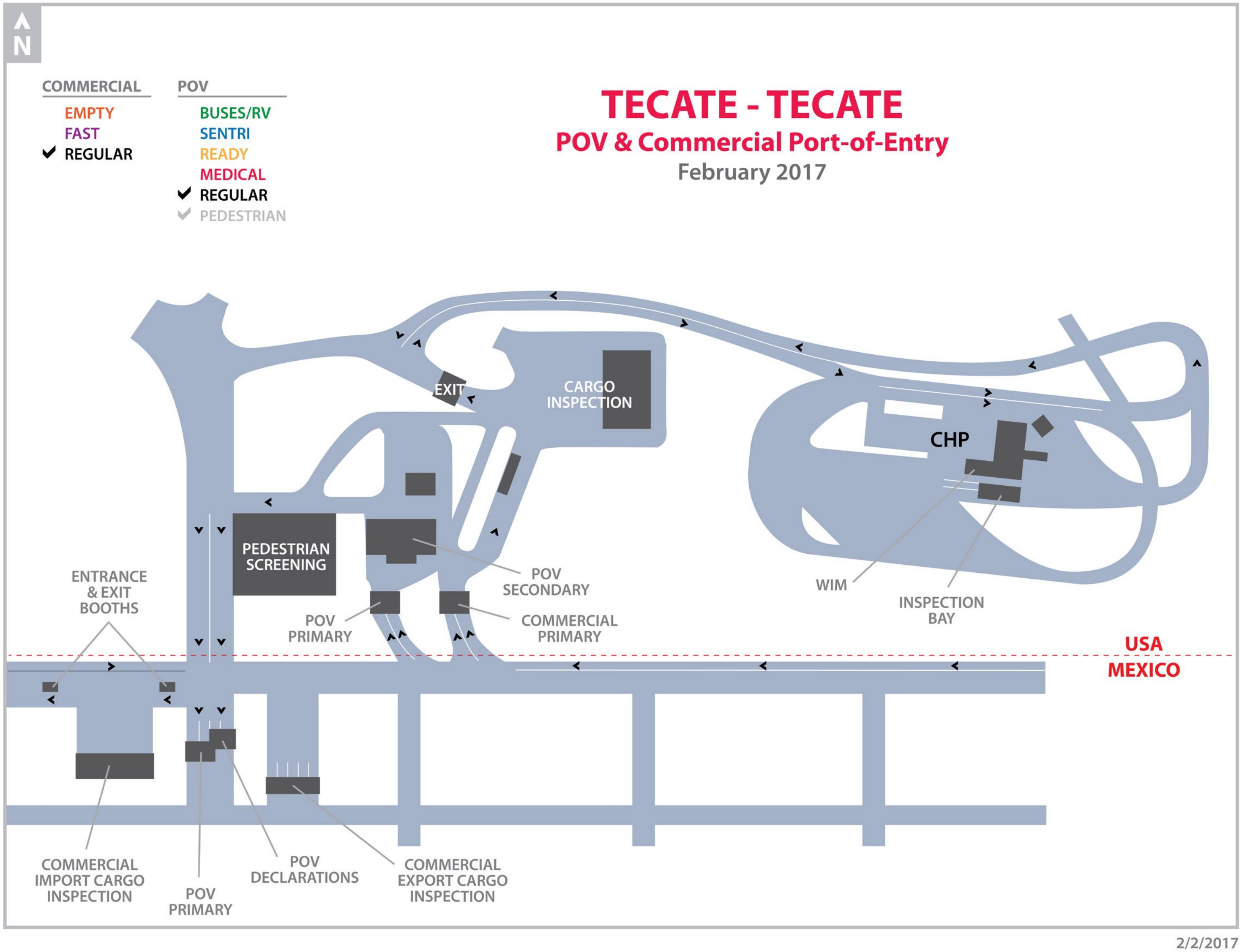
Tecate/Tecate

The Tecate port of entry is located east of the San Diego/Tijuana urban core and is a relatively small port of entry that serves both commercial, privately-owned vehicles, and pedestrians. Figure 13 provides the general layout of both the commercial and privately-owned vehicle port of entry facilities in both Mexico and the United States. The configuration includes:

- One northbound commercial lane through the Mexican export lot and up to two northbound commercial lanes entering the United States;
- Up to two northbound privately-owned vehicle lanes with one inspection booth per lane;
- Up to two northbound pedestrian booths;
- One southbound commercial lane through the U.S. Federal compound and Mexican import lot;
- One southbound privately-owned vehicle lane on the U.S. side of the border feeding up to four primary inspection lanes in Mexico;
- Southbound pedestrians located on the western edge of the port of entry and up to 14 northbound pedestrian booths on the west side of the port of entry.

All the commercial and privately-owned vehicle lanes at Tecate operate as regular lanes. Though not shown in the figure, when private vehicle traffic exceeds the capacity of the port of entry and commercial traffic is light, CBP can process privately-owned vehicles through the commercial portion of the port of entry. This capability is unique to Tecate.

Figure 13. Tecate/Tecate Port of Entry Layout



Calexico West/Mexicali Centro

A schematic showing Calexico West, known as Mexicali Centro in Mexico, is provided in Figure 14. Calexico West serves privately-owned vehicles (POVs), including recreational vehicles and vehicles towing trailers, as well as pedestrians. Buses and commercial vehicles exclusively use the Calexico East POE. The Calexico East POE is described later.

Calexico West has ten northbound primary inspection booths and traffic through those booths is divided into three different streams, two of which are merged together just before the POE. The traffic streams are:

- Regular POV lanes;
- SENTRI lanes; and
- A medical lane which is managed by the City of Mexicali to facilitate medical tourism by allowing eligible travelers to bypass most of the regular lane queue.

The vehicle inspection booths are typically configured so that up to three booths can service the SENTRI lane POVs, with the balance serving the regular lane POVs. Most traffic exits the Calexico West POE onto East 1st Street. POVs routed through secondary exit directly onto Imperial Avenue (SR 111). The secondary inspection area is located adjacent to the primary inspection booths.

There are also six northbound pedestrian booths.

Southbound traffic into Mexicali Centro has three lanes through the U.S. Federal compound feeding up to 11 primary inspection lanes in Mexico, an unknown number of which would be designated for declarations.

Calexico East/Mexicali II

Commercial vehicles and POVs have separate crossing facilities at Calexico East. Pedestrians also are processed at this POE. Figure 15 and Figure 16 provide a traffic flow schematic for both sets of crossings at the POE. The schematic is split across two figures. POV and commercial facilities are described separately.

CALEXICO EAST POV FACILITIES

The POV crossing consists of eight northbound inspection booths. Traffic through those booths is divided into three different vehicle streams:

- SENTRI lane POVs typically use the left most primary inspection booths, though additional lanes can be assigned to serve the SENTRI traffic as warranted.
- Regular POV traffic utilizes from one to three of the right most primary inspection booths. All busses utilize the right most lane so that passengers can debus and be individually cleared for entry into the United States. The bus and regular POV traffic is intermixed.
- Ready Lane traffic is served by one to five of the available booths in between the SENTRI and regular POV booths.
- Calexico East also includes up to four northbound pedestrian inspection booths.
- The number of southbound pedestrian inspection booths in Mexico is unknown.

Figure 14. Calexico West/Mexicali Centro Port of Entry Layout

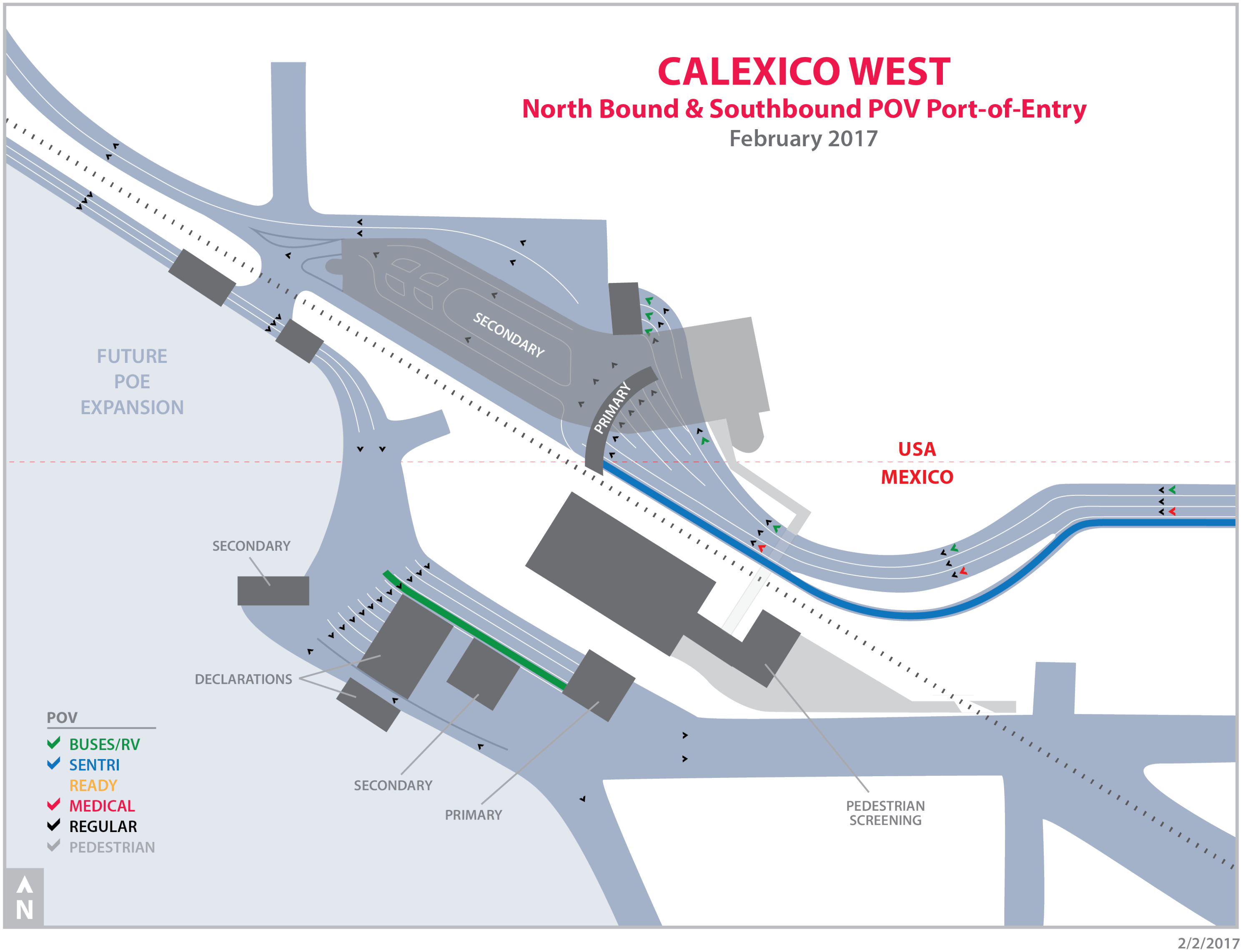


Figure 15. Calexico East Port of Entry Layout

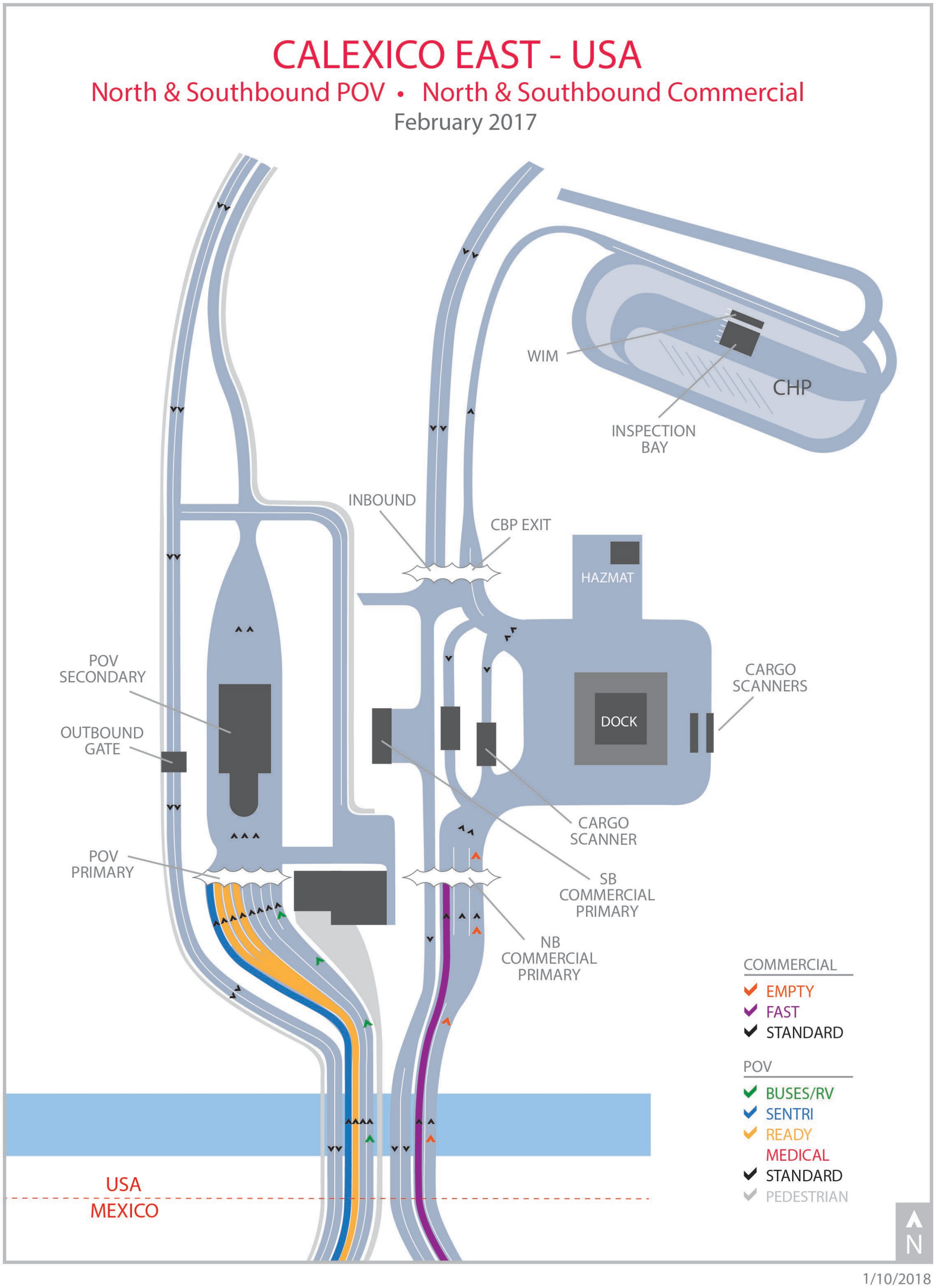
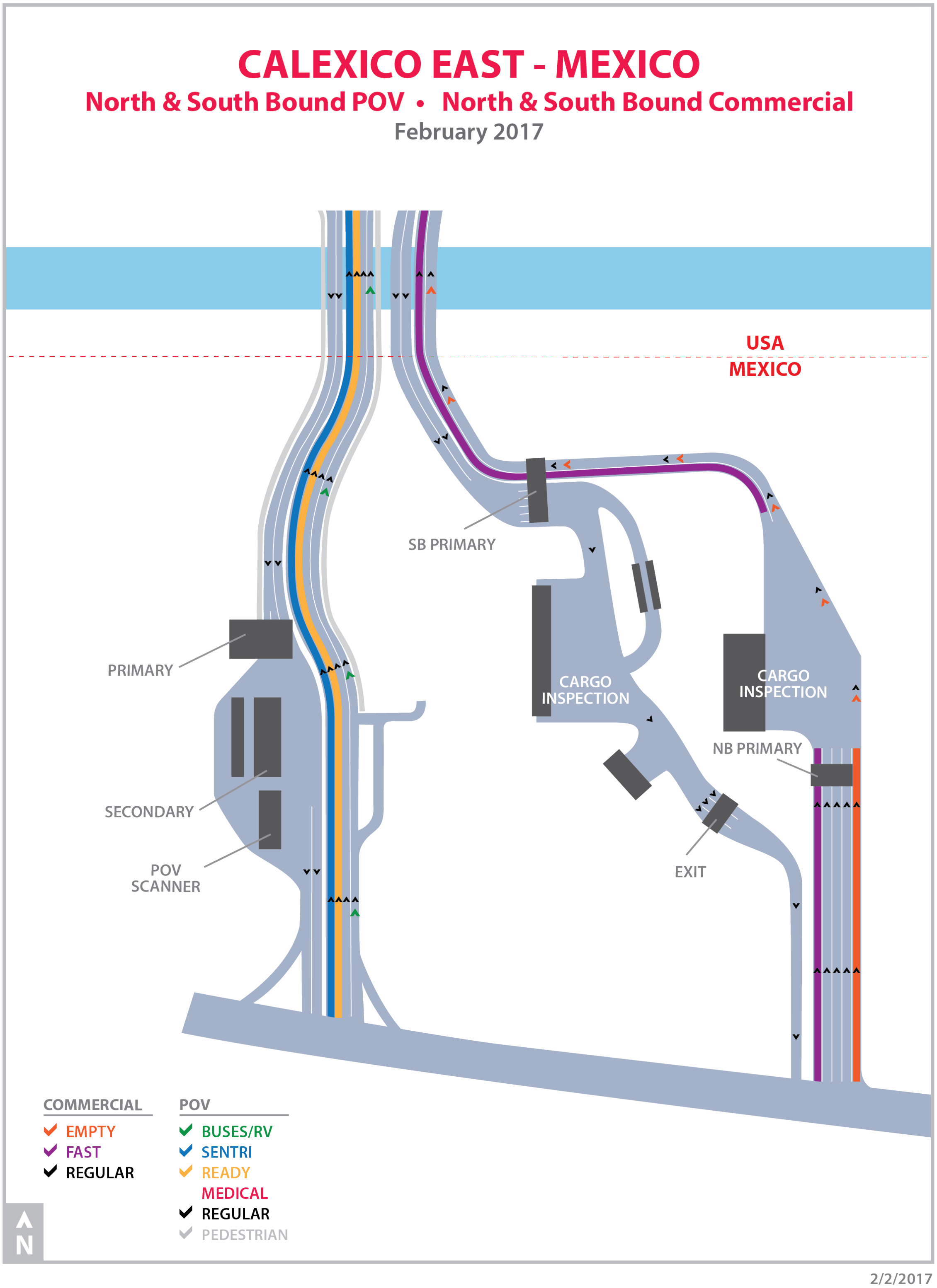


Figure 16. Mexicali II Port of Entry Layout



Ready Lane POV processing is only available at Calexico East, which makes it the most utilized border crossing program at the Calexico East POE. All the POV traffic exits around the secondary inspection area onto SR-7. Traffic exits the Calexico East POE onto SR-7. The secondary inspection area is located adjacent to the primary inspection booths.

Southbound privately-owned vehicles utilize two lanes to traverse the U.S. Federal compound, which is large enough to accommodate periodic southbound inspections on outgoing vehicles. Within the Mexican Aduanas portion of the facility there are four primary inspection lanes and a large declarations area. The secondary inspection area in Mexico also includes vehicle scanners.

CALEXICO EAST COMMERCIAL FACILITIES

As shown (Figure 15 and Figure 16) northbound commercial vehicles go through six different key clearance processes as they cross the border:

- Aduanas entrance booth;
- Aduanas cargo inspection area;
- CBP primary inspection booth;
- CBP cargo inspection area;
- CBP exit booth; and
- CHP scales and safety inspections.

At each booth that the commercial vehicle passes through, and at the CHP scales, there is the potential for queuing and idling. The U.S. Federal compound cargo inspection areas include VACIS and gantry non-intrusive scanners. A portion of vehicles are also referred to loading docks for physical inspection of the vehicle and cargo, which may require several hours.

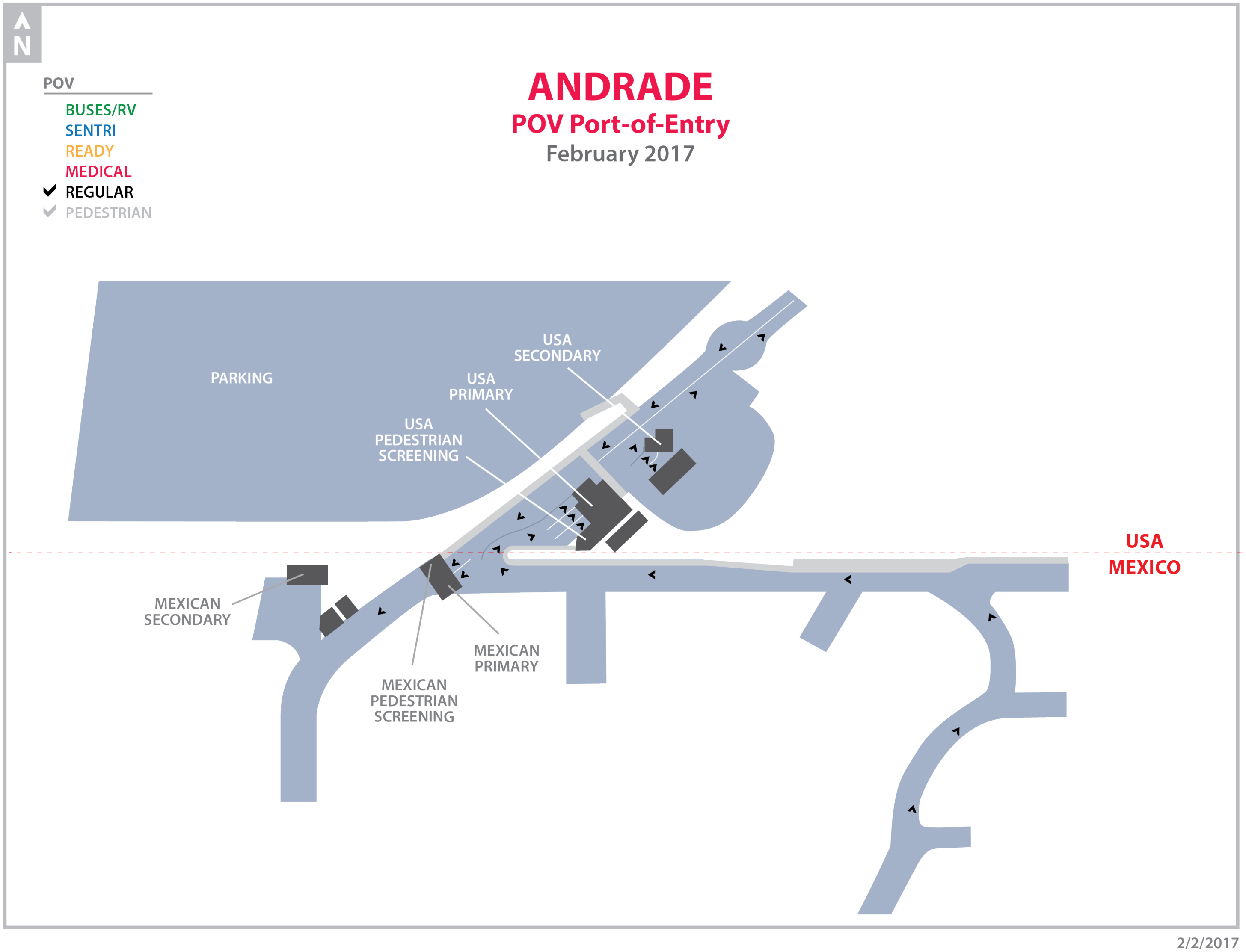
Southbound commercial traffic has up to two lanes entering the U.S. Federal compound and one lane exiting. There are up to six lanes entering the Mexican import lot, which would allow for separation of empty and regular commercial vehicles. The Aduanas cargo inspection area includes three non-intrusive vehicle scanners.

Andrade/Algodones

Andrade/Algodones (Figure 17) is a small port of entry complex on the eastern edge of California, adjacent to the Colorado River in the U.S. State of Arizona, and near the border between the Mexican Baja California and Sonora states. Northbound there is a single lane exiting Mexico which feeds into three POV lanes. Commercial vehicles are no longer processed at Andrade/Algodones. Southbound, there is a single lane for privately-owned vehicles exiting the United States and through the Mexican Aduanas area.

There are four northbound pedestrian inspection booths at Andrade/Algodones. The number of southbound pedestrian inspection booths in Mexico is unknown.

Figure 17. Andrade/Algodones Port of Entry Layout



2.4 Air Quality Methodology Peer-Review

This section documents the framework and outcomes from the February 16, 2017 emissions peer review roundtable covering proposed methods and data for the emissions analysis.

Goal

The goal of the emissions peer review roundtable was to propose and vet,, in collaboration with SANDAG, Caltrans, and ICTC, strategies to determine the necessary emission data and methodology to estimate particulate matter (PM), oxides of nitrogen (NO_x), reactive organic gases (ROG), carbon monoxide (CO), and greenhouse gas (GHG) emissions at the POEs due to cross-border passenger vehicle and commercial truck northbound and southbound delays.

Topics

The roundtable focused on the methodologies and data discussed in Sections 2.1 through 2.3 above.

- Scope of the analysis (annual average PM, NOx, ROG, CO, and GHG emissions).
- Overview of northbound and southbound border crossing process at each POE for both privately owned vehicles (POV) and commercial vehicles (trucks).
- The seasonal and daily variability of volumes and delay at each POE, seasonal effects (including fuel and temperature effects) on emission rates, and the identification of "design day" characteristics to estimate annual average emissions.
- Overview of the JWC analysis template.
- Discussion of the types of strategies that might be considered in the study and data being collected to address them.
- Current understanding of Baja California and California fuel formulations and impact on emissions.
- Current Mexican and US inspection and maintenance programs and their effect on emissions.
- Comparison of Mexican mileage accrual to assumptions in EMFAC2014 (EMFAC2014 was the current version of EMFAC at the time).

Logistics

The roundtable discussion and webinar was hosted at SANDAG offices on February 16, 2017, from 10 AM to 2 PM. A briefing package was distributed on February 8th. A webcast was provided for remote participants. The topics and agenda emphasized reaching consensus over technical and data issues, rather than detailing the specific strategies for analysis. Spanish-English translation services were provided both in the room and on the phone for those participating through the webcast.

The agenda included:

- Welcome and introductions.
- Overview of the project purpose, participating agencies, and consultant team. The purpose and need for the peer review roundtable and the significance of this work and input from participants.
- Review of the overall approach as detailed in the JWC template.
- Discuss the specific configuration and operational details of each port of entry, along with the border crossing process for northbound and southbound travelers.
- Review of the EMFAC and MOVES emissions models, and the types of data required as input to ensure that appropriate emission rates are estimated.
- Brainstorm strategies, policies, and projects that the study might consider as recommendations to reduce emissions at the ports-of-entry. (Note that the specific strategies, policies, and projects to be tested were selected in coordination with the economic portion of the study by SANDAG, ICTC, and Caltrans.)

Email invitations were distributed in English and Spanish on January 24th, 2017. Along with copies of the preliminary methodology and links to the JWC Template online. Attendees at the emissions peer review roundtable are listed in Table 11 below.

Table 11. Roundtable Participants

Group Category	Group/Organization	Participant Name	Location
U.S. Local Agencies	Imperial County Air Pollution Control District (ICAPCD)	Belen Lopez	Webcast
		Matt Dessert	Webcast
	San Diego County Air Pollution Control District (SDCAPCD)	David Shina	Webcast
		Laura Shield	Webcast
		Nick Cormier	Webcast
U.S. State Agencies	California Air Resources Board (CARB)	Vernon Hughes	Webcast
U.S. Federal Agencies	FHWA Office of Planning	Sylvia Grijalva	Webcast
	U.S. Customs and Border Protection (CBP)	Amy Archibald	SANDAG
		Carlos Rodriguez	SANDAG
		Sally Carrillo	SANDAG
	USEPA Border Liaison Office	Jeremy Bauer	SANDAG
U.S. Academics	San Diego State University (SDSU)	Jenny Quintana	SANDAG
		Paul Ganster	SANDAG
	University of California, Davis - Department of Civil and Environmental Engineering	Deb Niemeier	Webcast
Mexico State Agencies	Secretaría de Infraestructura y Desarrollo Urbano Del Estado (SIDUE)	Carlos López Rodríguez	SANDAG
		Karlo Limon	SANDAG
		Victor Rangel	SANDAG
	Secretaría de Protección al Ambiente de Baja California (SPA)	Margarito Quintero Nuñez	Webcast

Table 11. Roundtable Participants (Continued)

Group Category	Group/Organization	Participant Name	Location
Mexico Federal Agencies	Consulate of Mexico (San Diego)	Hon Rafael Laveaga Rendón (Represented by Guadalupe Leyva)	SANDAG
	Secretaria De Medio Ambiente Y Recursos Naturales (SEMARNAT)	Daniel López Vicuña	Webcast
		Judith Trujillo Machado	Webcast
		Rodrigo Perrusquía Máximo	Webcast
Mexico Academics	El Colegio de la Frontera Norte (COLEF) - Departamento de Estudios Urbanos y del Medio Ambiente	Tito Alegría Olazábal	Webcast
	Universidad Autónoma de Baja California (UABC) - Instituto de Ingeniería	Marco Antonio Reyna Carranza	Webcast
Project Study Team	Caltrans	Ilene Gallo	SANDAG
		Maurice Eaton	SANDAG
		Sergio Pallares	SANDAG
	ICTC	Mark Baza	SANDAG
		Virginia Mendoza	SANDAG
	SANDAG	Elisa Arias	SANDAG
		Hector Vanegas	SANDAG
		Marcial Gutierrez	SANDAG
		Muggs Stoll	SANDAG
		Rachel Kennedy	SANDAG
		Sanchita Mukherjee	SANDAG
		Wu Sun	SANDAG
		Zach Hernandez	SANDAG
Consultant Team	HDR	Alejandro Solis	SANDAG
	T. Kear Transportation Planning and Management	Susan Kear	Webcast
		Tom Kear	SANDAG

Discussion and Outcomes

Questions and discussion occurred both during the peer review round table, and through follow-up discussions.

- Several questions related to the development of vehicle activity profiles for the JWC template came up during the peer review roundtable, including questions about the application of microsimulation, the representation of different lane types and process, differentiation by vehicle classes, and sources of data. TKTPM described and clarified that VISSIM micro-simulation models were used characterize process specific vehicle activity during development of the JWC template, and the resulting tool was then used to characterize how vehicle activity differed by lane type and vehicle class. The resulting data, regarding vehicle speed and instantaneous power demand, is applicable across all ports-of-entry. It was also clarified that the analysis is conducted for each type of lane and process. There was discussion of POE specific activity. Both TKTPM and HDR went into detail regarding onsite primary data collection, public secondary data sources, and how those data are combined and utilized to support both the emissions and the economic analysis for this study. These sources include data collected through at-border surveys conducted for this study and recent San Ysidro and Calexico studies. It was also explained that there are areas and processes within the POEs for which security measures do not allow any data to be made available, and that reasonable representations of those processes are incorporated into the analysis such that the predicted delay and queues matched observed average and peak delay and queues.

- The section of the roundtable focusing on POE configuration and operations was initiated with a description of what is required for privately-owned and commercial vehicles to cross the border, combined with preliminary diagrams documenting how each lane-type approaches, and passes through, the ports-of-entry along with the location of inspection processes. Questions came up regarding the location of traffic and exposure to POE emissions in adjacent neighborhoods. The consultant team noted that the queue lengths are accounted for in the emission estimates, but that the study considers emissions, not concentration and exposure to, those emissions.

- During discussion of the emission factor models questions and discussion focused on: how period level data will be disaggregated to hourly data, the correlation between black carbon emissions and PM2.5 emissions as modeled by this study, and how vehicle type distributions are developed for the POEs. The Project Study Team decided to retain the analysis of PM2.5 emissions and not to add black carbon to the list of pollutants being analyzed. TKTPM explained that traffic flows were derived from control totals, such as Bureau of Transportation Statistics (BTS) Border Crossing/Entry Data, and disaggregated based on primary data such as onsite traffic counts, and secondary data such as PeMS sensors and data provided by CBP and the California Highway Patrol. HDR explained that the direct observations were gathered for peak and off-peak travel seasons, 2-4 days per season, for each type of observation. TKTPM noted that a statistical target of a 90 percent confidence rate at the 10 percent level (i.e., having 90 percent confidence in identifying a 10 percent difference as statistically significant), is typically met for key variables.

- Potential strategies that this study will evaluate for reducing delays are selected by the Project Study Team. This portion of the discussion focused on some of the types of strategies that might be included. One question that came up was if the cause of delays would be identified. HDR and TKTPM clarified that while the study modeled the delay, specific causal effects would not necessarily be identified and that doing so was not part of this study. There was specific interest in consideration of increased POE staffing to ensure that infrastructure is fully utilized, along with better coordination between federal, state, and local agencies to implement high impact low cost actions, and remove bottlenecks.

Several additional comments and questions were received (and addressed) via email:

- USEPA's Border Liaison office suggested that the study consider additional peer review as the model and reports were completed, as well as sensitivity checks. The potential for consideration of induced demand was also discussed in their comment. The SR-11 model under development for the Otay Mesa East POE will be used by SANDAG to forecast typical daily volumes at San Ysidro and Otay Mesa, with HDR extrapolating those data to other POEs (Version 2.0, February 12, 2018). Analysis of induced demand is limited to what those tools consider. Additional peer review and sensitivity tests are not funded at this time.

- USEPA Office of Transportation Air Quality (OTAQ) commented on the limitations and potential challenges of using the MOVES model to estimate emission factors for vehicles certified, domiciled, and/or fueled in Mexico. This study uses the EMFAC2017 model, with off-model adjustments to estimate emission factors for those vehicles.

- UABC noted that the historic center of border cities in Mexico are closely located to the older POE. Because there are numerous trips between the POE and the urban centers, a percentage of the POE emissions could be attributed to the urban centers. It was also noted that solutions need to address both politics and infrastructure. With specific recommendations for unified cargo processing (joint CBP/Aduanas cargo inspections), and improved coordination between pedestrian facilities and transit. The Project Steering Committee did not choose to include unified cargo processing in this study, but may consider it in the future as additional data become available from the Nogales POE and the Otay Mesa pilot project. Transit improvements are being analyzed but it is outside the scope of this study to look at specific changes.

- There were also a handful of technical questions, and requests for supporting documentation and calculation detail, and comments suggesting additional data to consider.

Another outcome of the emissions roundtable were follow-up meetings with Aduanas and CBP regarding operational details at the POEs. Meetings were held on March 6, 2017 (Aduanas), and March 15, 2017 (CBP). The agencies clarified details regarding the processes of some types of commercial shipments, and how buses and bus passengers cross the border. Some approximate throughput and processing data was also shared to improve the modeling of emissions resulting from secondary inspections.

3 Analysis Scenarios

Volume 1 of this report describes the analysis scenarios and traffic forecasting methodologies in detail. Some if that information is repeated here.

3.1 Overview of Conceptual Scenarios for Emissions Analysis

The future conceptual scenarios for emissions analyzed as part of this study are defined for each border sub-region (i.e., San Diego County-Tijuana/Tecate and Imperial County-Mexicali), POE, and year of analysis. Baseline 2016 represents existing conditions. Conceptual scenarios for future years and both sub-regions are summarized based on the following characteristics:

- **Baseline 2025 Scenario:** One scenario that includes limited improvement to border-crossing capacity without the Otay Mesa East (OME) POE. This scenario is estimated for all currently existing POEs.
- **Baseline 2025 Scenario Plus Capacity Enhancements, Transit and Active Transportation Scenario:** One scenario considering significant border crossing capacity improvements such as the additional 5x5 POE at Otay Mesa East, improvements at existing POEs like Calexico East with the expansion of the All-American Canal bridge, as well as transit and bicycle/pedestrian access improvements in the vicinity of POEs.
- **Baseline 2035 Scenario Plus Capacity Enhancements, Transit and Active Transportation Scenarios:** Two scenarios considering significant border crossing capacity improvements, transit, and bicycle/pedestrian access improvements as described for 2025 in the previous bullet. There is one scenario for a 5x5 POE at Otay Mesa East, and one for a 10x10 POE at Otay Mesa East.

The conceptual scenarios match the mode types available for each land POE. Broadly, each POE has a baseline scenario that represents existing border-crossing volumes and circumstances. For all the POEs (except Andrade) the baseline includes some planned improvements. San Ysidro and Otay Mesa POEs have additional baseline scenarios that include the existence of the Otay Mesa East (OME) POE. Similarly, Calexico West and East POEs have baseline scenarios that incorporate capacity improvements at the All-American Canal. For each of the four largest POEs (San Ysidro, Otay Mesa, Calexico West, and Calexico East) there is a scenario that includes enhanced transit service and bike and pedestrian access improvements, designated as Transit and Active Transportation scenarios.

For the economic and emissions analyses, the conceptual scenarios comprise the most likely growth in traffic volumes for 2025. The emissions analysis also considers 2035 as a year to be analyzed, and the economic analysis additionally considers a sensitivity scenario with a +/-10 percent change in crossing volumes and/or wait-times, to represent changes in policies, level of economic activity, or other factors. A tabular explanation of the scenarios and sensitivity analysis utilized in this project is presented in Table 12. Specific assumptions used to reflect capacity enhancements are detailed in the footnote to Table 12.

Table 12. Conceptual Scenarios for Economic and Emissions Analyses

<table>
<tr><th rowspan="3">POE</th><th>Scenario</th><th colspan="2">Scenario 1: Most Likely Growth Traffic Volume</th><th>Scenario 2: Sensitivity Analysis</th></tr>
<tr><th>Forecast Year</th><th>2025</th><th>2035</th><th>2025</th></tr>
<tr><th>Type of Analysis</th><th>Economic and Emissions</th><th>Emissions</th><th>Economic</th></tr>
<tr><td rowspan="3">San Ysidro</td><td>Baseline</td><td>Existing + Phase 3 improvements[28] (without Otay Mesa East)</td><td></td><td rowspan="6">Baseline plus Capacity Enhancements and Transit and Active Transportation Scenario for all POEs: Sensitivity analysis of a plus or minus 10 percent change in crossing volumes and/or wait times (due to changes in policies, level of economic activity, or other factors).[29]</td></tr>
<tr><td>Baseline Plus Capacity Enhancements and Transit and Active Transportation</td><td>Existing + Phase 3 improvements, Tijuana BRT[30], bike/pedestrian access improvements[31] (with Otay Mesa East in a 5x5 configuration)</td><td>Existing + Phase 3 improvements, Tijuana BRT, bike/pedestrian access improvements (with Otay Mesa East in a 5x5 configuration)</td></tr>
<tr><td>Baseline Plus Capacity Enhancements and Transit and Active Transportation</td><td></td><td>Existing + Phase 3 improvements, Tijuana BRT, bike/pedestrian access improvements (with Otay Mesa East in a 10x10 configuration)</td></tr>
<tr><td rowspan="3">Otay Mesa</td><td>Baseline</td><td>Existing + southbound electronic commercial clearance[32], Otay Mesa Commercial Modernization[33] (without Otay Mesa East)</td><td></td></tr>
<tr><td>Baseline plus Capacity Enhancements and Transit and Active Transportation</td><td>Existing + Otay Mesa Pedestrian Modernization[34], enhanced transit service[35], bike/pedestrian access improvements (with Otay Mesa East in a 5x5 configuration)</td><td>Existing + Otay Mesa Pedestrian Modernization, enhanced transit service, bike/pedestrian access improvements (with Otay Mesa East in a 5x5 configuration)</td></tr>
<tr><td>Baseline plus Capacity Enhancements and Transit and Active Transportation</td><td></td><td>Existing + Otay Mesa Pedestrian Modernization, enhanced transit service, bike/pedestrian access improvements (with Otay Mesa East in a 10x10 configuration)</td></tr>
</table>

[28] Phase 3 improvements at San Ysidro include the addition of 10 southbound POV lanes with additional southbound primary inspection booths and 8 northbound POV lanes with 15 additional northbound inspection booths. This work was completed in 2019. *Source: General Services Administration*
[29] This refers to changes in CBP staff vehicle processing rates at the POEs and is represented by a change in the processing rates in the SR 11 Binational Travel Demand Model.
[30] Tijuana BRT is a public bus service in Tijuana operated by Sistema Integral de Transporte de Tijuana (SITT). One route serves communities between the southern terminus along Bulevar Simon Bolivar and the San Ysidro POE, and the second route connects the southern terminus along Bulevar Simon Bolivar with the Otay Mesa POE. *Source: SITT*
[31] Bike/pedestrian access improvements include completion of planned bike and pedestrian facilities connecting to the POEs identified in the Imperial County Transportation Commission's Pedestrian and Bicycle Transportation Access Study (2015). In addition, in San Ysidro this includes the Border to Bayshore Bikeway which will construct a bike route connecting the San Ysidro POE to the City of Imperial Beach through the community of San Ysidro.
[32] Southbound electronic commercial clearance refers to expedited processing for the Mexican import cargo (U.S. export shipments) as part of Aduanas' PITA program.
[33] Otay Mesa Commercial Modernization refers to a General Services Administration (GSA) led effort to renovate and expand commercial facilities at the Otay Mesa POE, including 6 additional commercial processing booths and other related improvements. *Source: General Services Administration*
[34] Otay Mesa Pedestrian Modernization refers to a GSA led effort to renovate and expand pedestrian facilities at the Otay Mesa POE. The construction is expected to include 6 additional pedestrian processing lanes and other related improvements. *Source: General Services Administration*
[35] Enhanced transit service refers to increased frequencies in existing services or newly implemented services, e.g. South Bay Rapid bus service connecting Otay Mesa POE with Downtown San Diego via eastern Chula Vista.

Table 12 (continued). Conceptual Scenarios for Economic and Emissions Analyses

POE	Scenario	Scenario 1: Most Likely Growth Traffic Volume		Scenario 2: Sensitivity Analysis
	Forecast Year	2025	2035	2025
	Type of Analysis	Economic and Emissions	Emissions	Economic
Otay Mesa East	Baseline plus Capacity Enhancements and Transit and Active Transportation	Proposed Otay Mesa East facility in an 5x5 configuration + southbound electronic commercial clearance	Proposed Otay Mesa East facility in an 5x5 configuration + southbound electronic commercial clearance	Baseline plus Capacity Enhancements and Transit and Active Transportation Scenario for all POEs (description above).
	Baseline plus Capacity Enhancements and Transit and Active Transportation		Proposed Otay Mesa East facility in an 10x10 configuration + southbound electronic commercial clearance	
Tecate	Baseline	Existing + southbound electronic commercial clearance (with Otay Mesa East)	Existing + southbound electronic commercial clearance (with Otay Mesa East)	
Calexico West	Baseline	Existing + Phase 1 improvements[36]		Baseline Scenario for all POEs: Sensitivity analysis of a plus or minus 10 percent change in crossing volumes and/or wait times (due to changes in policies, level of economic activity, or other factors).
	With All American Canal	Phase 1 and 2 improvements[37], plus Calexico East with expanded bridge over the All-American Canal[38]		
	Transit and Active Transportation	Phase 1 and 2 improvements, plus Calexico East with expanded bridge over the All-American Canal, enhanced transit service[39], bike/pedestrian access improvements[40]	Phase 1 and 2 improvements, plus Calexico East with expanded bridge over the All-American Canal, enhanced transit service, bike/pedestrian access improvements	

[36] Phase 1 improvements at Calexico West include the addition of 5 southbound POV lanes and a southbound bridge over the New River as well as 10 northbound POV lanes. This work was completed in 2018. *Source:* *General Services Administration*

[37] Phase 2 improvements at Calexico West include a new pedestrian processing facility, 5 additional southbound POV lanes and 6 additional northbound POV lanes. This phase is currently unfunded but expected to be constructed by the corresponding analysis year (2025).

[38] "Expanded bridge over the All-American Canal" is part of proposed improvements to increase capacity at the Calexico East POE. Envisioned expansion comprises 2 additional northbound POV lanes and 2 additional northbound commercial lanes. The bridge expansion component is proposed to address the current bottleneck observed over this section of the approach road. These improvements are expected to be constructed before 2025. *Source: California Transportation Commission*

[39] Enhanced transit service refers to increased frequencies in existing services or newly implemented services connecting to Imperial County POEs.

[40] Bike/pedestrian access improvements at Imperial County POEs include completion of planned bike and pedestrian facilities connecting to the POEs identified in the Pedestrian and Bicycle Transportation Access Study (Imperial County Transportation Commission, 2015).

Table 12 (continued). Conceptual Scenarios for Economic and Emissions Analyses

POE	Scenario	Scenario 1: Most Likely Growth Traffic Volume		Scenario 2: Sensitivity Analysis
	Forecast Year	2025	2035	2025
	Type of Analysis	Economic and Emissions	Emissions	Economic
Calexico East	Baseline	Existing + Phase 1 improvements at Calexico West, and southbound electronic commercial clearance	Existing + Phase 1 improvements at Calexico West, and southbound electronic commercial clearance	Baseline Scenario for all POEs: Sensitivity analysis of a plus or minus 10 percent change in crossing volumes and/or wait times (due to changes in policies, level of economic activity, or other factors).
	With All American Canal	Existing + expanded bridge over the All-American Canal, additional 3 commercial primary booths and 6 additional POV primary booths, Phase 1 improvements at Calexico West, and southbound electronic commercial clearance	Existing + expanded bridge over the All-American Canal, additional 3 commercial primary booths and 6 additional POV primary booths, Phase 1 improvements at Calexico West, and southbound electronic commercial clearance	
	Transit and Active Transportation	Existing + expanded bridge over the All-American Canal, Phase 1 improvements at Calexico West, enhanced transit service, and bike/pedestrian access improvements	Existing + expanded bridge over the All-American Canal, Phase 1 improvements at Calexico West, enhanced transit service, and bike/pedestrian access improvements	
Andrade	Baseline	Existing	Existing	

4 Summary Statistics for Key Air Quality Variables

In addition to the summary statistics prepared for the study (Volume 1), vehicle fleet and fuel source data were analyzed in more detail to support application of the EMFAC2017 model. The SPSS software package was used for all statistical analysis. The presentation of the analysis here assumes that those interested in these data understand general linear regression models and logistic regression models. However, the results, consisting of tables and descriptions of vehicle class distributions, age distribution, odometer distributions, vehicle domicile data, the percentage of vehicles running on U.S. and Mexican fuel, and gasoline/diesel proportion of the fleet, can all be read without knowledge of the underlying statistics.

4.1 POV Vehicle Class Analysis

Multinomial logistic regression models are used to identify statistically significant variations in the mix of vehicle classes across lane types and POEs. For passenger vehicles, the model was constructed using a forward stepwise approach by county (San Diego and Imperial) considering:

- Lane type (SENTRI, Ready, Regular)
- Domicile (United States, Mexico),
- POE (each POE in the County),
- All second order terms (i.e. lane type x domicile, lane type x POE; and domicile x POE)

POV vehicles are grouped into three classes

- LDA – Light-duty autos.
- LDDT1 – Light-duty truck 1, with an “equivalent test weight” (ETW) of not more than 3,750 lbs.
- LDT2 and MDV – Light-duty truck 2 and medium-duty vehicles, with ETW greater than 3,750 lbs. and a gross vehicle weight rating (GVWR) that is not more than 8,500 lbs.

The model was built stepwise forward after a stepwise backward test identified singularities in the Hessian matrix, which indicates that assumptions regarding the lack of collinearity between terms are violated when fitting a full model.

For San Diego County, at the 5% confidence level, the final model reduced to two covariates, domicile and lane type, as the only significant independent variables (Table 13). However, a check of the parameter estimates (Table 14) indicates that the effect of the POE is only significant for San Ysidro, and that Otay Mesa and Tecate data can be combined.

For Imperial County, at the 5% confidence level, the multinomial logit model reduces to domicile as the only statistically significant independent variable, allowing vehicle class data from all lane types and POEs to be combined for a larger sample size. Table 15 below shows likelihood ratio tests demonstrating that POE and lane type can be dropped.

Table 13. Test of lane type and POE significance in modeling variability in vehicle class distribution (San Diego County)

Likelihood Ratio Tests[a]

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
Domicile	92.624	8.572	2	.014
LPOE	142.552	58.499	4	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.
a. San Diego or Imperial = San Diego

Table 14. Multinomial logit model parameters for vehicle class (San Diego County)

Parameter Estimates[a]

Class Recode[b]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B): Lower Bound	Upper Bound
LDA	[Domicile=1]	.495	.284	3.025	1	.082	1.640	.939	2.864
	[Domicile=2]	.833	.256	10.586	1	.001	2.300	1.393	3.798
	[LPOE=1]	.639	.273	5.466	1	.019	1.895	1.109	3.238
	[LPOE=2]	-.070	.272	.067	1	.796	.932	.547	1.589
	[LPOE=3]	0[c]	.	.	0	.	.	.	.
LDT1	[Domicile=1]	.591	.291	4.130	1	.042	1.806	1.021	3.196
	[Domicile=2]	.697	.261	7.127	1	.008	2.008	1.204	3.351
	[LPOE=1]	.026	.281	.009	1	.926	1.026	.591	1.782
	[LPOE=2]	-.059	.278	.046	1	.831	.942	.547	1.624
	[LPOE=3]	0[c]	.	.	0	.	.	.	.

a. San Diego or Imperial = San Diego
b. The reference category is: LDT2 and MDV.
c. This parameter is set to zero because it is redundant.

Table 15. Test of lane type and POE significance in modeling variability in vehicle class distribution

Likelihood Ratio Tests[a]

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
Lane	179.942	8.245	4	.083
Domicile	179.556	7.859	2	.020
LPOE	230.322	58.625	4	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.
a. San Diego or Imperial = San Diego

The resulting vehicle class mix data is therefore binned by domicile, and by San Ysidro, Otay Mesa plus Tecate, and combined Imperial County POEs. The U.S. Fleet differences between San Diego County POEs were observed to be virtually identical, with the obvious differences between POEs being limited to the Mexico fleet. This relates more to the effect size of the model parameter rather than statistical significance. It is not uncommon to have statistically significant covariates that have small effects. The resulting vehicle class data is shown in Table 16.

Table 16. Vehicle Class Distribution by LPOE (Adjusted Estimates)

	San Ysidro LPOE		Otay Mesa/Tecate LPOEs		Imperial County LPOEs	
	US Fleet	MX Fleet	US Fleet	MX Fleet	US Fleet	MX Fleet
LDA	43.6%	61.6%	43.6%	39.8%	59.3%	61.9%
LDT1	36.0%	25.5%	36.0%	39.8%	21.8%	24.6%
LDT2 & MDV	20.4%	12.9%	20.4%	20.4%	18.9%	13.5%

Fuel source and domicile data were then estimated using the same stratification of POEs. Resulting fuel source (Mexico and U.S.) and domicile estimates are shown in Table 17 and Table 18. Binary logistic regression was used to refine binning of fuel source and domicile, though not relied upon.

Table 17. Mexican fuel use by lane type

	San Ysidro								Otay Mesa/Tecate								Imperial County			
	SENTRI Lane		Ready Lane		Regular Lane		Southbound		SENTRI Lane		Ready Lane		Regular Lane		Southbound		All Northbound Lanes		Southbound	
	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet	U.S. Fleet	Mex Fleet
Mexico Gasoline	17.5%	47.8%	30.5%	62.2%	19.4%	69.4%	23.0%	58.2%	15.1%	44.2%	17%	54.5%	23.8%	54.2%	18.4%	52.3%	16.2%	59.7%	16.2%	59.7%
U.S. Gasoline	82.5%	52.2%	69.5%	37.8%	80.6%	30.6%	77.0%	41.8%	84.9%	55.8%	83%	45.5%	79.7%	45.8%	81.6%	47.7%	83.8%	40.3%	83.8%	40.3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 18. Mexican and US domicile by lane type

	San Ysidro			Otay Mesa/Tecate			Imperial County		
	SENTRI And Ready Lane	Regular Lane	Southbound	SENTRI and Ready Lane	Regular Lane	Southbound	SENTRI and Ready Lane	Regular Lane	Southbound
Mexico Domicile	81.2%	52.0%	74.6%	77.2%	56.8%	70.9%	77.3%	57.5%	65.7%
U.S. Domicile	18.8%	48.0%	25.4%	22.8%	43.2%	29.1%	22.7%	42.5%	34.3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Given the propensity for the Mexican POV fleet to use Mexican fuel, and the U.S. vehicle fleet to use U.S. (i.e., California) fuel, a qualitative assessment of how this data would affect results is be presented with the emissions data.

4.2 POV Age Distribution Analysis

General linear models were used to identify statistically significant variations in vehicle age distribution across lane types and POEs. For passenger vehicles, the general linear model considers first and second order terms, and takes the form:

Model:	age= (class) (lane) (domicile) (class*lane) (class*POE) (class*domicile) (lane*POE) (lane*domicile) (POE*domicile)
Where:	Age = Expected age Class=LDA, LDT1, LDT2 +MDV Lane = Regular, ready, SENTRI Domicile=United States, Mexico

Models were fit for each POE group (San Ysidro, Otay Mesa + Tecate-, and combined Imperial County) identified in the vehicle class distributions above. Results (Table 19) indicated that all covariates are statistically significant at the 5% level.

Table 19. Test of covariates in general linear model for vehicle age

Tests of Between-Subjects Effects[a]

Dependent Variable: Model Year

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Model	4381565142.940[b]	14	312968938.781	7113522.944	.000
Lane	1189.475	2	594.738	13.518	.000
R_Class	996.938	2	498.469	11.330	.000
Domicile	1.543	1	1.543	.035	.852
Domicile * Lane	79.852	2	39.926	.907	.404
Domicile * R_Class	37.241	2	18.621	.423	.655
Lane * R_Class	55.006	4	13.752	.313	.870
Error	47296.060	1075	43.996		
Total	4381612439.000	1089			

a. Grouping for Class Cross classification table = San Ysidro
b. R Squared = 1.000 (Adjusted R Squared = 1.000)

However, a check of the parameter estimates (Table 20) and effect size shows that lane type explains nearly 100% of the variability, with other effects explaining only about 0.1% to 0.2% of the difference between age distributions (see partial Eta Squared statistic)

Table 20. General linear model parameters for POV age (San Ysidro POE)

Parameter Estimates[a]

Dependent Variable: Model Year

Parameter	B	Std. Error	T	Sig.	95% Confidence Lower	95% Confidence Upper	Partial Eta Squared
[Lane=6]	2006.392	1.029	1950.23	.000	2004.374	2008.411	1.000
[Lane=7]	2003.114	.900	2226.11	.000	2001.348	2004.880	1.000
[Lane=8]	2001.488	1.275	1570.06	.000	1998.987	2003.990	1.000
[R_Class=1]	4.000	1.345	2.974	.003	1.360	6.639	.008
[R_Class=2]	1.901	1.459	1.303	.193	-.962	4.764	.002
[R_Class=3]	0[b]	.	.	.	.	.	.
[Domicile=1]	1.485	1.345	1.104	.270	-1.155	4.124	.001
[Domicile=2]	0[b]	.	.	.	.	.	.
[Domicile=1] * [Lane=6]	-1.593	1.242	-1.282	.200	-4.030	.844	.002
[Domicile=1] * [Lane=7]	-.971	1.097	-.886	.376	-3.123	1.180	.001
[Domicile=1] * [Lane=8]	0[b]	.	.	.	.	.	.
[Domicile=2] * [Lane=6]	0[b]	.	.	.	.	.	.
[Domicile=2] * [Lane=7]	0[b]	.	.	.	.	.	.
[Domicile=2] * [Lane=8]	0[b]	.	.	.	.	.	.
[Domicile=1] * [R_Class=1]	-1.265	1.375	-.920	.358	-3.963	1.434	.001
[Domicile=1] * [R_Class=2]	-.928	1.449	-.640	.522	-3.770	1.915	.000
[Domicile=1] * [R_Class=3]	0[b]	.	.	.	.	.	.
[Domicile=2] * [R_Class=1]	0[b]	.	.	.	.	.	.
[Domicile=2] * [R_Class=2]	0[b]	.	.	.	.	.	.
[Domicile=2] * [R_Class=3]	0[b]	.	.	.	.	.	.
[Lane=6] * [R_Class=1]	-1.441	1.595	-.903	.367	-4.571	1.689	.001
[Lane=6] * [R_Class=2]	-.757	1.746	-.433	.665	-4.183	2.670	.000
[Lane=6] * [R_Class=3]	0[b]	.	.	.	.	.	.
[Lane=7] * [R_Class=1]	-.463	1.544	-.300	.764	-3.493	2.566	.000
[Lane=7] * [R_Class=2]	-.683	1.655	-.413	.680	-3.931	2.565	.000
[Lane=7] * [R_Class=3]	0[b]	.	.	.	.	.	.
[Lane=8] * [R_Class=1]	0[b]	.	.	.	.	.	.
[Lane=8] * [R_Class=2]	0[b]	.	.	.	.	.	.
[Lane=8] * [R_Class=3]	0[b]	.	.	.	.	.	.

a. Grouping for Class Crossclassification table = San Ysidro

b. This parameter is set to zero because it is redundant.

Model tests for POV age at Otay Mesa plus Tecate, and the combined Imperial County POEs mirror those from San Ysidro. Therefore, vehicle age for POVs was binned by lane type for each San Ysidro, Otay Mesa, plus Tecate, and the combined Imperial County POEs. The resulting age distributions are shown in Table 21.

Table 21. POV age distribution by LPOE and lane type

Age	San Ysidro				Otay Mesa and Tecate				Imperial County			
	SENTRI	Ready	Regular	SB	SENTRI	Ready	Regular	SB	SENTRI	Ready	Regular	SB
0	5.56%	3.62%	4.06%	3.68%	4.01%	0.25%	3.39%	1.93%	4.94%	7.60%	6.25%	6.20%
1	8.17%	5.43%	4.93%	5.31%	4.68%	1.72%	3.55%	2.85%	9.52%	7.60%	4.26%	6.64%
2	6.21%	3.85%	5.80%	4.30%	4.35%	1.48%	1.42%	2.05%	5.88%	4.56%	4.40%	4.87%
3	6.21%	1.81%	3.77%	3.33%	3.34%	0.74%	2.87%	1.89%	5.87%	3.80%	3.51%	4.28%
4	5.88%	3.62%	2.32%	4.28%	6.69%	3.69%	4.11%	4.42%	5.99%	3.80%	2.90%	4.04%
5	6.21%	2.04%	4.35%	3.59%	3.01%	1.72%	1.83%	2.01%	3.27%	1.90%	2.25%	2.47%
6	10.44%	7.69%	3.19%	6.93%	8.39%	4.19%	2.01%	4.42%	8.38%	6.46%	5.36%	6.52%
7	4.25%	3.85%	3.48%	3.88%	3.01%	4.68%	1.97%	3.55%	7.95%	3.04%	4.02%	4.94%
8	7.52%	9.05%	6.66%	7.36%	4.68%	7.39%	4.07%	5.88%	4.39%	4.56%	4.84%	4.64%
9	3.92%	3.85%	3.19%	4.21%	5.35%	5.17%	4.38%	4.98%	4.26%	3.42%	4.86%	4.33%
10	4.25%	5.43%	2.32%	5.07%	6.35%	8.36%	4.11%	6.72%	4.52%	5.70%	6.76%	5.84%
11	8.17%	10.15%	5.80%	8.12%	5.69%	7.14%	10.35%	7.74%	6.74%	10.70%	7.83%	8.18%
12	4.25%	3.17%	4.06%	4.47%	7.36%	5.17%	5.65%	5.76%	2.76%	3.80%	4.97%	4.03%
13	3.27%	4.07%	5.51%	4.35%	3.34%	5.91%	6.17%	5.46%	4.50%	7.22%	4.75%	5.29%
14	1.63%	4.52%	4.93%	4.55%	5.02%	7.39%	8.27%	7.16%	3.03%	4.56%	4.95%	4.28%
15	3.27%	4.30%	6.07%	4.47%	6.69%	4.68%	4.94%	5.17%	2.76%	2.28%	5.80%	4.03%
16	1.63%	6.11%	6.94%	4.83%	5.02%	5.67%	4.88%	5.31%	5.38%	3.42%	6.99%	5.63%
17	1.63%	4.98%	3.48%	3.75%	4.35%	4.68%	6.39%	5.11%	2.37%	1.52%	2.77%	2.35%
18	2.29%	3.39%	4.06%	3.13%	1.00%	4.43%	3.33%	3.41%	2.50%	3.80%	3.56%	3.31%
19	0.33%	1.36%	3.77%	1.96%	0.67%	3.94%	3.24%	3.07%	0.13%	1.14%	2.42%	1.43%
20	0.65%	1.36%	2.32%	1.64%	1.34%	2.96%	2.16%	2.40%	1.12%	2.28%	1.37%	1.52%
21	0.33%	1.81%	2.90%	1.64%	1.34%	2.22%	1.83%	1.93%	0.76%		1.24%	0.79%
22	1.31%	0.68%	0.58%	1.02%	1.00%	1.48%	1.08%	1.27%	0.99%	1.52%	0.57%	0.93%
23	0.65%	0.68%	1.45%	0.89%		1.48%	0.90%	1.01%		1.90%	0.32%	0.62%
24		1.13%	0.58%	0.64%	0.33%	0.74%	1.94%	1.00%	0.99%	1.14%	0.36%	0.74%
25	0.65%	0.23%	0.58%	0.53%	0.33%	0.74%	0.90%	0.70%			0.28%	0.13%
26	0.33%	0.68%	1.16%	0.62%		0.74%	0.71%	0.58%		1.52%	0.74%	0.72%
27		0.45%	0.58%	0.32%	0.67%	0.25%	0.18%	0.32%		0.38%	0.19%	0.18%
28	0.33%	0.23%	0.29%	0.28%	0.33%		0.56%	0.23%		0.38%		0.09%
29	0.33%			0.15%		0.25%	0.86%	0.38%	0.50%		0.19%	0.23%
30				0.12%	0.33%	0.49%	0.18%	0.37%			0.39%	0.18%
31	0.33%			0.13%			0.37%	0.11%				
32				0.08%	1.00%		0.18%	0.26%			0.39%	0.18%
33				0.04%		0.25%		0.13%				
34												
35							0.34%	0.10%	0.50%			0.15%
36			0.29%	0.08%	0.33%		0.18%	0.12%				
37				0.02%			0.18%	0.05%				
38											0.19%	0.09%
39				0.02%			0.18%	0.05%				
40		0.23%		0.06%							0.19%	0.09%
41												
42												
43							0.34%	0.10%				
44												
45		0.23%	0.58%	0.15%							0.13%	0.06%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

4.3 POV Odometer Analysis

General linear models are used to identify statistically significant variations in vehicle odometer readings as a function of age across lane types and POEs. Passenger vehicles and commercial vehicles are analyzed separately.

For passenger vehicles, the general linear model considers first and second order terms, taking the form:

Model:	Odom = (age) (class) (lane) (domicile) (age*class) (age*lane) (age*POE) (age*domicile) (class*lane) (class*domicile) (lane*domicile)
Where:	Odom = Expected odometer Age = Age Class=LDA, LDT1, LDT2 plus MDV Lane = Regular, Ready, SENTRI Domicile = U.S., Mexico

Models were fit for each POE group (San Ysidro, Otay Mesa with Tecate, and combined Imperial County) identified in the vehicle class distributions above. Results (Table 19) indicated that all covariates are statistically significant at the 5% level.

The refined models indicated that for San Ysidro and the combined Otay Mesa and Tecate POEs, odometer is only a function of vehicle age (i.e., domicile, class, and lane were not statistically significant at the 5% level). For the combined Imperial County POEs, the second order terms of “lane x domicile” and “lane x class” were statistically significant but (combined) were found to explain less than 2% of variation in observed odometer readings; as shown by the “Partial Eta Squared” statistic in Table 22 below.

Because the observed Odometer data is similar enough across groupings to only distinguish the odometer data as a function of age, it is likely that the data lack the statistical power to make potentially important distinctions. The default odometer data by age and vehicle class from EMFAC was therefore used in the derivation of emission rates for this analysis.

Table 22. Test of covariates in general linear model for vehicle age.

Tests of Between-Subjects Effects[a]

Dependent Variable: ODOM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Model	26863740416903.742[b]	13	2066441570531.057	113.447	.000	.541
Lane * Domicile	173549089012.459	3	57849696337.486	3.176	.023	.008
R_Class * Lane	247475953675.003	6	41245992279.167	2.264	.035	.011
ln_Age	.000	0	.	.	.	.000
ln_Age_Sqrd	.000	0	.	.	.	.000
Error	22787105669021.820	1251	18215112445.261			
Total	49650846085925.560	1264				

a. Grouping for Class Crossclassification table = Imperial County
b. R Squared = .541 (Adjusted R Squared = .536)

4.4 Commercial Vehicle Class Analysis

Multinomial logistic regression models are used to identify statistically significant variations in the mix of vehicle classes across lane types and POEs. For commercial vehicles, the model was constructed using a forward stepwise approach:

- Lane type (Fast, Regular)
- POE (Otay Mesa, Tecate, Calexico East),
- Fuel (gasoline diesel)
- All second order terms (i.e. lane x fuel, lane x POE; and fuel x POE)

Commercial vehicle classes are grouped:

- Class 7-8: Heavy-duty diesel vehicles (HDDV) consisting of trucks with a gross vehicle weight rating (GVWR) more than 26,000 lbs.
- Class 3-6: Light heavy-duty truck 1 (LHDT1), light heavy-duty truck 2 (LHDT2) and medium heavy-duty vehicles (MHDV) with a GVWR from 8,500 to 26,000 lbs.
- Commercial Vans: Medium-duty vehicles with a GVMR from 6,000 to 8,500 lbs.

After a stepwise backward test identified singularities in the Hessian matrix, which indicates that assumptions regarding the lack of collinearity between terms are violated, second-order terms, apart from lane x POE, were dropped from the model. A stepwise backwards process was manually performed to fit the model, moving from result statistics for the full model (Table 23) to a reduced model (Table 24) and a final model (Table 25).

Table 23. Test of significance for full model of class by POE, fuel type, and lane type in modeling variability in vehicle class distribution.

Likelihood Ratio Tests

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
General location of survey	56.994[a]	.000	0	.
Diesel_(Y/N)	269.023	212.029	3	.000
Lane Type	56.994[a]	.000	0	.
General location of survey * Lane Type	67.113	10.118	6	.120

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.
a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Table 24. Test of significance for reduced model of class by POE, fuel type, and lane type in modeling variability in vehicle class distribution:

Likelihood Ratio Tests

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
General location of survey	87.462	20.349	6	.002
Diesel_(Y/N)	284.825	217.712	3	.000
Lane Type	73.644	6.531	3	.088

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Table 25. Test of significance for final model of class by POE, fuel type, and lane type in modeling variability in vehicle class distribution:

Likelihood Ratio Tests

Effect	Model Fitting Criteria: -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests: Chi-Square	df	Sig.
General location of survey	65.263	21.452	6	.002
Diesel_(Y/N)	269.298	225.486	3	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

The results indicate that at the 5% significance level the vehicle class mix is a function of which commercial POE is being considered (Otay Mesa, Tecate, or Calexico East) and the fuel type (gas or diesel). Observed distribution of vehicle class by POE and fuel type is show in Table 26. Because of the correlation between fuel use and vehicle class, this can be further reduced (Table 27). Gas and diesel market shares were then compiled by vehicle class and POE for use with these data (Table 28).

Table 26. Observed commercial vehicle class by POE

	Class 7-8 (HHDT)		Class 3-6 (LHDT1, LHDT2, MHDT)		Van (MDV)	
	Gas	Diesel	Gas	Diesel	Gas	Diesel
Otay Mesa	0.39%	89.96%	3.47%	5.41%	0.77%	0.00%
Tecate	0.00%	75.90%	12.80%	7.10%	3.50%	0.70%
Calexico East	0.00%	88.20%	4.30%	5.90%	1.30%	0.30%

Table 27. Simplified commercial vehicle class by POE

	Class 7-8 (HHDT)	Class 3-6 (LHDT1, LHDT2, MHDT)	Van (MDV)
Otay Mesa, and Otay Mesa East	90%	9%	1%
Tecate	76%	20%	4%
Calexico East	88%	10%	2%

Table 28. Gas and diesel fuel use by POE and vehicle class

	Class 7-8 (HHDT)		Class 3-6 (LHDT1, LHDT2, MHDT)		Van (MDV)	
	Gas	Diesel	Gas	Diesel	Gas	Diesel
Otay Mesa, and Otay Mesa East	0.0%	100.0%	39.1%	60.9%	100.0%	0.0%

Tecate	0.0%	100.0%	64.3%	35.7%	83.3%	16.7%
Calexico East	0.0%	100.0%	42.2%	57.8%	81.2%	18.8%

Binary logit models and contingency tables were used to look for statistical significance of POE, lane type, and fuel type in determining the probability of fuel purchases being made in the United States or Mexico. While POE, lane type, and fuel type were all statistically significant at the 5% level, the effect size for fuel type was found to be about fifty times the effect size of POE or Lane Type. Therefore, the use of Mexican sourced fuel is based solely on the type of fuel used (Table 29).

Table 29. Market share of Mexican and US gas and diesel fuel

Fuel Type	Fuel Purchased in U.S.	Fuel Purchased in Mexico.
Gasoline	14%	86%
Diesel	68%	32%

4.5 Commercial Vehicle Age Distribution Analysis

General linear models were used to identify statistically significant variations in vehicle age distribution across lane types and POEs. For commercial vehicles, the general linear model considers first and second order terms, and takes the form:

Model:	Age= (class) (lane) (Fuel type) (POE) (class*fuel) (class*POE) (class*lane) (fuel*POE) (fuel*lane) (POE*lane)
Where:	Age = Age (of the engine) Class=Class 7-8 (HDDV), Class 3-6 (LHDT1, LHDT2, and MHDV), and Commercial Vans (MDVs) Lane = FAST, regular Fuel type = Gas, diesel POE = Otay Mesa, Tecate, Calexico East

Models were fit using a manual reverse stepwise approach. Model fit statistics for the full model and the final model are shown in Table 30 and Table 31. The results indicate that commercial vehicle age distribution varies by class (class 7-8, class 3-6, and commercial van), by lane type (FAST, Regular), and fuel (gas, diesel) which yields 12 groupings for age distribution. Variation by POE is not statistically significant at the 5% level. The analysis can be further simplified by noting that there are virtually no class 7-8 gasoline powered commercial vehicles, and that class 3-6 gasoline powered vehicles are rare enough that FAST and regular lane data need to be combined. Similarly, commercial van data needed to be pooled. The resulting commercial vehicle age distribution data is provided in Table 32.

Table 30. Test of significance for full model of age by class, lane, fuel, and POE in modeling variability in vehicle age distribution

Tests of Between-Subjects Effects

Dependent Variable: Age of truck engine

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	58044.991[a]	21	2764.047	75.320	.000
Class	387.400	3	129.133	3.519	.015
Lane	69.883	1	69.883	1.904	.168
Fuel	431.981	1	431.981	11.771	.001
LPOE	2.694	2	1.347	.037	.964
Class * Fuel	39.187	2	19.594	.534	.587
Class * LPOE	130.378	5	26.076	.711	.616
Class * Lane	72.832	2	36.416	.992	.372
Fuel * LPOE	37.648	2	18.824	.513	.599
Lane * Fuel	240.225	1	240.225	6.546	.011
Lane * LPOE	107.905	1	107.905	2.940	.087
Error	16734.009	456	36.697		
Total	74779.000	477			

a. R Squared = .776 (Adjusted R Squared = .766)

Table 31. Test of significance for final model of age by class, lane, fuel, and POE in modeling variability in vehicle age distribution

Tests of Between-Subjects Effects

Dependent Variable: Age of truck engine

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	57697.688[a]	11	5245.244	143.097	.000
Class	572.767	3	190.922	5.209	.002
Lane	68.066	1	68.066	1.857	.174
Fuel	640.500	1	640.500	17.474	.000
Class * Fuel	24.047	2	12.023	.328	.721
Class * Lane	127.851	2	63.926	1.744	.176
Lane * Fuel	231.824	1	231.824	6.324	.012
Error	17081.312	466	36.655		
Total	74779.000	477			

a. R Squared = .772 (Adjusted R Squared = .766)

Table 32. Commercial Vehicle Age Distributions

Age	Class 7-8, Diesel, FAST	Class 7-8, Diesel, Reg	Class 3-6, Gas, Fast & Reg	Class 3-6, Diesel, FAST	Class 3-6, Diesel, Reg	Van, Gas & Diesel, FAST & Reg
0	2.1%	1.1%				
1	5.6%	0.7%				
2	2.8%	0.7%		10.0%		
3	3.5%	2.2%	4.3%		5.9%	
4	5.6%	7.7%			5.9%	
5	9.1%	7.4%				
6	6.3%	6.3%	4.3%		5.9%	
7	7.7%	11.4%		10.0%	5.9%	
8	20.9%	14.5%		10.0%		
9	14.7%	7.7%			11.8%	28.5%
10	2.1%	4.8%		20.0%		
11	2.1%	3.7%				14.3%
12	1.4%	3.3%	4.3%	10.0%	5.9%	14.3%
13	0.7%	2.6%		10.0%	5.9%	
14		0.4%	13.0%		5.9%	14.3%
15	0.7%	7.0%		10.0%		
16	2.1%	2.6%	8.7%			14.3%
17	1.4%	3.0%	4.3%	10.0%	5.9%	14.3%
18	2.1%	1.8%	4.3%		23.3%	
19	2.1%	3.0%	8.7%	10.0%		
20	0.7%	1.1%			11.8%	
21	2.1%	0.7%	4.3%			
22	0.7%	2.2%	8.7%			
23	1.4%	1.5%	13.0%			
24		0.7%				
25 +	2.1%	1.9%	22.1%		5.9%	
Total	100%	100%	100%	100%	100%	100%

4.6 Commercial Vehicle Odometer Analysis

General linear models are used to identify statistically significant variations in vehicle odometer readings as a function of age across lane types and POEs. For commercial vehicles, the general linear model considers first and second order terms, taking the form:

Model:	Odom = (age) (class) (lane) (POE) (fuel) (age*class) (age*lane) (age*POE) (age*fuel) (class*lane) (class*POE) (class*fuel) (lane*POE) (lane*fuel) (POE*fuel)
Where:	Odom = Expected odometer Age = Age (of the engine) Class=Class 7-8 (HDDV), Class 3-6 (LHDT1, LHDT2, and MHDV), and Commercial Vans (MDVs) Lane = FAST, regular POE Fuel type = Gas, diesel POE = Otay Mesa, Tecate, Calexico East

As with the commercial age distribution analysis above, models were fit using a manual reverse stepwise approach. Model fit statistics for the full model and the final model are shown in Table 33 and Table 34. The results indicate that odometer can be represented as a function of commercial vehicle age and class. Figure 18 through Figure 20 plot estimates of the resulting odometer data against default data from EMFAC2014 (EMFAC 2014 was the current version of the model at the time of the odometer analysis. No updates were made to commercial vehicle odometer assumptions for EMFAC2017). Because the EMFAC 2014 odometer data falls within the 95% confidence intervals of the observed odometer data, EMFAC2017 odometer assumptions are used to develop commercial vehicle emission rates for this analysis.

Table 33. Test of significance for full model of odometer by age, class, lane, POE, and fuel type in modeling variability in observed odometer data

Tests of Between-Subjects Effects

Dependent Variable: Odometer (1,000's)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	122790636.833[a]	28	4385379.887	42.531	.000
Class	1311269.123	3	437089.708	4.239	.006
Lane	722922.758	1	722922.758	7.011	.008
LPOE	313628.897	2	156814.449	1.521	.220
Fuel	10117.451	1	10117.451	.098	.754
AGE_Eng	750883.805	1	750883.805	7.282	.007
Class * AGE_Eng	510639.170	3	170213.057	1.651	.177
Fuel * AGE_Eng	127338.180	1	127338.180	1.235	.267
LPOE * AGE_Eng	449406.981	2	224703.490	2.179	.114
Lane * AGE_Eng	100308.647	1	100308.647	.973	.325
Class * Fuel	1978.970	1	1978.970	.019	.890
Class * LPOE	641574.761	5	128314.952	1.244	.287
Class * Lane	39015.421	2	19507.711	.189	.828
LPOE * Fuel	285806.009	2	142903.004	1.386	.251
Lane * Fuel	282585.745	1	282585.745	2.741	.099
Lane * LPOE	307007.932	1	307007.932	2.977	.085
Error	43718738.167	424	103110.232		
Total	166509375.000	452			

a. R Squared = .737 (Adjusted R Squared = .720)

Table 34. Test of significance for final model of odometer by age, class, lane, POE, and fuel type in modeling variability in observed odometer data

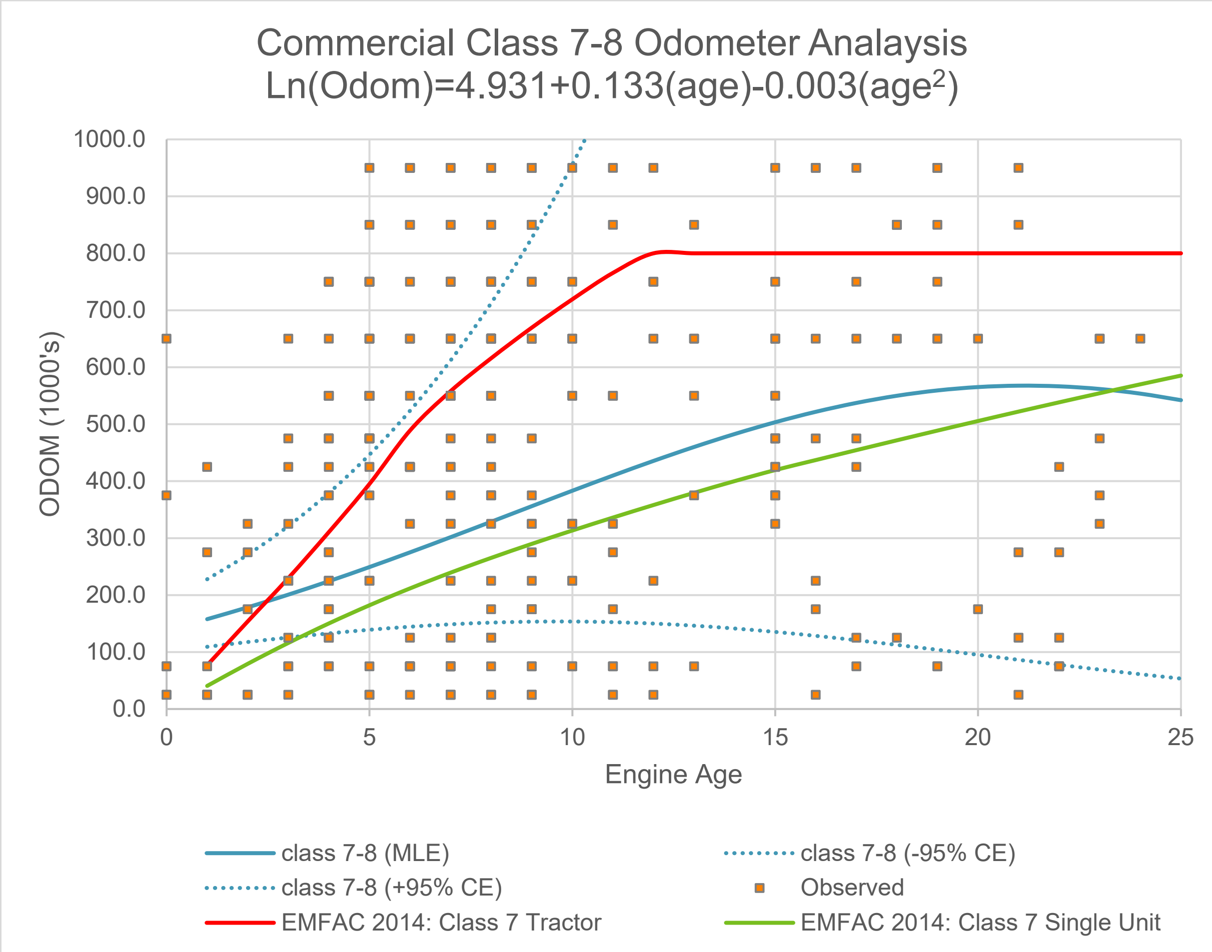
Tests of Between-Subjects Effects

Dependent Variable: Odometer (1,000's)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	120184263.609[a]	5	24036852.722	231.936	.000
Class	27433192.222	4	6858298.056	66.177	.000
AGE_Eng	2436019.348	1	2436019.348	23.506	.000
Error	46325111.391	447	103635.596		
Total	166509375.000	452			

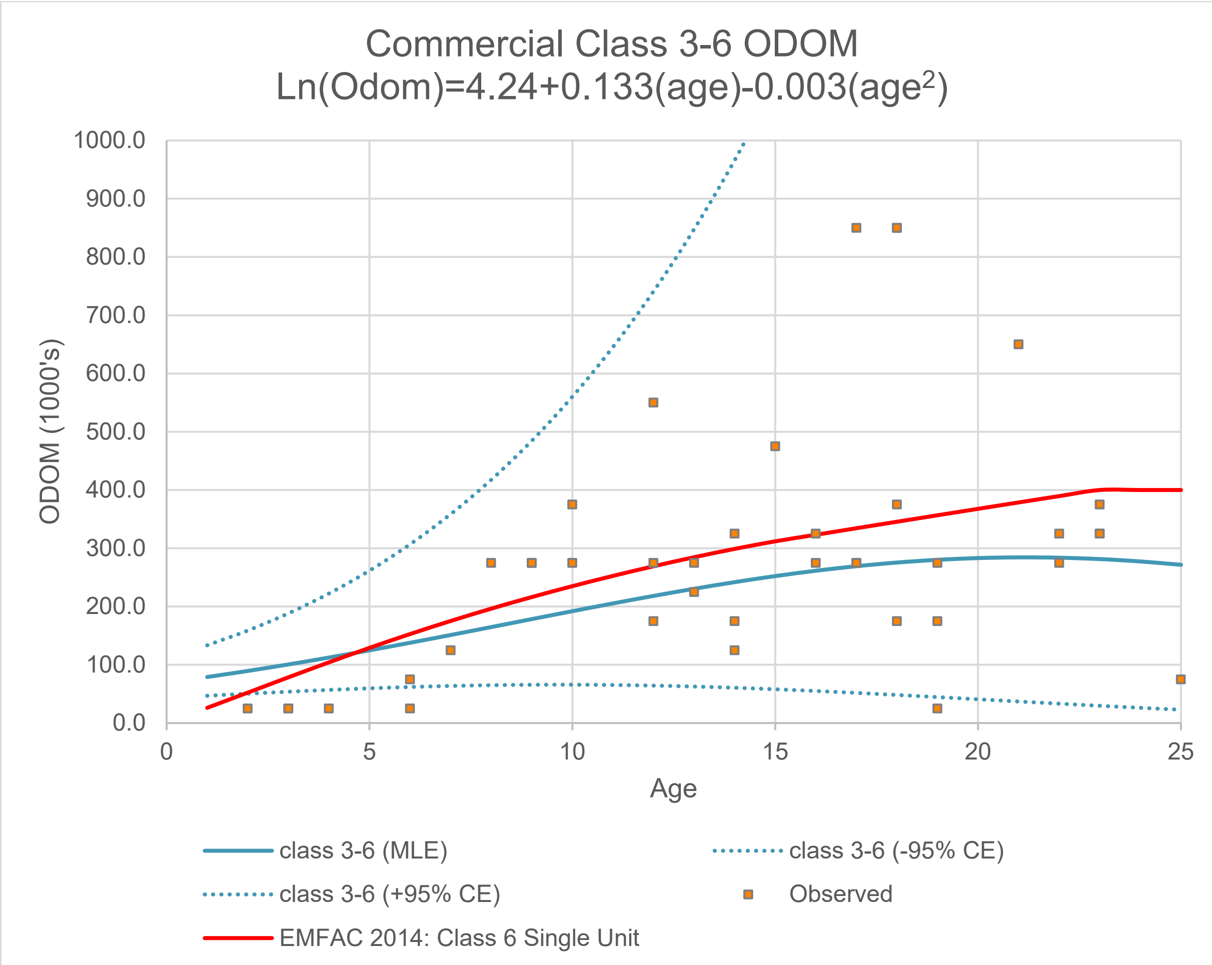
a. R Squared = .722 (Adjusted R Squared = .719)

Figure 18. Commercial class 7-8 odometer data



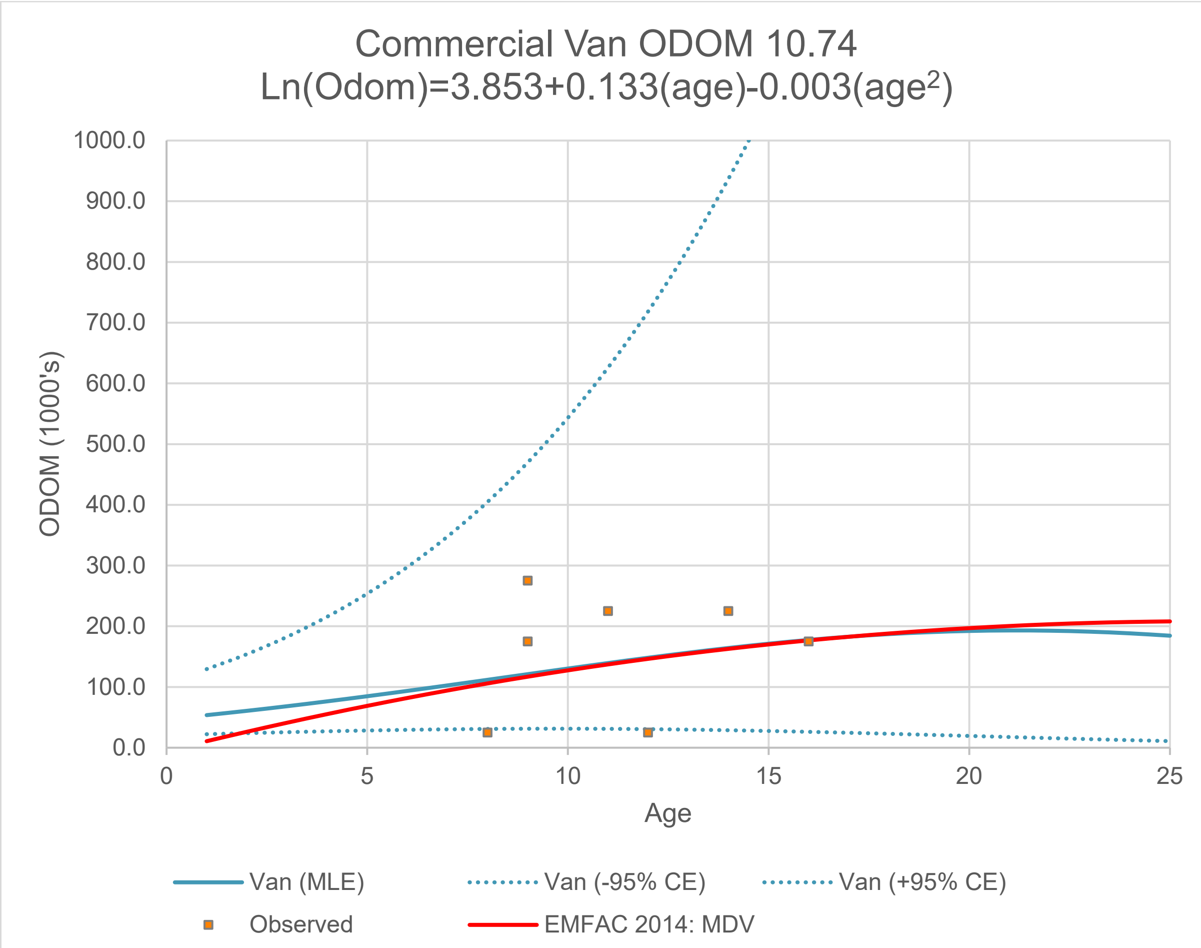
Note: ODOM data was binned in 50K and 100K mile bins

Figure 19. Commercial class 3-6 odometer data



Note: ODOM data was binned in 50K and 100K mile bins

Figure 20. Commercial van odometer data



Note: ODOM data was binned in 50K and 100K mile bins

5 Assessment of San Diego County POE Emissions

San Diego County results for POV, and commercial vehicle POEs are presented in separate sections below. The spatial domain of interest varies by pollutant. Seasonal PM10, PM2.5, and CO are presented for each POE. A single ROG result, a single NOx result, and a single CO_2 result are presented, which represent the combined emissions from all POV (or commercial) border crossings in San Diego county. These pollutants are precursors to regional pollutants such as ground-level ozone or contribute to anthropogenic climate change. Excel spreadsheets that calculate emissions for each POE by lane type, process, and hour of the day are available as electronic appendices.

The five San Diego County scenarios described in Section 3 are addressed for ROG, NOx, CO_2, PM10, PM2.5, and CO:

- <u>Baseline 2016</u> POV: This scenario reflects how each POE operates in 2016.
- <u>Baseline 2025</u> POV: This scenario reflects how each POE is anticipated to operate in 2025. Key changes relative to 2016 include:
  - ✓ Phase 3 at San Ysidro improvements, including 10 southbound inspection lanes, and an additional eight northbound inspection lanes.
  - ✓ Otay Mesa commercial POE modernization, including six additional northbound commercial primary inspection booths.
  - ✓ Electronic clearance for all Aduanas primary commercial inspections.

  (Additional details are shown in Table 12, presented earlier.)
- <u>Baseline 2025 plus OME 5x5 and Transit Improvements</u>: This scenario adds the 5x5 Otay Mesa East POE as a tolled facility with average crossing times of about 20 minutes, along with changes in POV and bus volumes associated with the planned active transportation and transit improvements discussed in Section 3.
- <u>Baseline 2035 plus OME 5x5 and Transit Improvements</u>: This scenario adds an additional decade of traffic volume growth to the above Baseline 2025 plus OME 5x5 and Transit Improvements scenario.
- <u>Baseline 2035 plus OME 10x10 and Transit Improvements</u>: This scenario is similar to the above Baseline 2035 plus OME 5x5 and Transit Improvements scenario, with the Otay Mesa East POE expanded to a 10x10 POE.

Annual volume estimates for each POE are presented before the emissions results. In general (but not always) the volumes grow over time, and, are discussed in detail in Volume 1. The volumes include the effect of induced growth in person and commercial trips associated with the various capacity enhancements, and the mode shift from POVs to pedestrian and transit associated with active transportation and transit investments.

Emissions data are normalized based on the number of border crossings, and presented per 1,000 border crossings. This emphasizes the combined effect of reduced delay and queuing plus cleaner, more efficient, vehicles. For POVs, the emissions are reduced by both congestion relief (capacity enhancement, active transportation and transit improvements) and through less polluting vehicles over time (as older "dirtier" vehicles are retired and replaced by newer "cleaner" models). Emissions from queued traffic are much greater than emissions from free flow traffic, and where congestion relief strategies fail to keep pace with demand, queues expand and emissions can increase over time, despite the emission reduction benefits from less polluting vehicles under future scenarios. For example, POV emissions tend to

- Increase between 2016 and 2025 without the Otay Mesa East 5x5 POE because congestion increases more than cleaner vehicles and fuels can offset;
- Decline slightly with in 2025 with the Otay Mesa East 5x5 POE through congestion relief;
- Decline again by 2035 with the Otay Mesa East 5x5 POE because the cleaner vehicles and fuels are generally offsetting the impact of increased congestion; and
- Decline slightly in 2035 with the Otay Mesa East 10x10 POE, except at the OME crossing where volumes are forecast to more than double.

Commercial vehicle emissions per border crossing are anticipated to drop through 2035; capacity enhancements reduce delay and improvements in vehicle technology, combine to produce that benefit. In 2035 with the OME 10x10 facility, shifts in demand (and congestion) between Otay Mesa and OME are anticipated to result in a slight increase in emissions at Otay Mesa. However, that increase could easily be explained by the accuracy of traffic forecasting and should not be considered as breaking the overall trend of lower emissions per vehicle crossing over time with continued investment at the POEs.

Adjustments for ROG emissions, based on Table 10, and the proportion of Mexican fuel at each POE, account for the effect that Mexican gasoline has on ROG emissions: CO_2 emissions reflect tailpipe CO_2, and are not corrected to account for low carbon fuel standards (LCFS) per EMFAC2017 guidance. The LCFS regulation is excluded from EMFAC2017 because most of the emissions benefits due to the LCFS come from the production cycle (upstream emissions) of the fuel rather than the combustion cycle (tailpipe). As a result, LCFS is assumed to not have a significant impact on CO_2 emissions from EMFAC's tailpipe emission estimates and adjustments for vehicles running Mexican fuels are no longer necessary.

Sections 5.1 and 5.2 below present the POV border crossing volumes and emissions, respectively. Sections 5.3 and 5.4 present the corresponding commercial vehicle volumes and emissions.

5.1 San Diego County Annual Northbound and Southbound POV Border Crossings

Figure 21 through Figure 25 show San Diego County POV volumes for each scenario. Volumes for each of the four POEs that process POVs are presented, along with the countywide totals. Volume 1 details the sources of existing and forecast traffic volumes[41].

To understand how volumes and emissions change between scenarios for POVs, note that:

- POV border crossings in both directions are anticipated to increase by 21% from 2016 to 2025 without OME. Induced demand with OME and the active transportation and transit improvements results in an additional 3% increase in border traffic, for overall volume growth of 24%.
- Across all San Diego County POEs, growth in POV volume from 2025 to 2035 is 14%, and, expanding OME from a 5x5 to a 10x10 facility increase the 2025 to 2035 growth by another 4 percentage points to 18%. However, those benefits accrue primarily at Otay Mesa and OME, where POV crossings are anticipated to drop. In contrast, POV traffic grows slightly from 2025 to 2035 at San Ysidro and Tecate.

The annual northbound volume for each POE was scaled to represent seasonal weekdays and weekend-days, and split into Regular lane, Ready Lane, and SENTRI lane volumes based on information from the Bureau of Transportation Statistics[42], a data set provided by CBP through SANDAG, and data collected for this study. Southbound flows were also adjusted for seasonality and day of the week. Weekdays represent Tuesday through Thursday, while weekends reflect Friday through Sunday conditions. Seasonal and weekday/weekend adjustments are provided in Table 35. The breakout of traffic by Regular lane, Ready Lane, and SENTRI lane for each POE is provided in Table 36.

[41] Note that Volumes reported herein add annual bus trips to the POV values reported in Volume 1.
[42] BTS https://www.bts.gov/content/border-crossingentry-data

Table 35. Northbound San Diego County POV seasonal weekday and weekend adjustments to annualized daily border crossing data

POE	Winter Weekday	Winter Weekend	Summer Weekday	Summer Weekend
San Ysidro				
Regular lane	111%	106%	97%	103%
Ready Lane	99%	96%	107%	86%
SENTRI lane	104%	106%	109%	101%
Southbound	109%	106%	109%	101%
Otay Mesa				
Regular lane	93%	107%	101%	98%
Ready Lane	98%	91%	107%	94%
SENTRI lane	102%	84%	104%	94%
Southbound	104%	107%	111%	110%
Otay Mesa East (when open)				
Regular lane	93%	107%	101%	98%
Ready Lane	98%	91%	107%	94%
SENTRI lane	102%	84%	104%	94%
Southbound	104%	107%	111%	110%
Tecate				
Regular lane	93%	93%	106%	105%
southbound	89%	101%	101%	115%

Table 36. Northbound San Diego County POV lane utilization

POE	Regular Lane	Ready Lane	SENTRI Lane
San Ysidro	22%	39%	39%
Otay Mesa	20%	57%	23%
Otay Mesa East (when open)	20%	57%	23%
Tecate	100%		

Southbound POV travel, through San Ysidro, Otay Mesa, and OME POEs are assumed to operate as if the POEs share capacity across a single system, with about 71% of the southbound POVs using San Ysidro. The remaining 29% of southbound POV traffic was assumed to split evenly between Otay Mesa and OME.

Figure 21. Baseline 2016 San Diego County POV Border Crossing Volume by POE

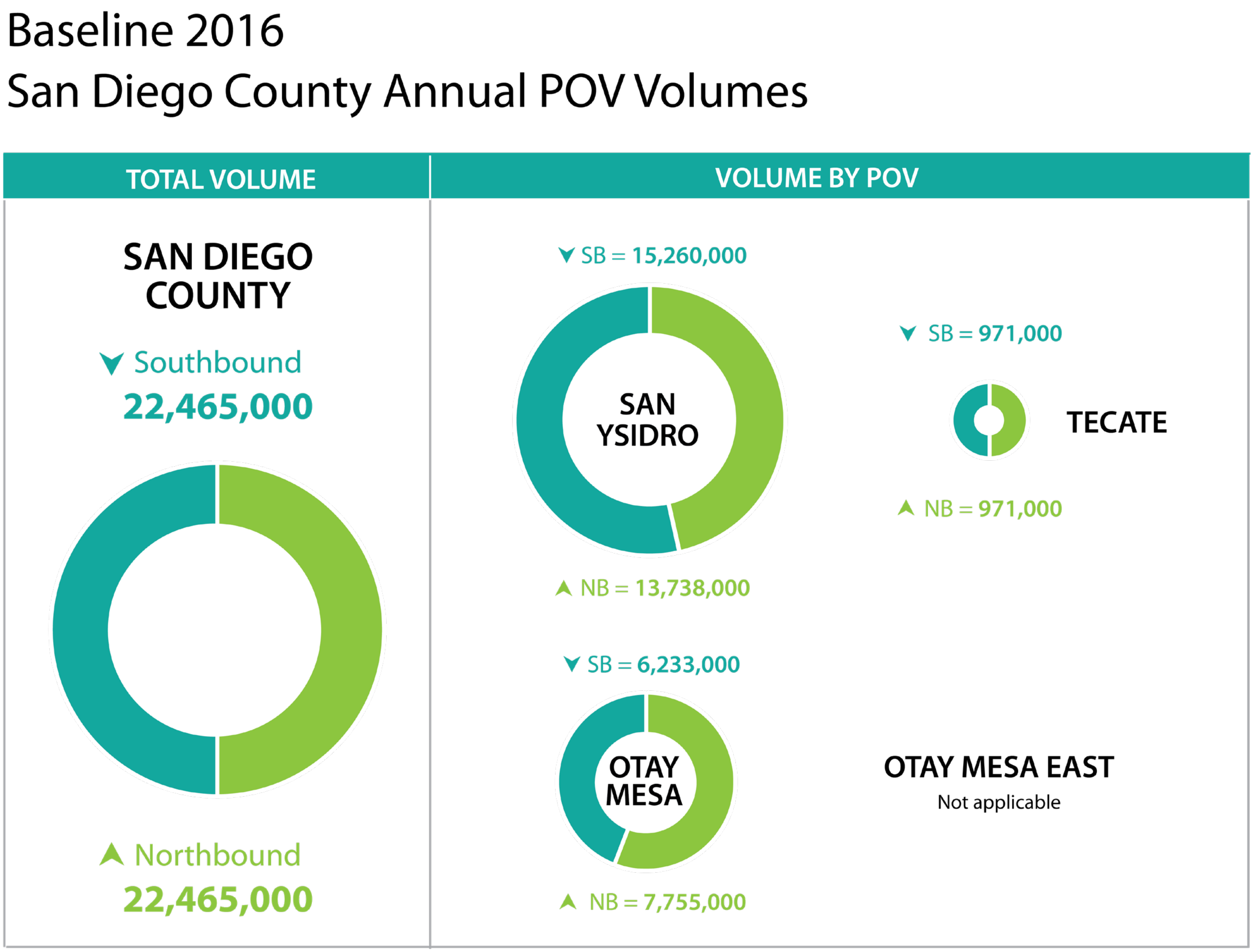


Figure 22. Baseline 2025 San Diego County POV Border Crossing Volume by POE

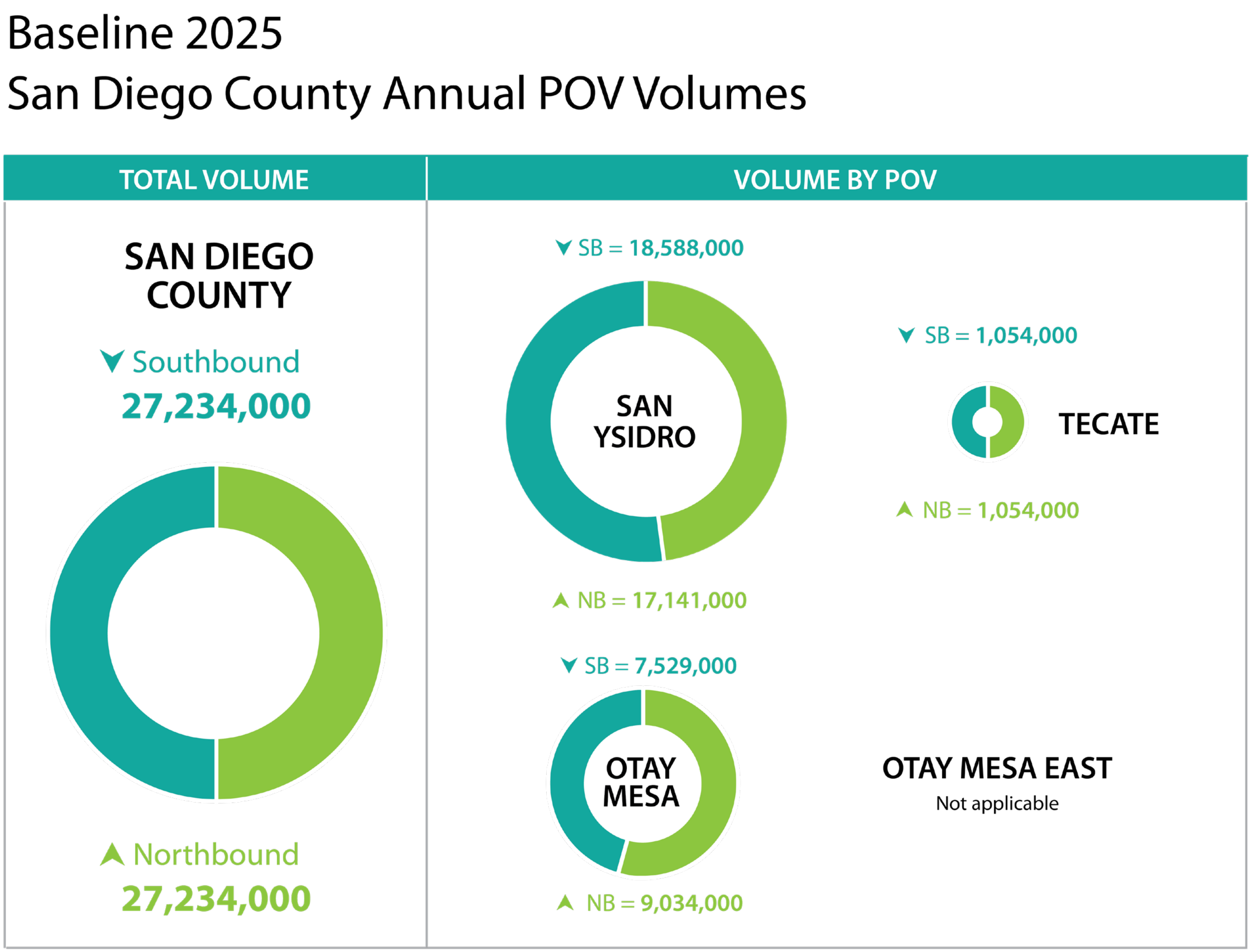


Figure 23. 2025 San Diego County POV Border Crossing Volume by POE with the Otay Mesa East 5x5 POE and Transit Improvements

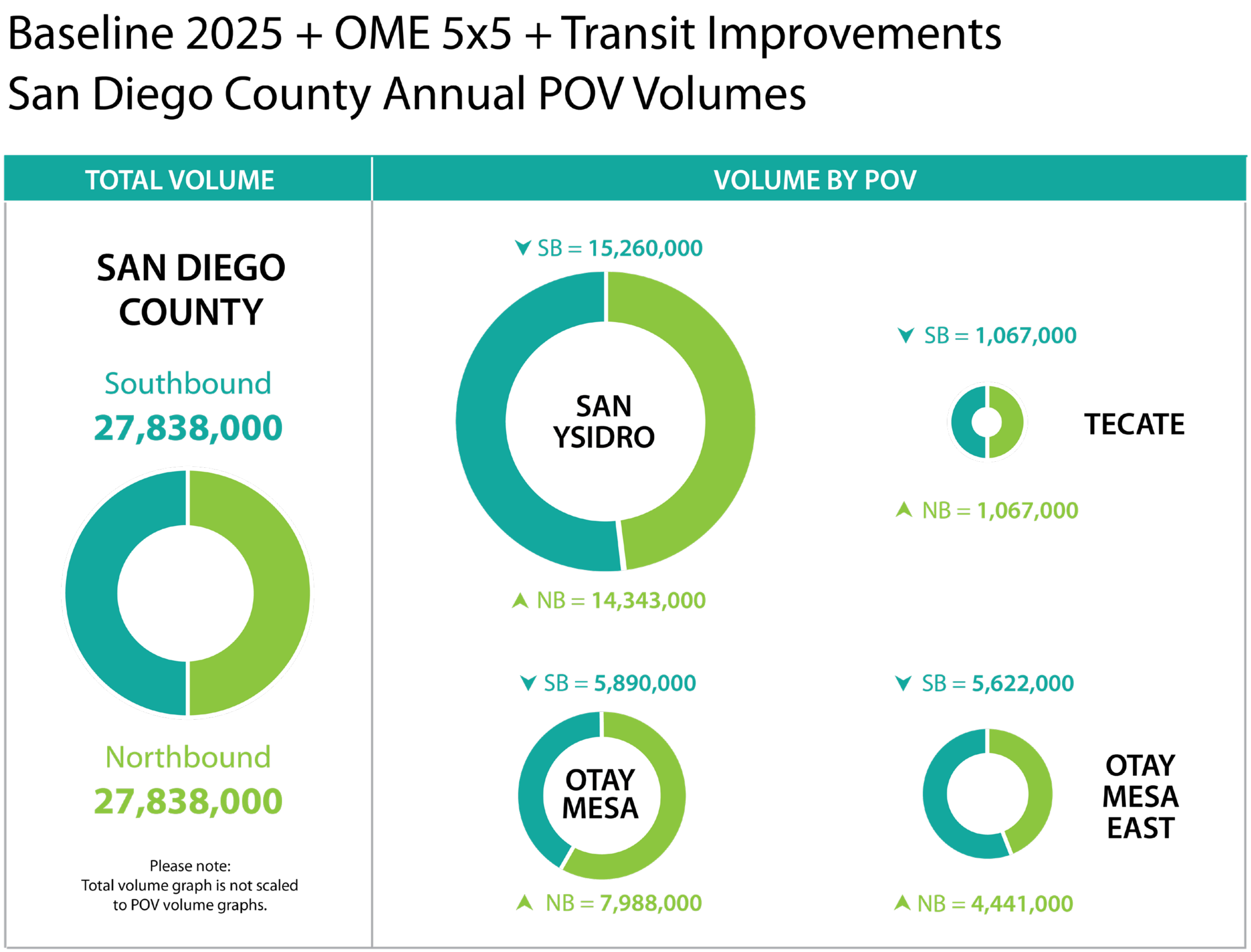


Figure 24. 2035 San Diego County POV Border Crossing Volume by POE with the Otay Mesa East 5x5 POE and Transit Improvements

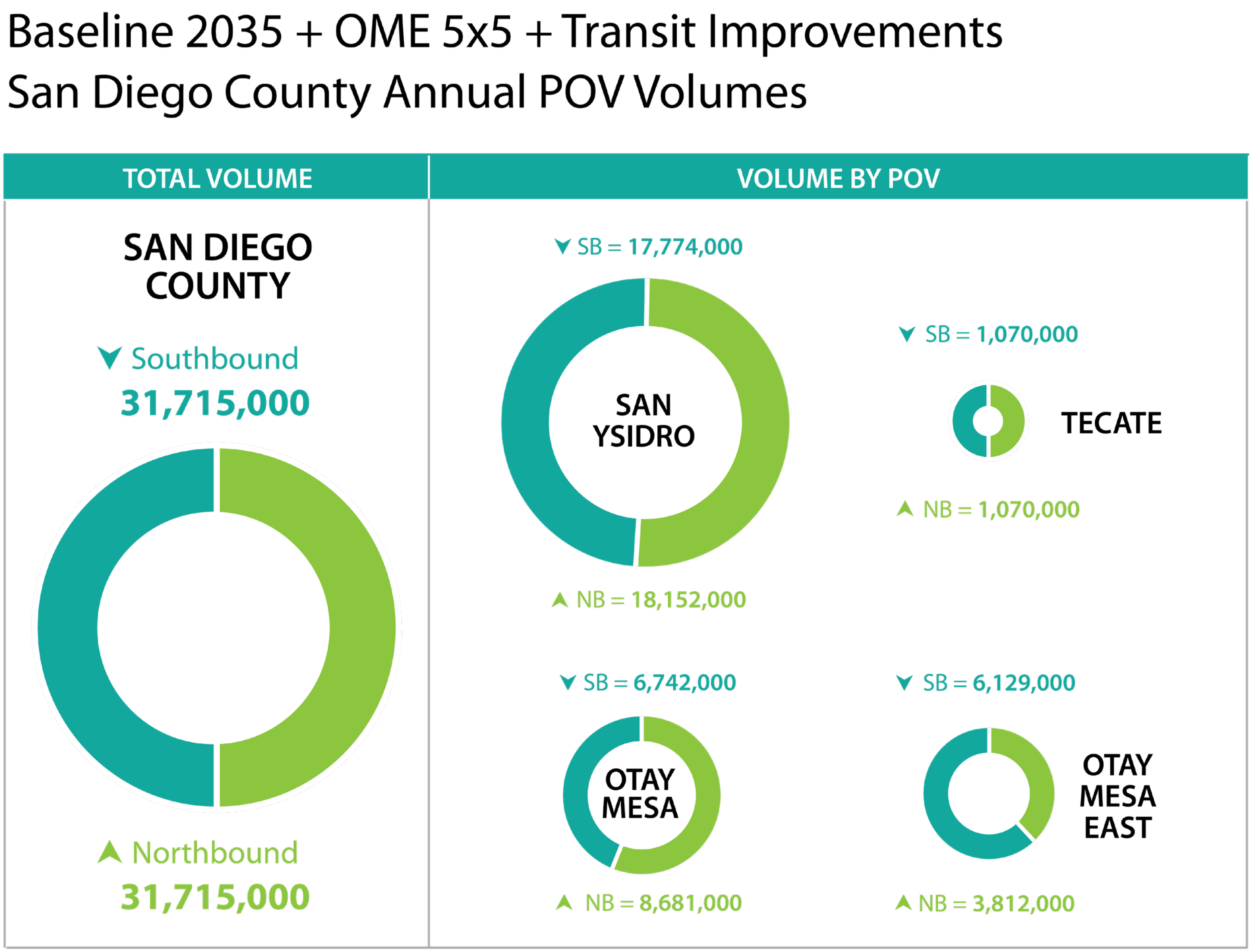
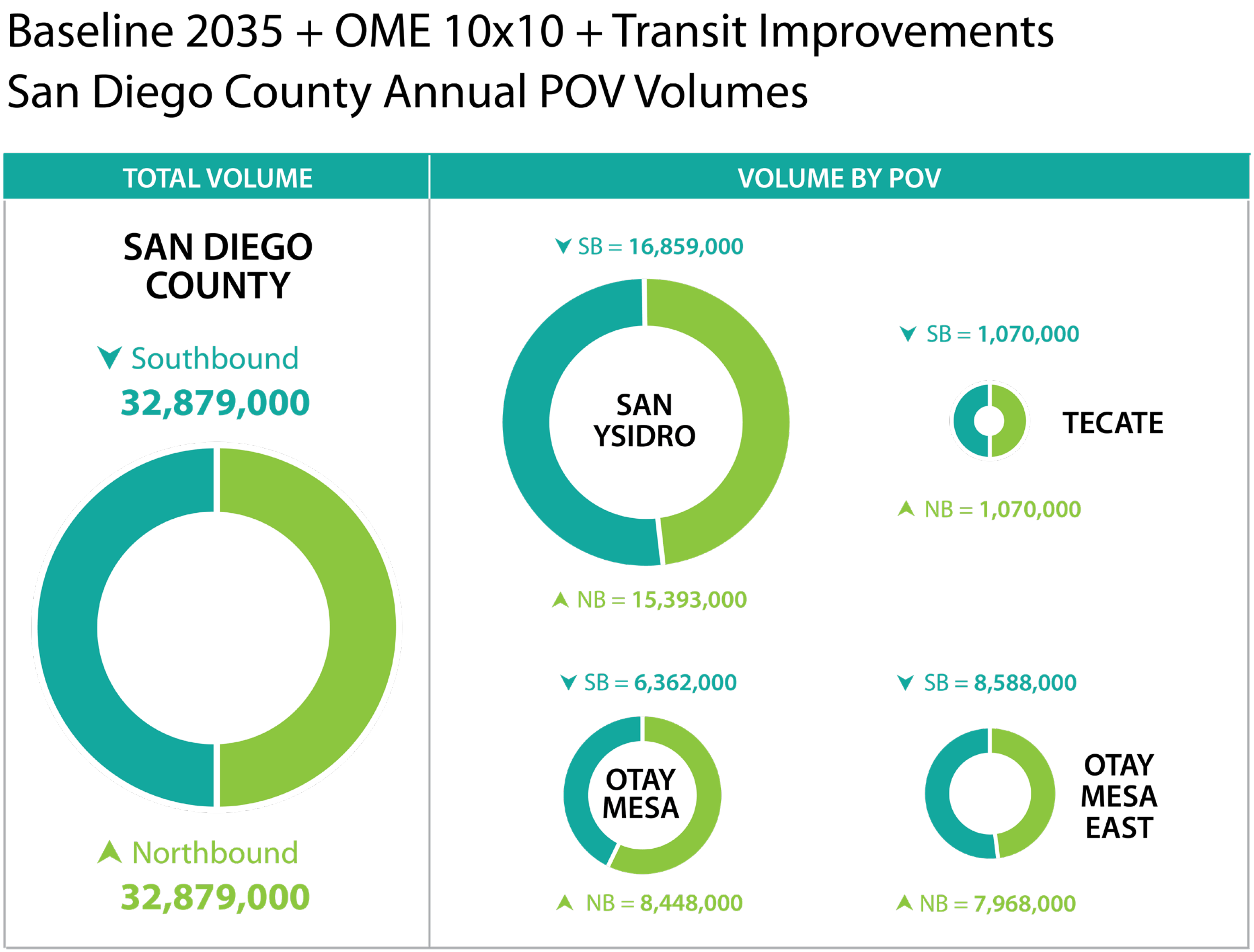


Figure 25. 2035 San Diego County POV Border Crossing Volume by POE with the Otay Mesa East 10x10 POE and Transit Improvements



5.2 San Diego County Annual Northbound and Southbound POV Emissions

Average daily seasonal emissions are reported for winter and summer "design days". The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all POE emissions for that season). Emissions are reported in units of grams per day, except for CO_2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

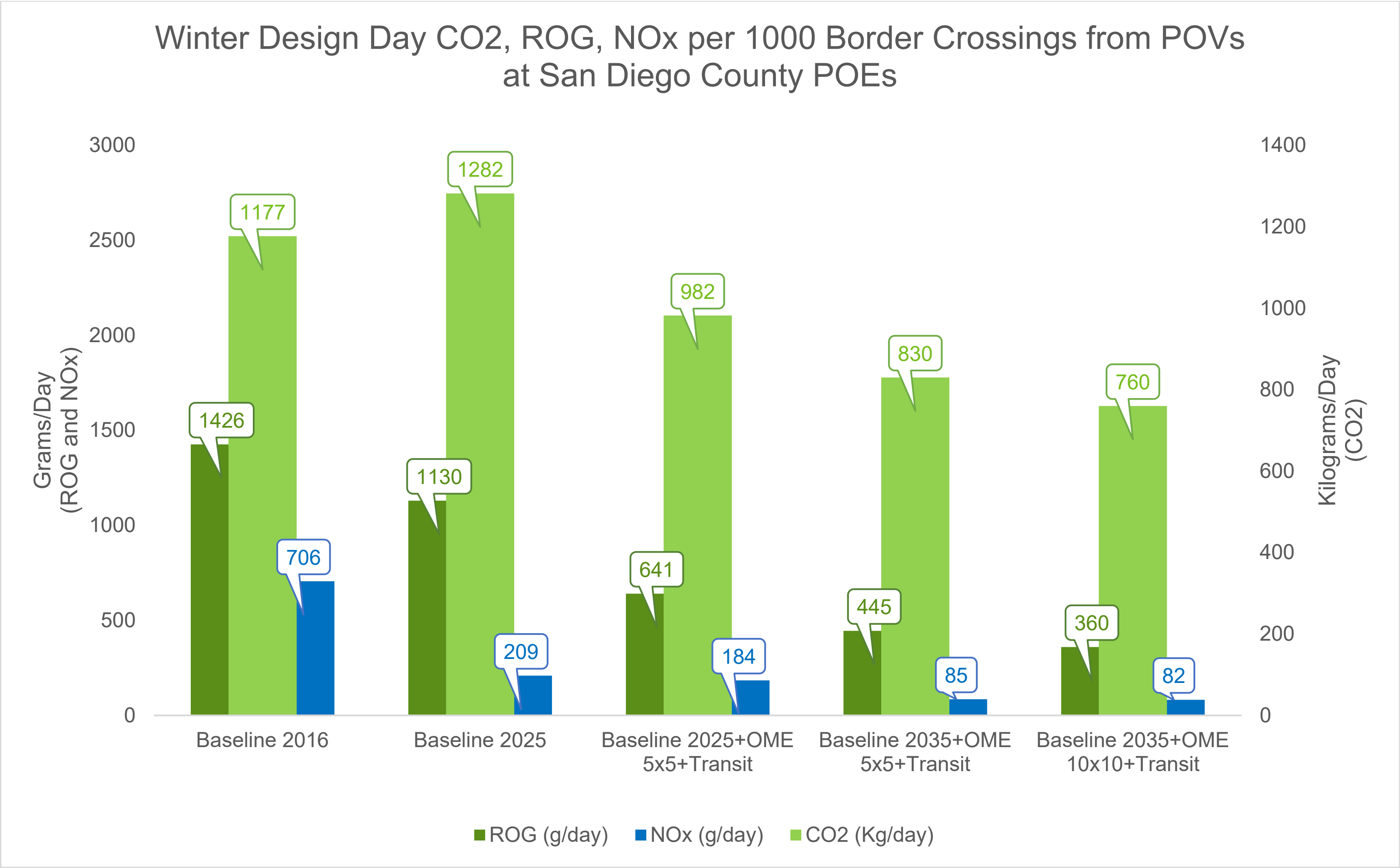
Figure 26 and Figure 27 report emissions for ROG, NOx, and CO_2 per 1,000 POVs crossing the through the POEs between San Diego County, and the state of Baja California. The results show ROG and NOx emission reductions from the 2016 to 2025 baseline scenarios and an increase in CO_2. This result reflects increased crossing volumes and delay at San Ysidro, and a less polluting vehicle fleet in 2025 as older vehicles age out of the fleet. Implementation of OME and the active transportation and transit enhancements reduce emissions through reduced border crossing delay. POV emissions are anticipated to continue dropping between the 2025 and 2035 OME with activate transportation and transit enhancement scenarios due to a cleaner overall vehicle fleet in 2035 and the predicted increase in alternative modes of travel.

PM10, PM2.5, and CO emission results are reported separately for each San Diego County POE in Figure 28 through Figure 35. There are two figures for each POE providing winter design day and summer design day results for all five analysis scenarios. Trends for each POE differ from the one another depending on where capacity improvements are built, and mode shift is anticipated to occur, due to the active transportation and transit enhancements.

- At San Ysidro, Otay Mesa, and Tecate, emissions of CO and PM2.5 per vehicle are expected to decline over time due to capacity enhancements, investments in non-POV modes, and cleaner-more efficient vehicle technologies. PM10 emissions, which are heavily influenced by break and tire wear, drop from 2016 to 2035, then remain relatively consistent.
- At OME emissions of winter CO per vehicle are anticipated to increase slightly from the 2035 5x5 scenario to the 2035 10x10 scenario. With the 10x10 OME POE demand is anticipated to increase more than the increased capacity, and the effect of increased delay increases the CO emissions.

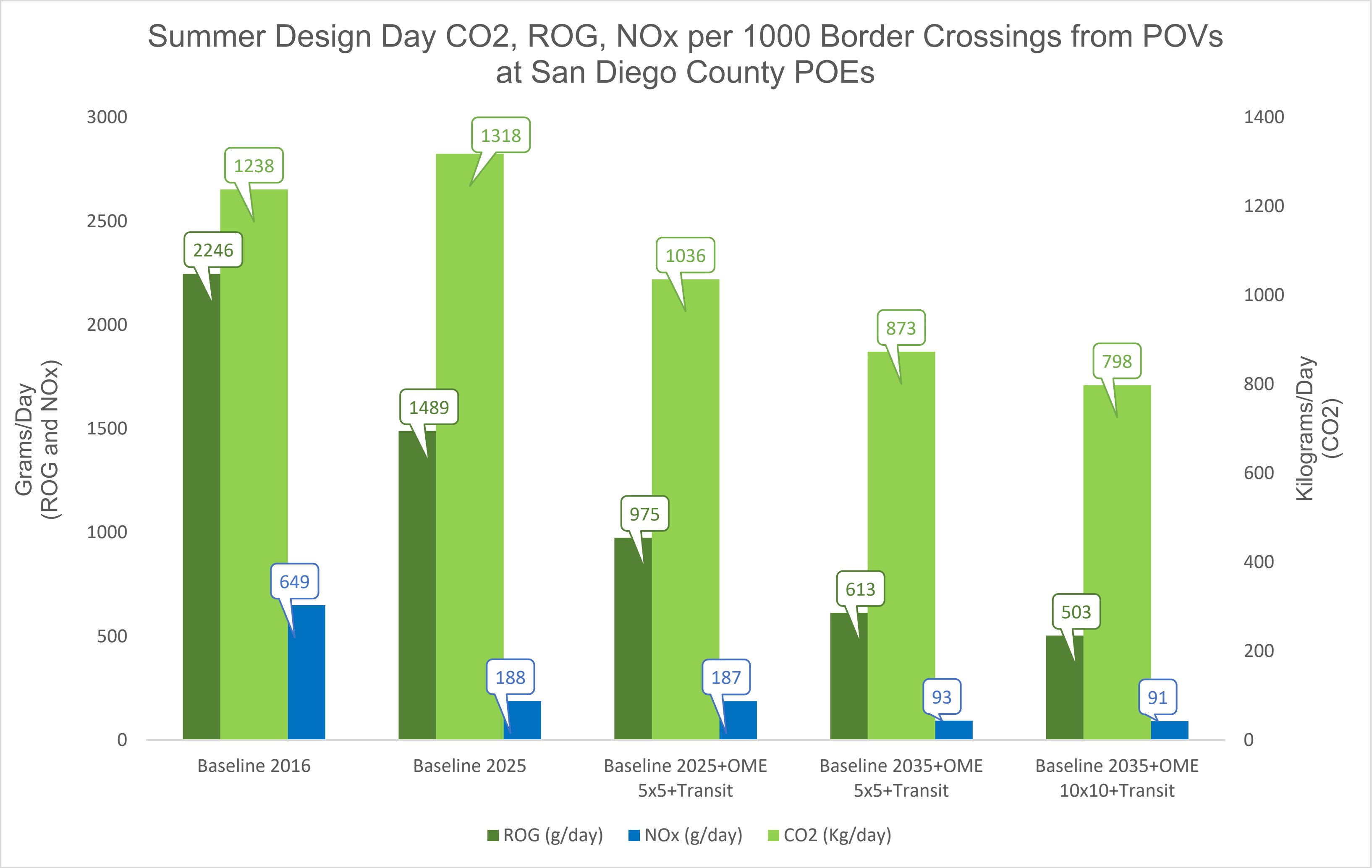
The trends for both the winter and summer design days are similar, with minor variations in emissions resulting from the seasonal traffic differences, and temperature effects on emissions. The overall trend is that emissions will drop over time through the combination of capacity investments, improved transit, active transportation, and a cleaner vehicle fleet in the future.

Figure 26. Winter Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at San Diego County POEs



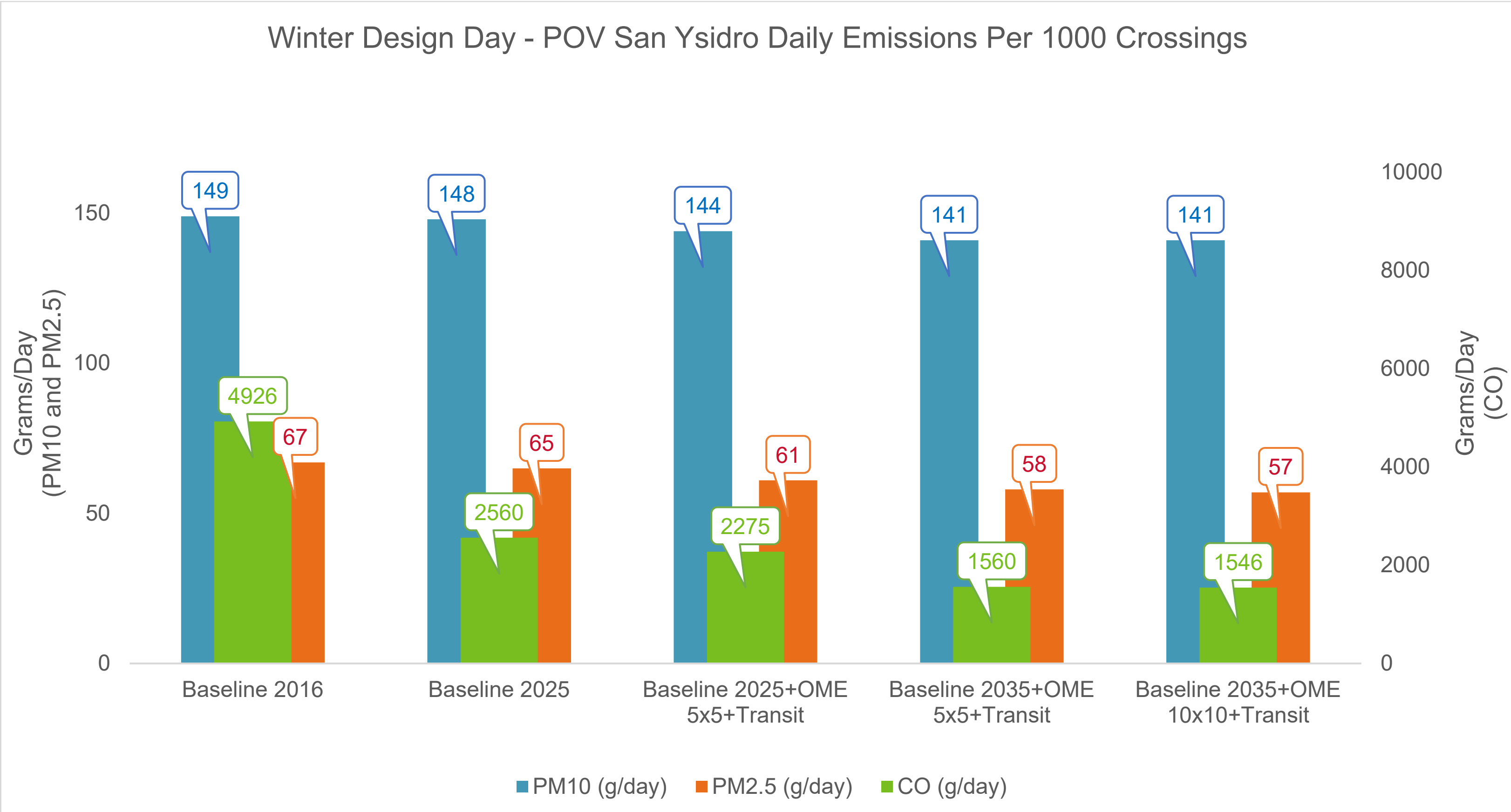
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 27. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at San Diego County POEs



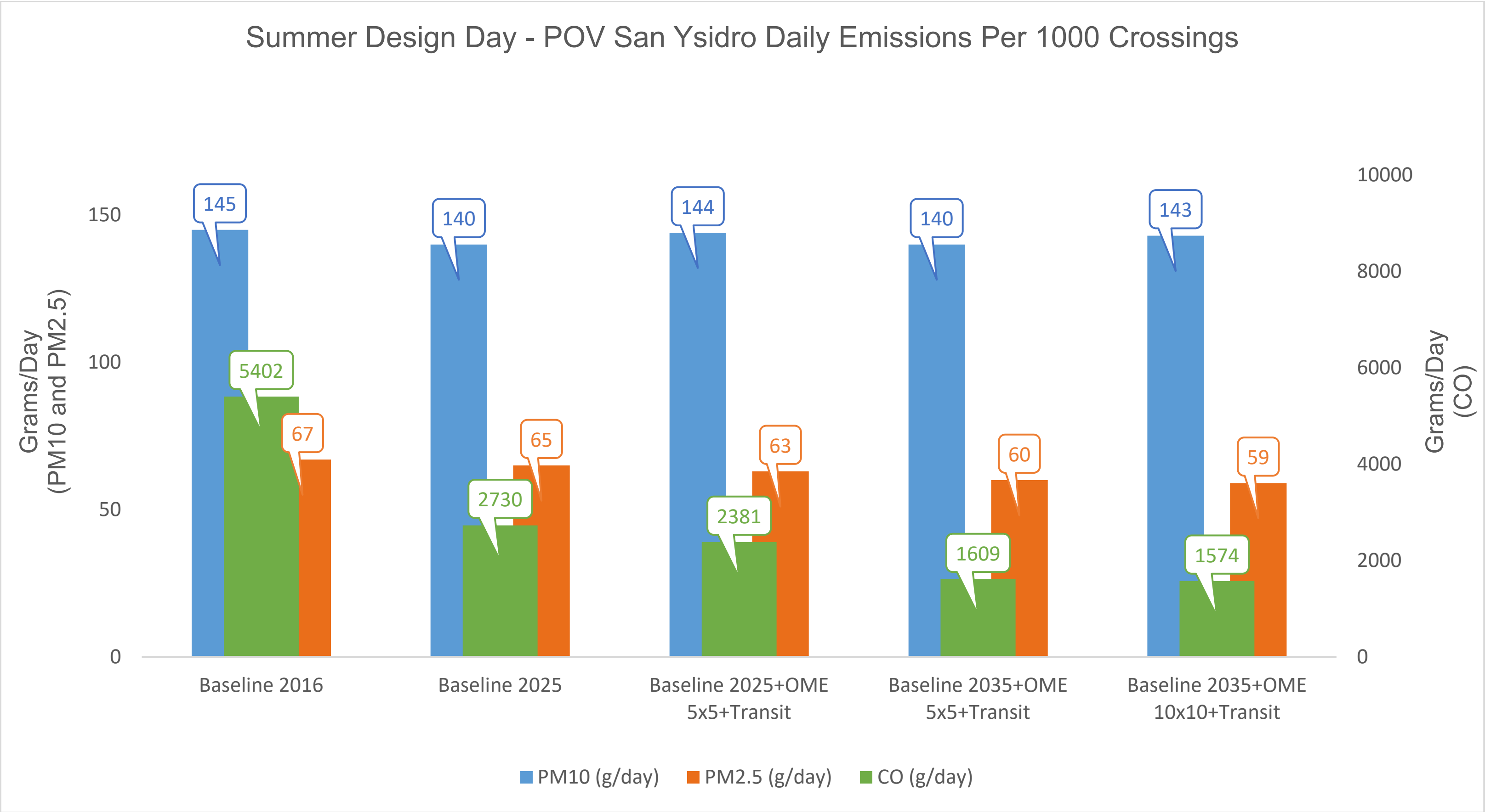
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 28. Winter Design Day PM10, PM2.5, and CO from POVs at the San Ysidro POE



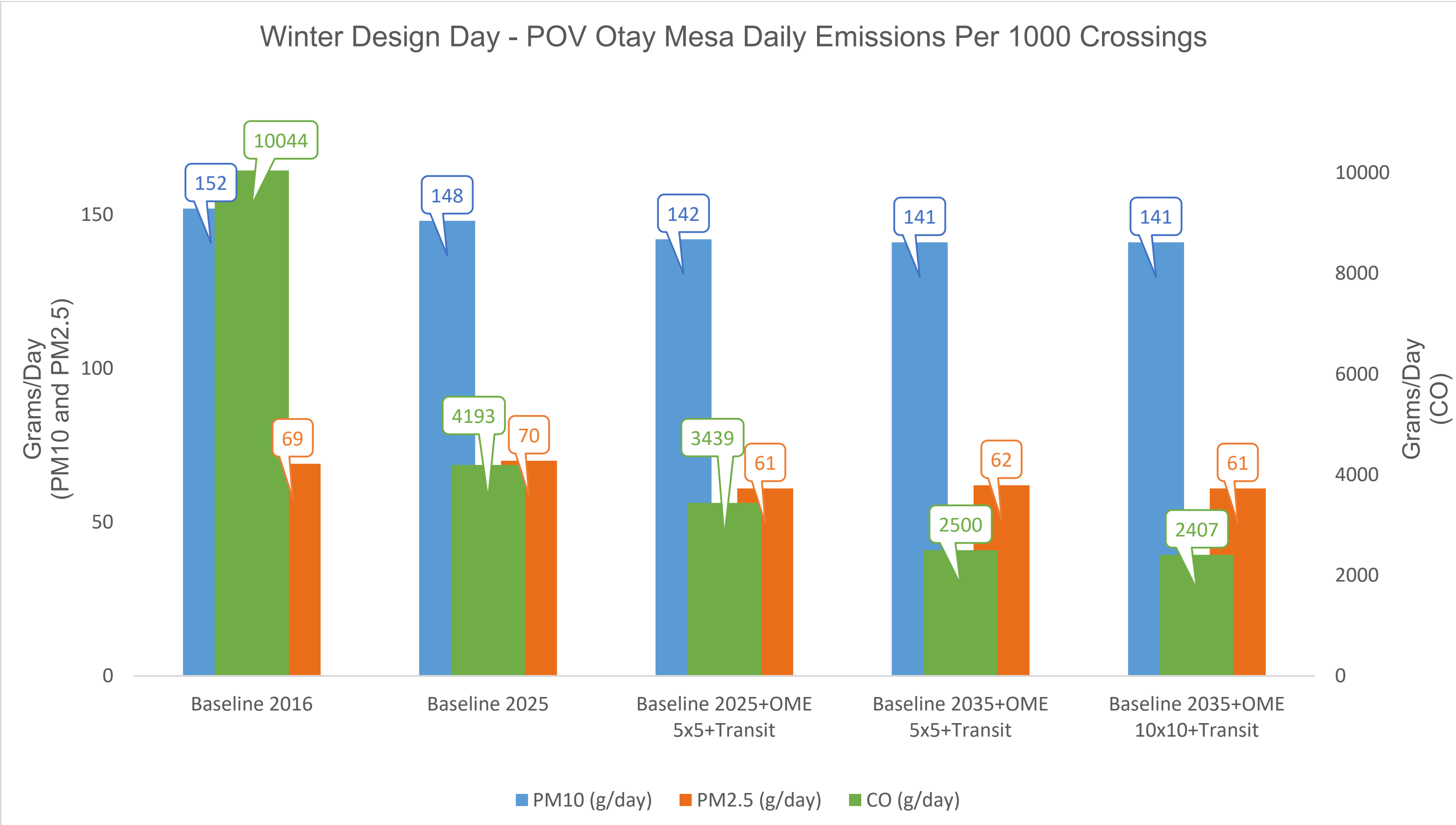
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 29. Summer Design Day PM10, PM2.5, and CO from POVs at the San Ysidro POE



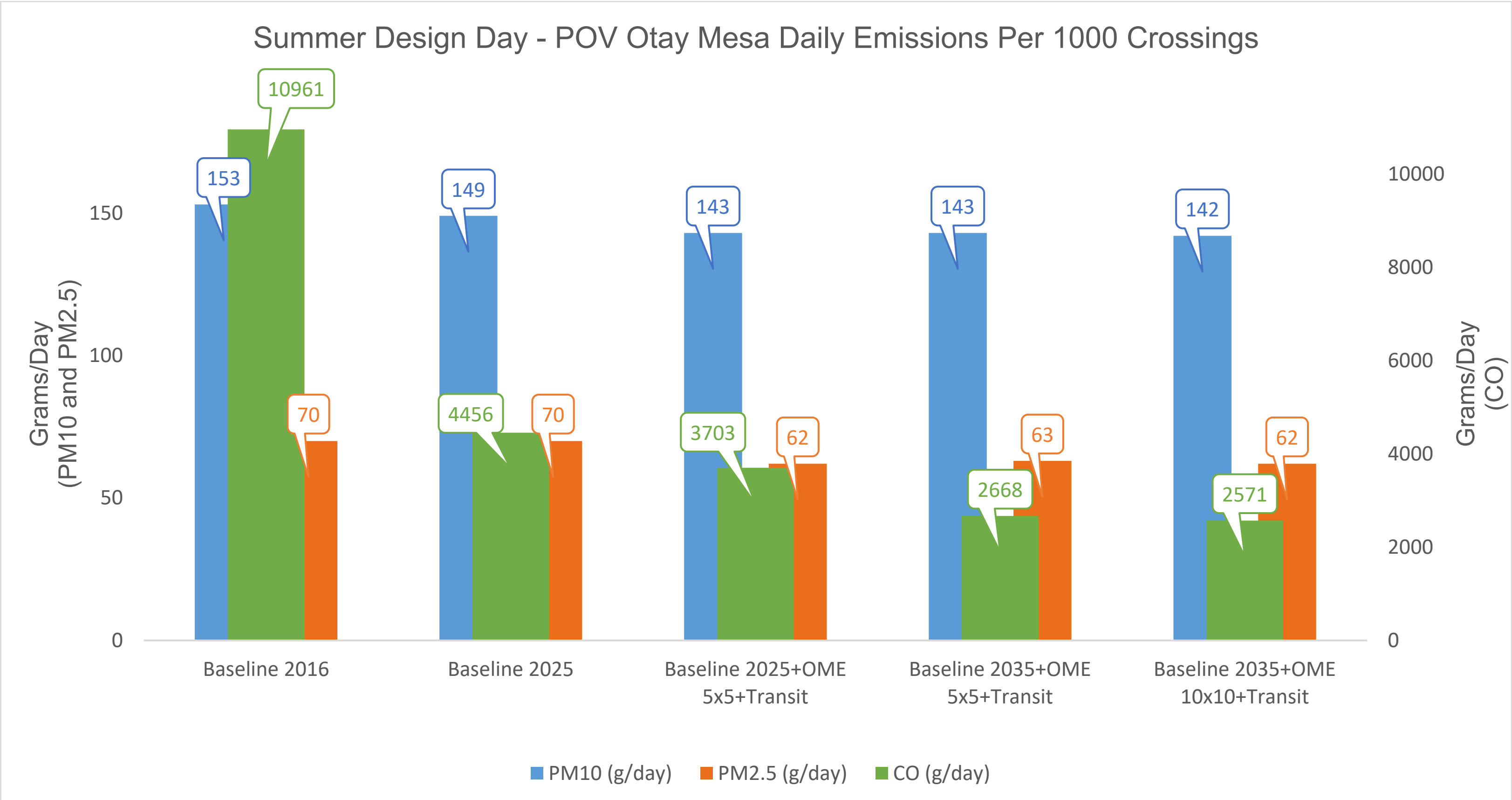
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 30. Winter Design Day PM10, PM2.5, and CO from POVs at the Otay Mesa POE



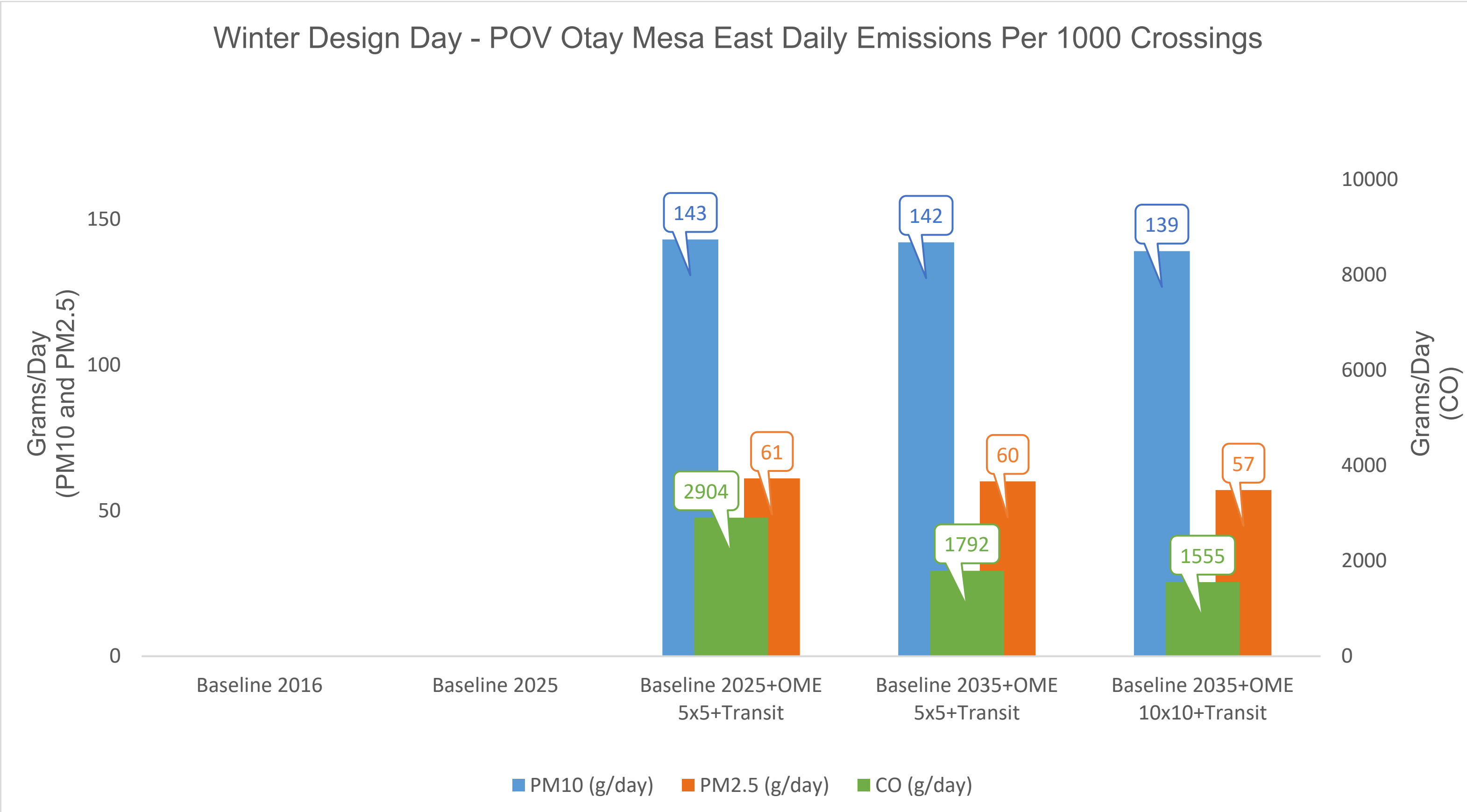
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 31. Summer Design Day PM10, PM2.5, and CO from POVs at the Otay Mesa POE



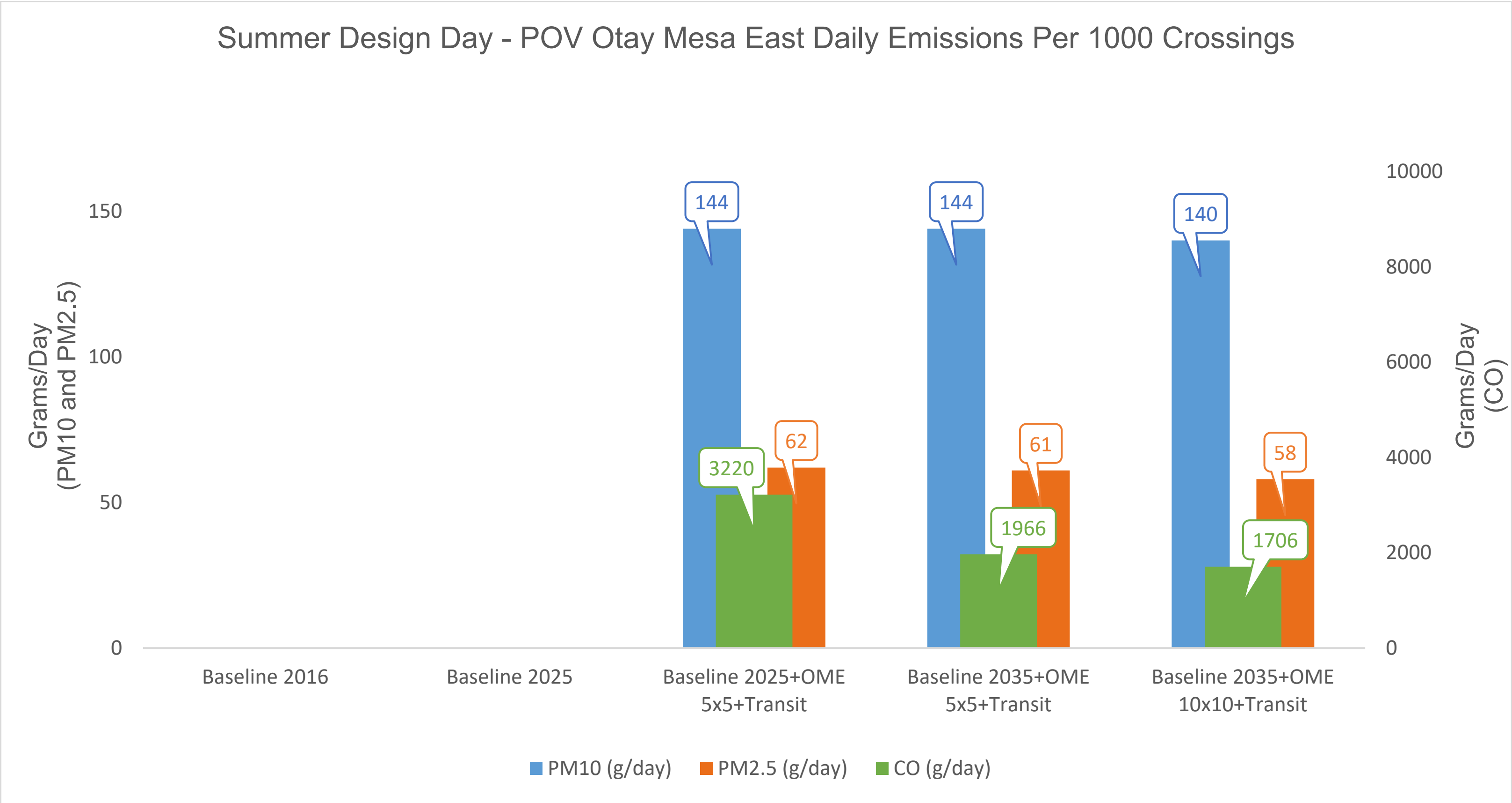
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 32. Winter Design Day PM10, PM2.5, and CO from POVs at the Otay Mesa East POE



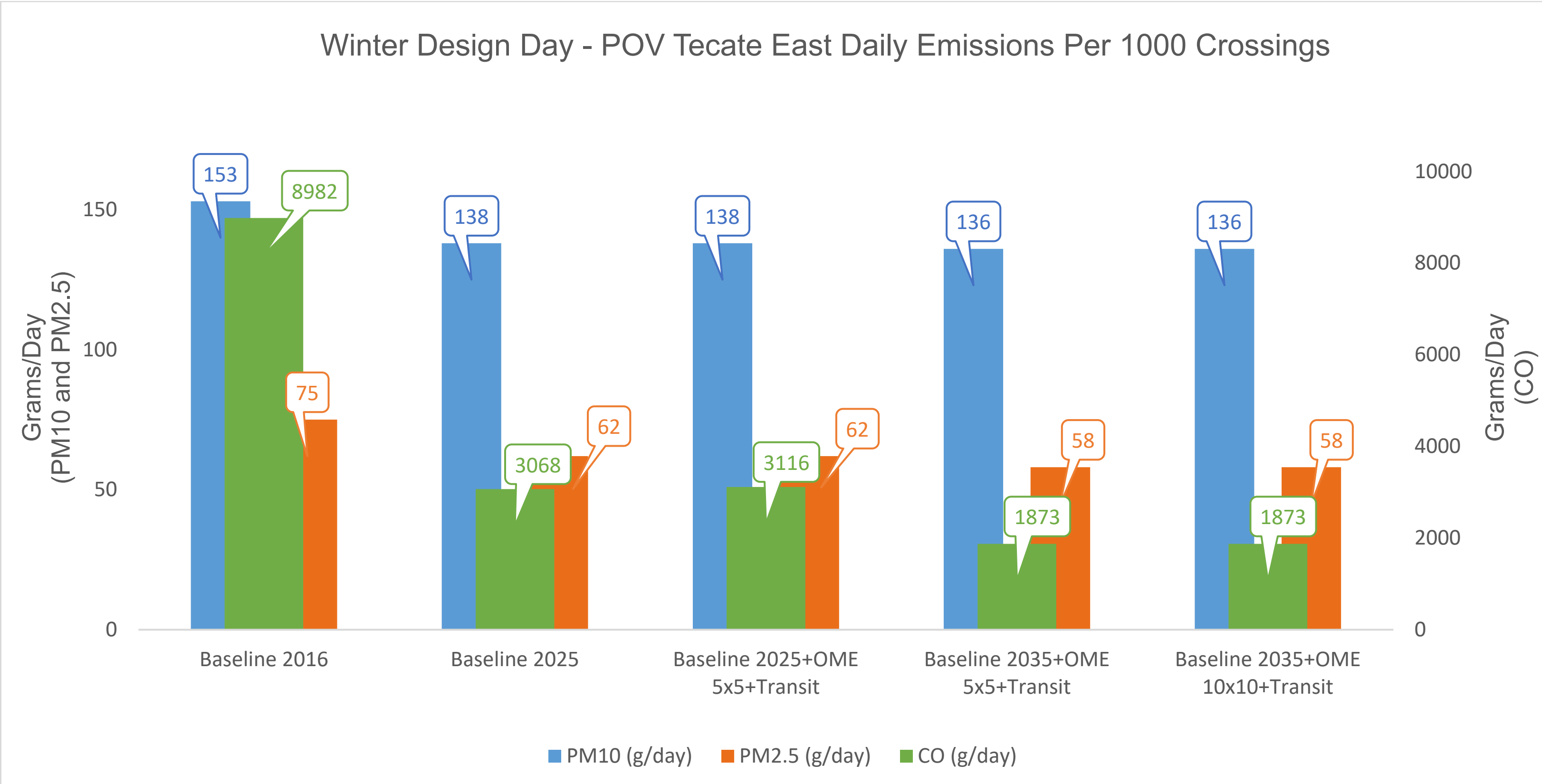
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 33. Summer Design Day PM10, PM2.5, and CO from POVs at the Otay Mesa East POE



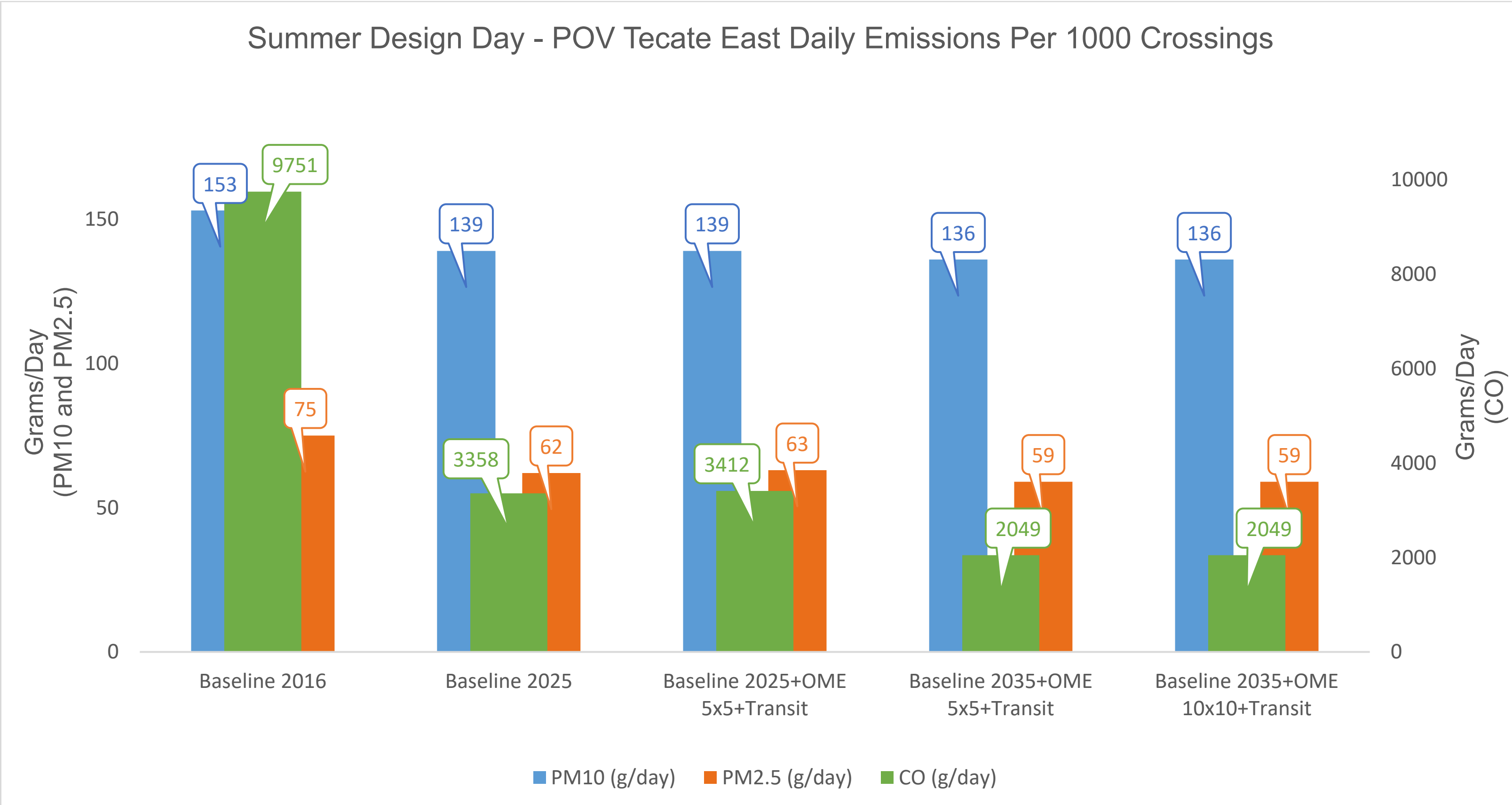
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 34. Winter Design Day PM10, PM2.5, and CO from POVs at the Tecate POE



Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 35. Summer Design Day PM10, PM2.5, and CO from POVs at the Tecate POE



Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

5.3 San Diego County Annual Northbound and Southbound Commercial Vehicle Border Crossings

San Diego County commercial vehicle traffic is shown in Figure 36 through Figure 40, for the five San Diego County analysis scenarios.

From 2016 to 2025, commercial border crossings in San Diego County are anticipated to increase by 21%. With the addition of Otay Mesa East, demand is expected to increase by an additional eleven percentage points of growth (for a total of 32%, with rounding). Anticipated growth through 2035 results in an 80% increase in commercial vehicle border crossings relative to 2016. Most of that growth occurs at the Otay Mesa, and Otay Mesa East POEs. Growth at Tecate through 2035 is anticipated to be limited to 18%.

Figure 36. Baseline 2016 San Diego County Commercial Vehicle Border Crossing Volume by POE

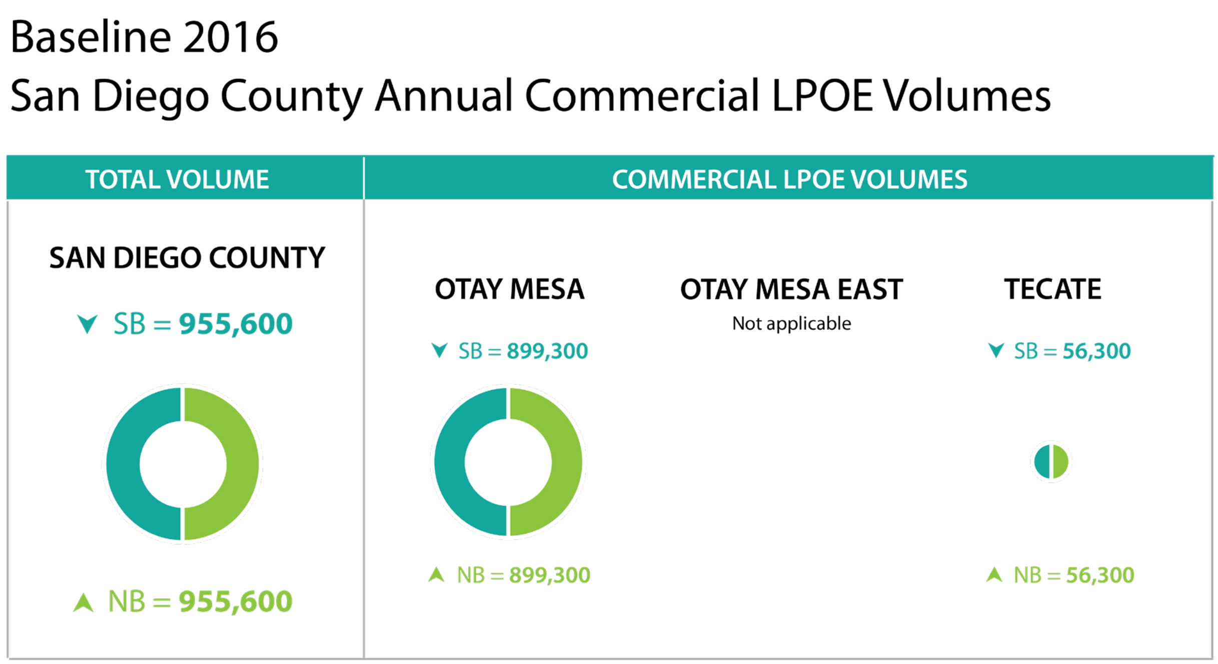


Figure 37. Baseline 2025 San Diego County Commercial Vehicle Border Crossing Volume by POE

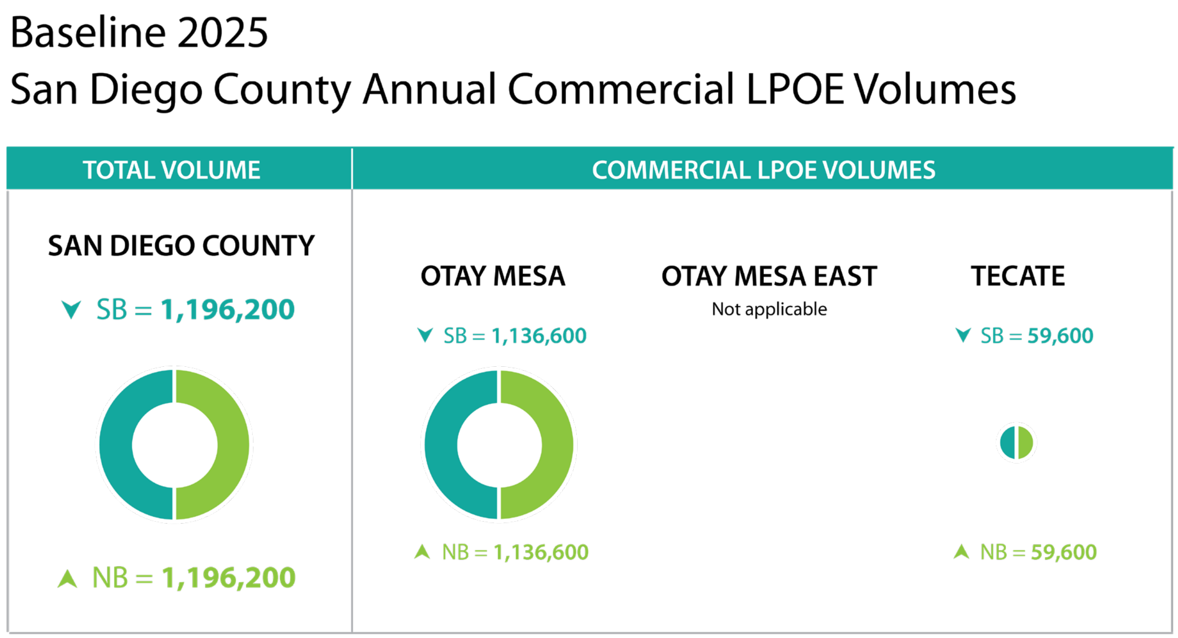


Figure 38. 2025 San Diego County Commercial Vehicle Border Crossing Volume by POE with the Otay Mesa East 5x5 POE

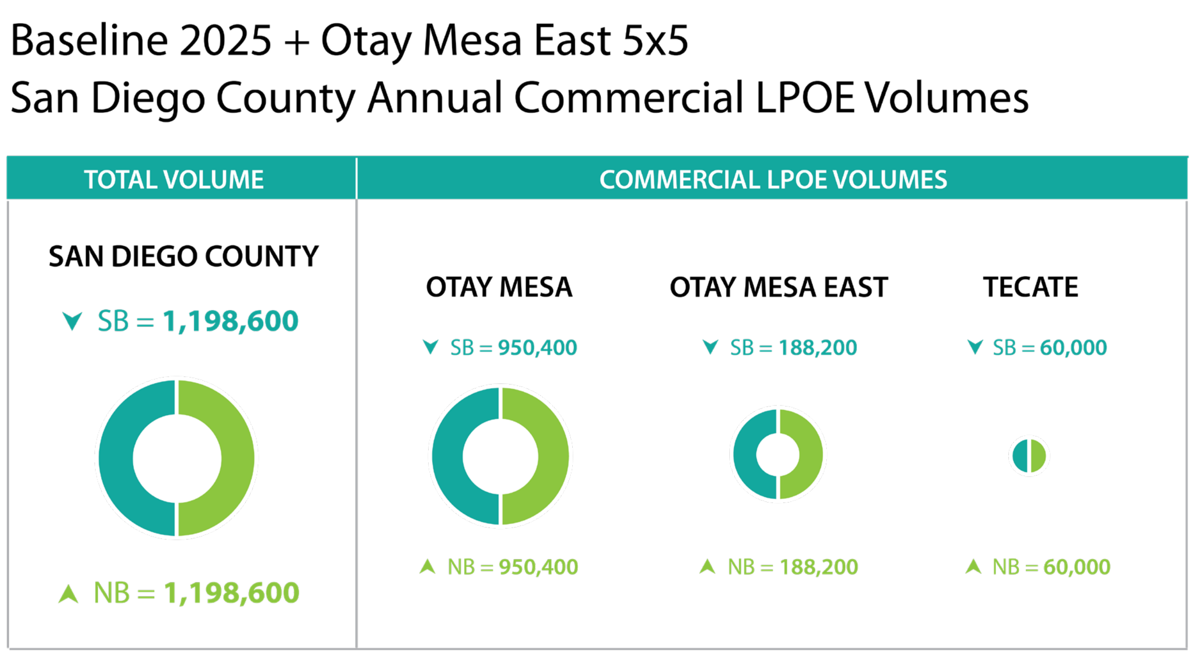


Figure 39. 2035 San Diego County Commercial Vehicle Border Crossing Volume by POE with the Otay Mesa East 5x5 POE

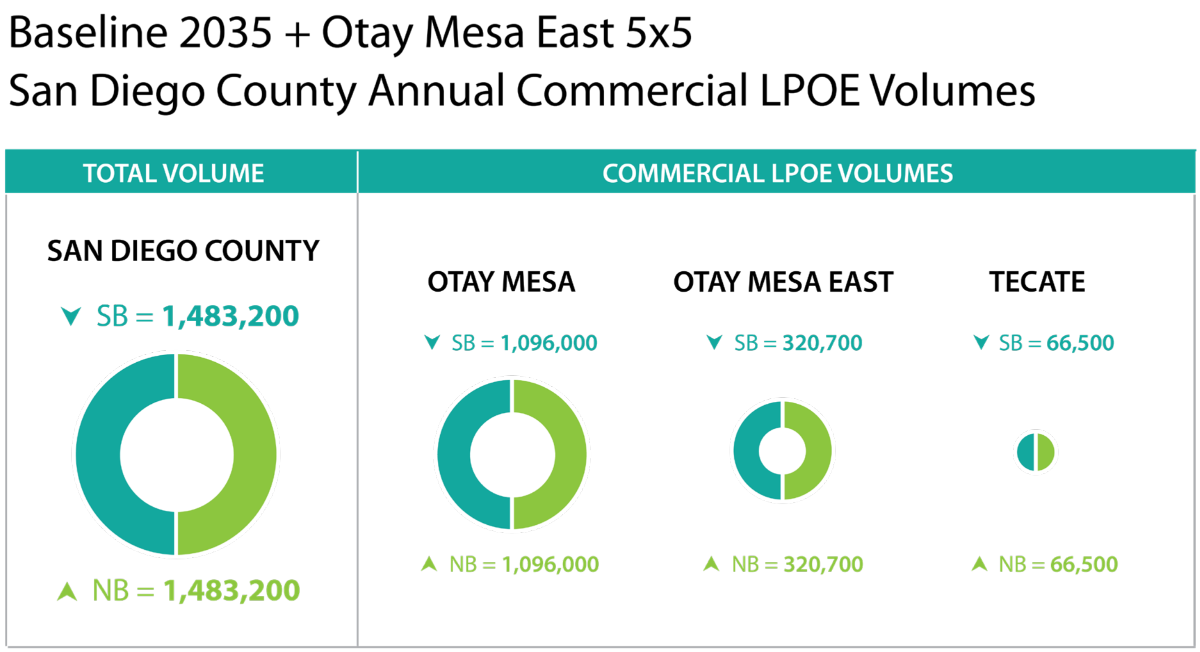
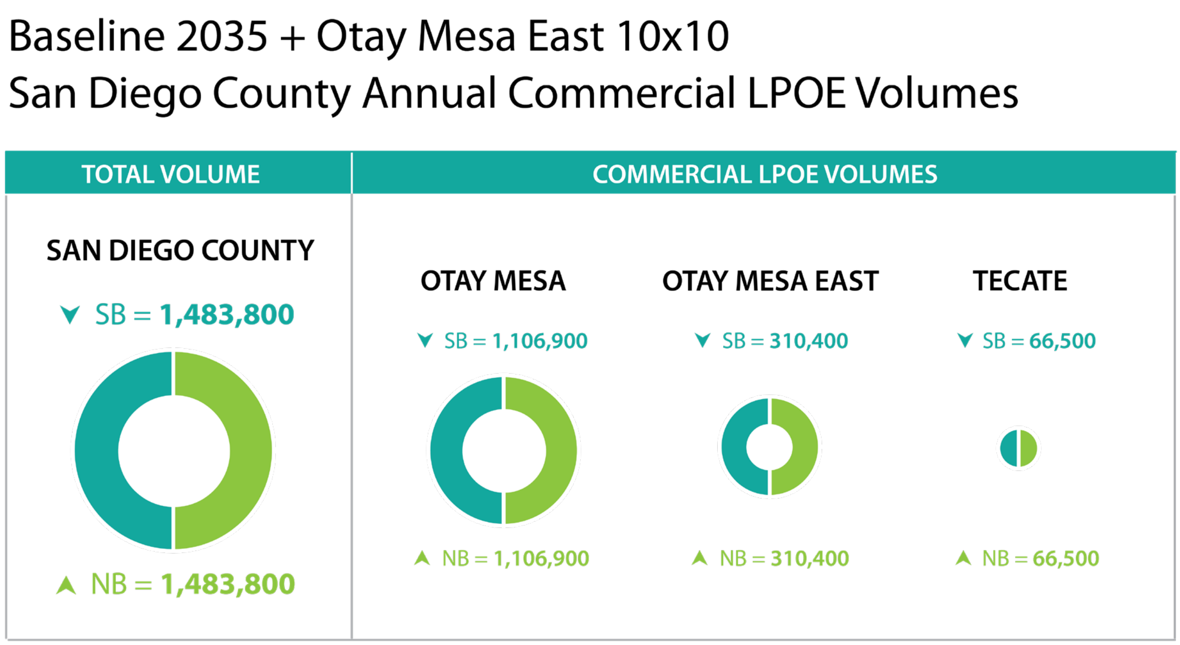


Figure 40. 2035 San Diego County Commercial Vehicle Border Crossing Volume by POE with the Otay Mesa East 10x10 POE



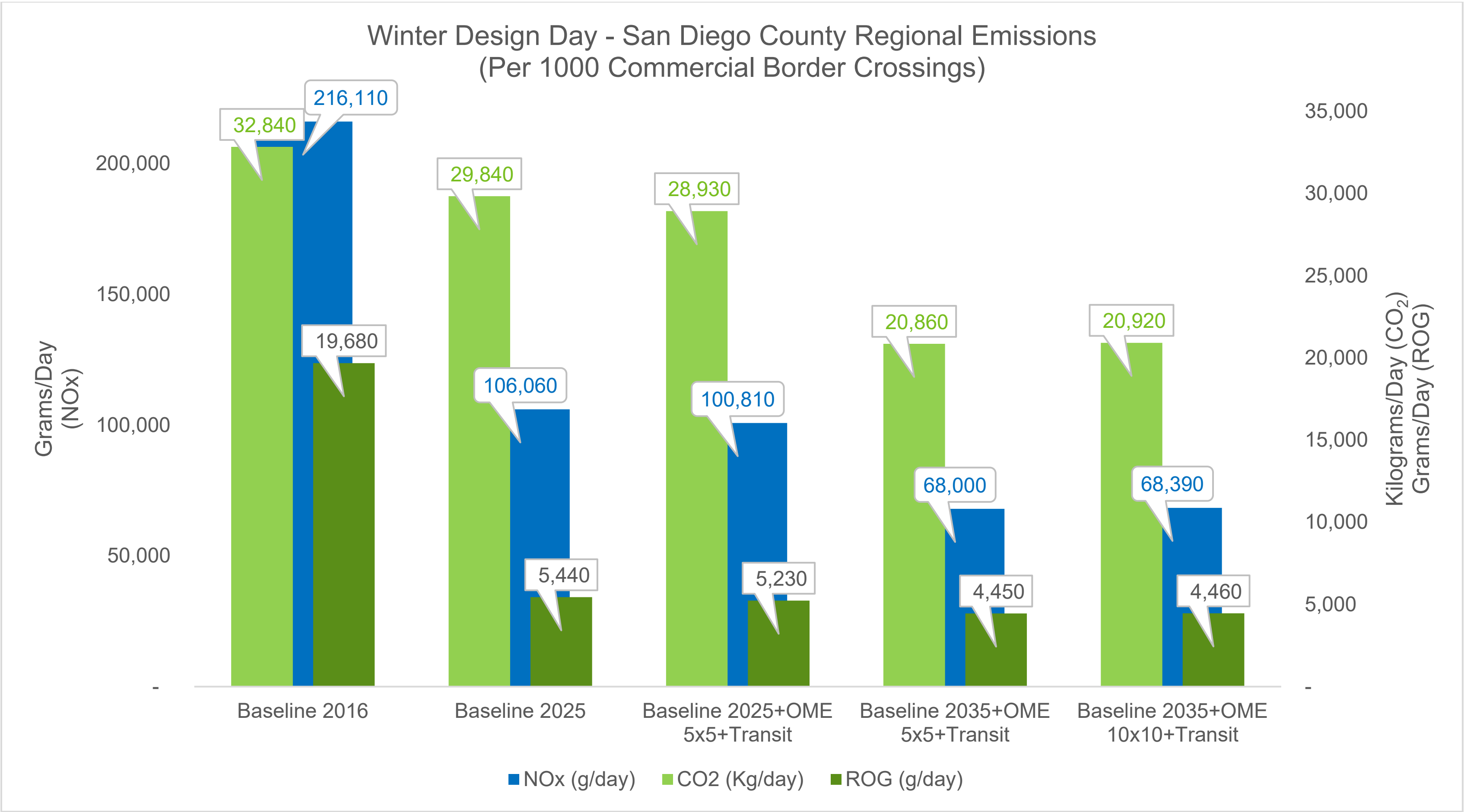
5.4 San Diego County Annual Northbound and Southbound Commercial Vehicle Emissions

Average daily seasonal emissions are reported for winter and summer “design days”. The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all POE emissions for that season). Emissions are reported in units of grams per day, except for CO_2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 41 and Figure 42 report emissions for ROG, NOx, and CO_2 per 1,000 commercial vehicles crossing the through the POEs between San Diego County, and the State of Baja California. The results show emission reductions from the 2016 to 2025 baseline scenarios. This result reflects both the capacity enhancements from the Otay Mesa Cargo Modernization program, and the benefit of a less polluting and more efficient 2025 commercial truck fleet relative to 2016. The capacity increase in 2025 through the addition of Otay Mesa East further reduces delay and emissions per commercial vehicle crossing, with the exception of a slight increase in winter season CO. By 2035 emissions of ROG, NOx, and CO_2 from each border crossing decrease further due to the cleaner 2035 truck fleet offsetting increased delays. Induced crossing demand and the redistribution of trips between Otay Mesa and OME are anticipated to slightly increase emissions with the OME 10x10 POE in 2035 (relative to the 5x5 POE). However, that increase could easily be explained by the accuracy of traffic forecasting and should not be considered as breaking the overall trend of lower emissions per vehicle crossing over time with continued investment at the POEs.

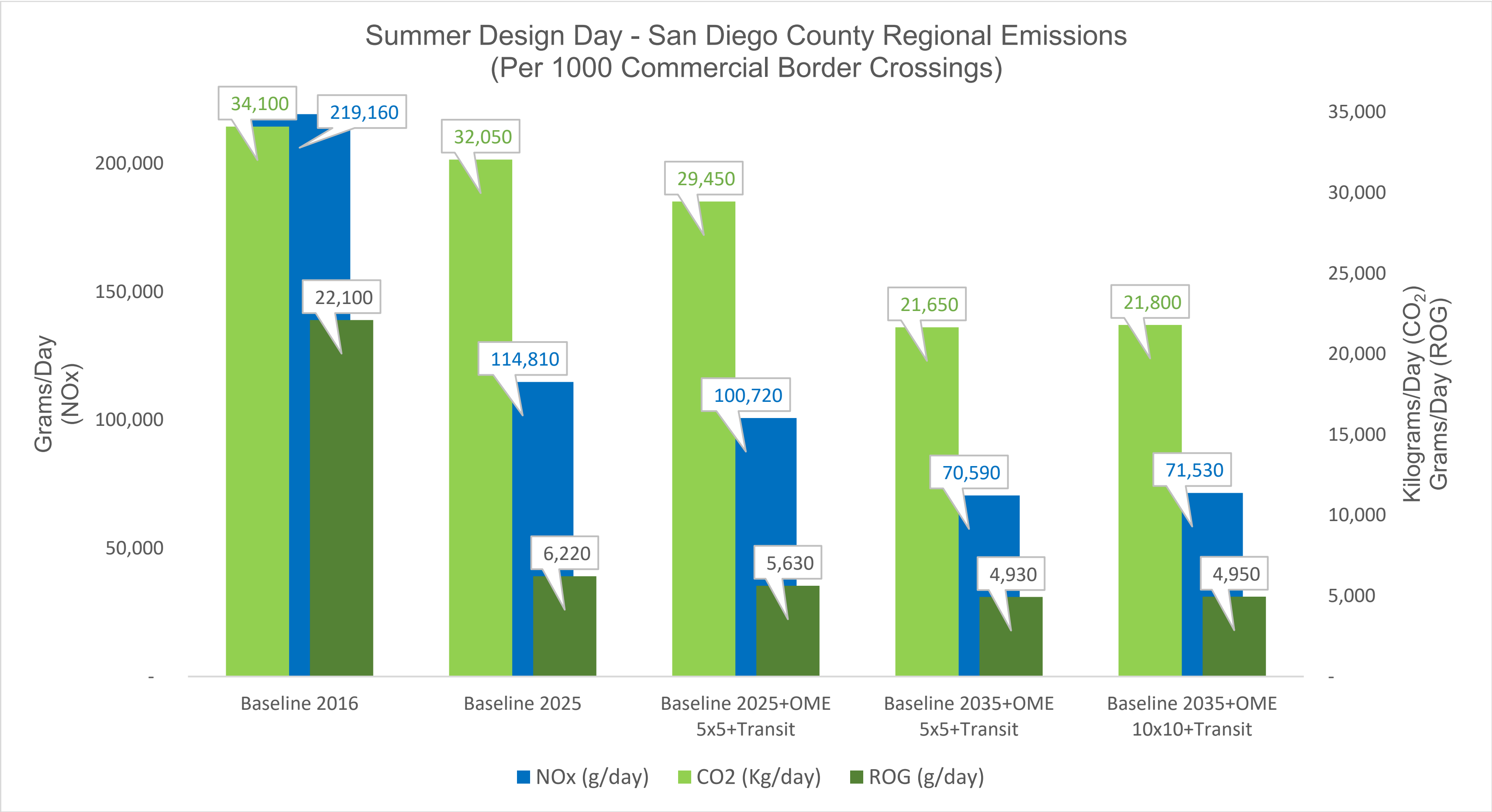
PM10, PM2.5, and CO emission results are reported separately for each San Diego County POEs in Figure 43 through Figure 48. There are two figures for each POE providing winter design day and summer design day results for all five analysis scenarios. Trends for each POE follow the county wide trend reported above.

Figure 41. Winter Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at San Diego County POEs



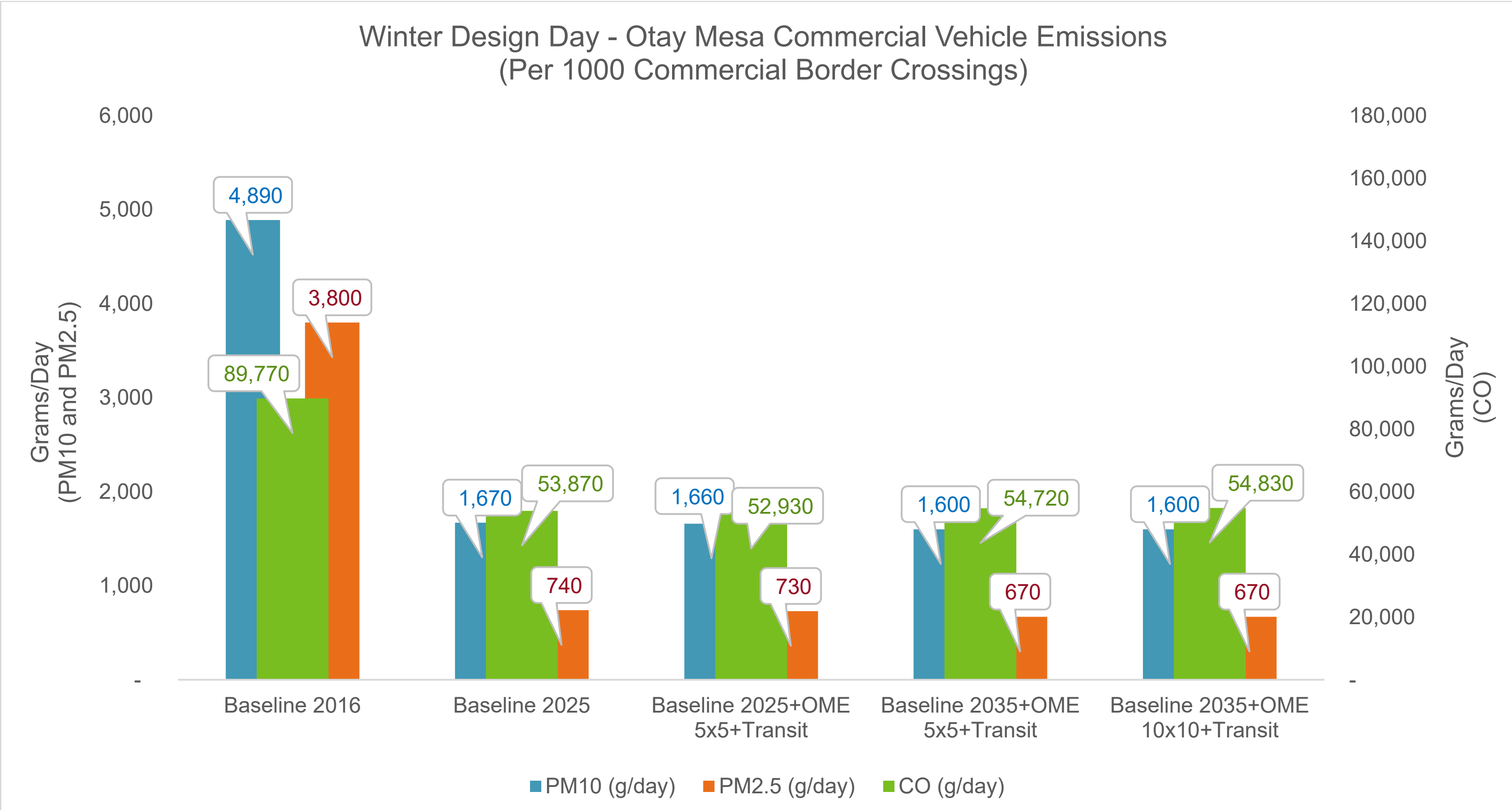
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 42. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at San Diego County POEs



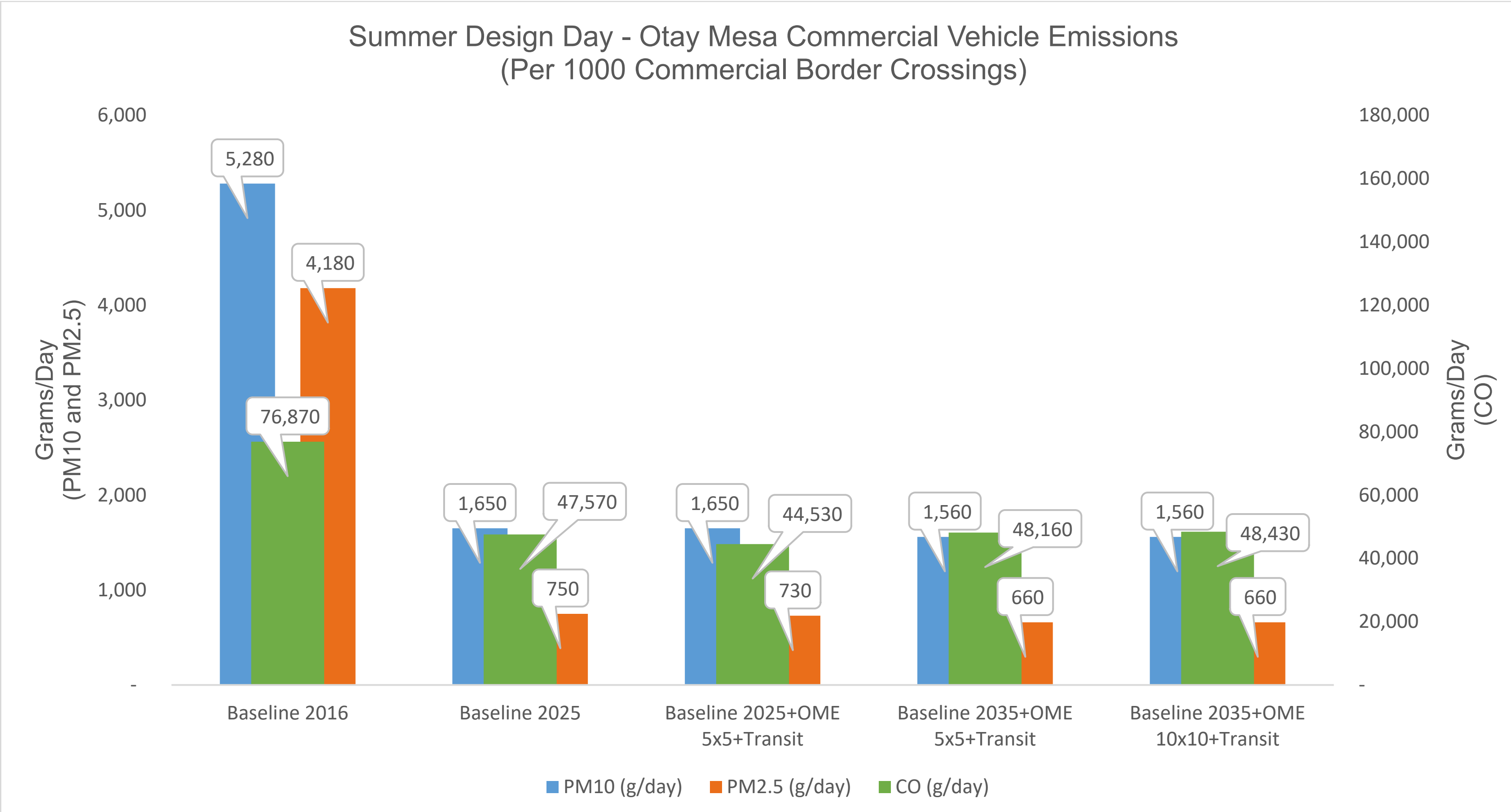
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 43. Winter Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa POE



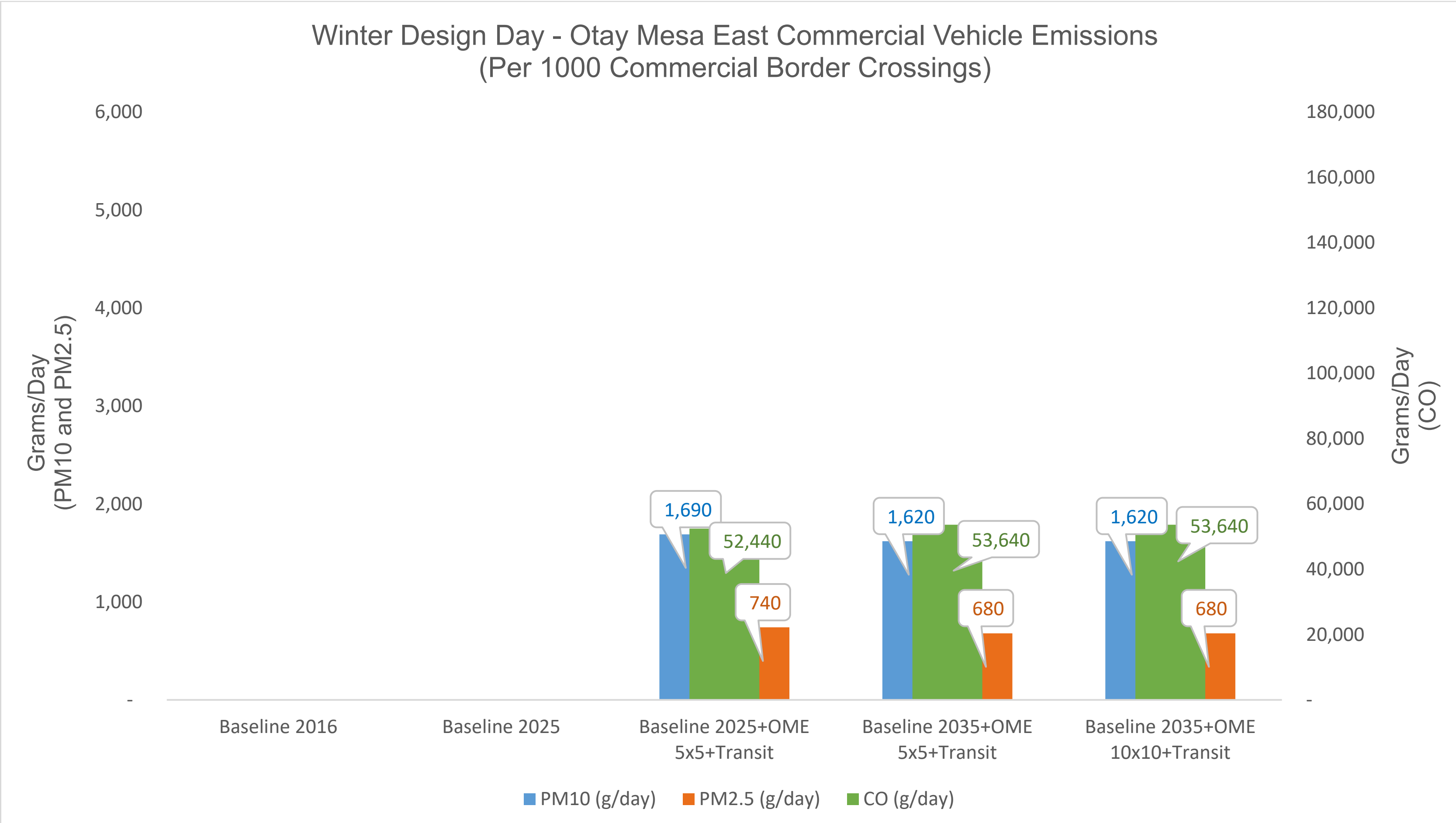
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 44. Summer Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa POE



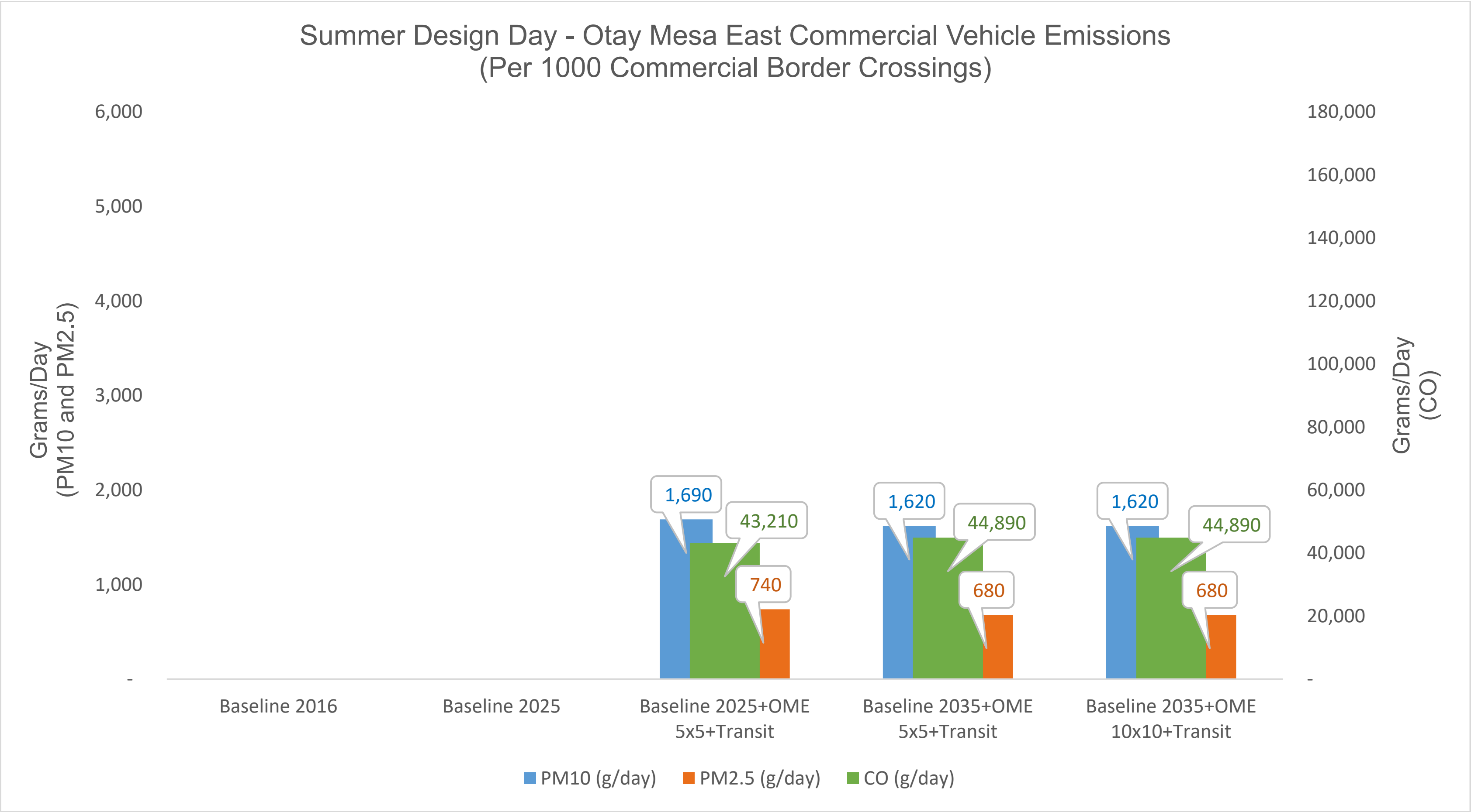
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 45. Winter Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa East POE



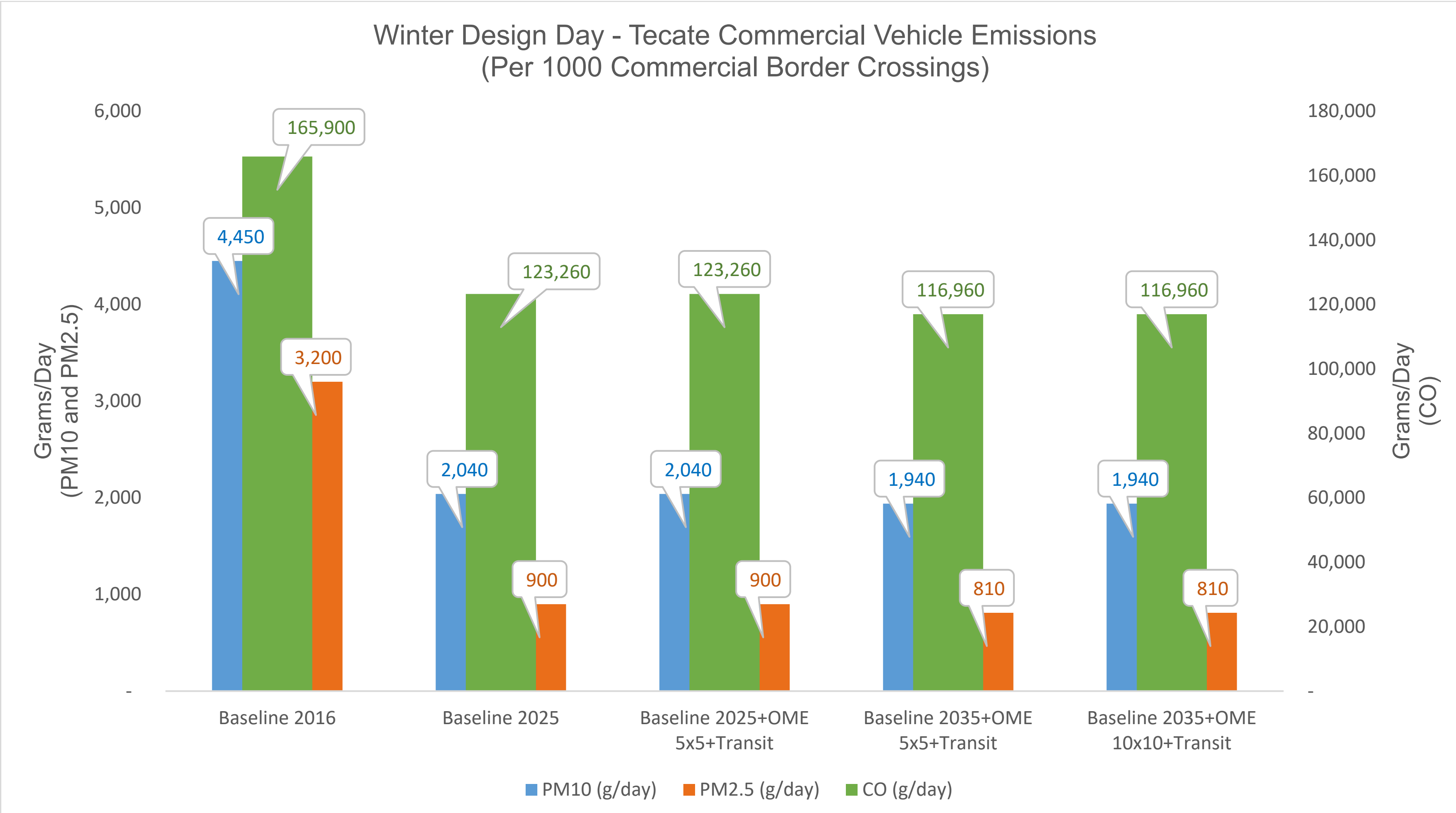
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 46. Summer Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Otay Mesa East POE



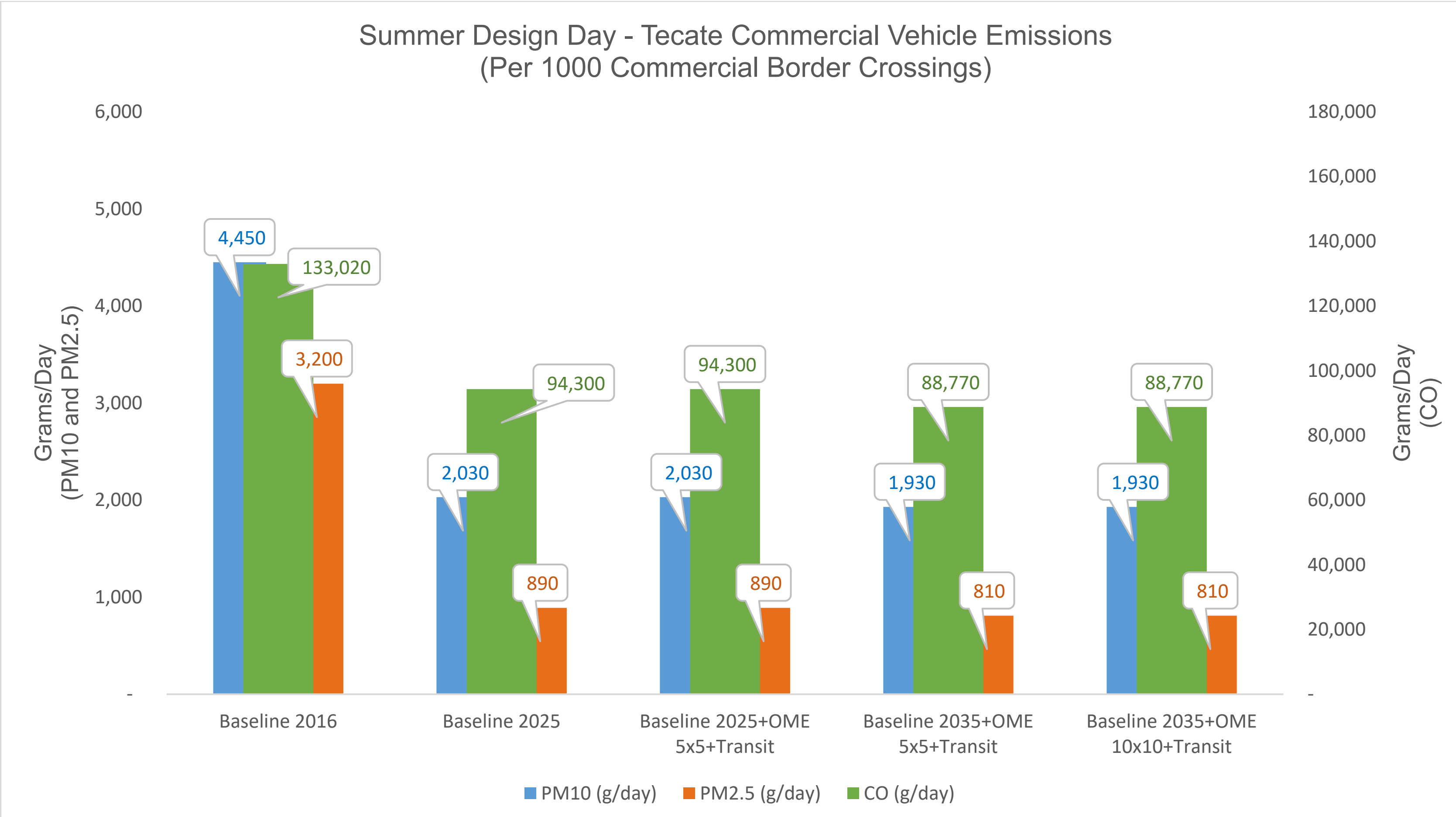
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 47. Winter Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Tecate POE



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 48. Summer Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Tecate POE



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

6 Assessment of Imperial County POE Emissions

Imperial County results for POV and commercial vehicle POEs are presented in separate sections below, mirroring how results were presented for San Diego County.

Seasonal PM10, PM2.5, and CO are presented for each POE. For each season, a single annual result is included for ROG, NOx, and CO_2, which represents the combined emissions from all POV border crossings in the county, and separately for all commercial border crossings in the county. Excel spreadsheets that calculate emissions for each POE by lane type, process, and hour of the day are available as electronic appendices.

The five Imperial County scenarios described in Section 3 for all POEs are addressed for ROG, NOx, CO_2, PM10, PM2.5, and CO:

- Baseline 2016 POV: This scenario reflects how each POE operates in 2016.
- Baseline 2025 POV: This scenario reflects how each POE is anticipated to operate in 2025. Key changes relative to 2016 include the Phase 1 improvements at Calexico West, including:
    - ✓ A new northbound POE facility for POVs with ten lanes.
    - ✓ Note that the planned removal of the ten existing northbound lanes does not officially occur until the Phase 2 improvements. Therefore, the POE is modeled as having twenty northbound lanes at Calexico West under this scenario.
- Baseline 2025 plus the All-American Canal (AAC) and Transit Improvements: This scenario adds:
    - ✓ Adds six additional northbound POV booths at Calexico East, and a widened bridge over the AAC. (The additional primary booths have yet to be approved by the US government.)
    - ✓ Assumes construction of Calexico West Phase 2A improvements, which five additional southbound lanes, six additional northbound lanes and removes the ten older northbound lanes at the existing facility. Thus, there are a total of 16 northbound lanes and 5 southbound lanes at Calexico West.
    - ✓ Changes in POV and bus volumes associated with the planned active transportation and transit improvements discussed in Section 3 are also included. (assumes OME 5x5.)
- Baseline 2035 plus AAC and Transit Improvements (OME 5x5): This scenario reflects an additional ten years of growth. (Assumes OME 5x5).

- Baseline 2035 plus AAC and Transit Improvements (OME 10x10): This scenario reflects an additional ten years of growth and assumes OME at a 10x10 configuration. (Note that the size of OME will not directly impact emissions in Imperial County.)

Annual volume estimates for each POE are presented before the emissions results. In general, the volumes grow from 2016 to 2025, and then decline slightly into 2035 as relatively flat growth in county wide border crossing demand is offset by growth in non-POV mode share at Calexico West. Details of the traffic forecasting are discussed in Volume 1. For Imperial County, forecasts were generally based on elasticities derived from San Diego forecasts. Forecasted border crossing volume includes the effect of induced growth in person and commercial trips associated with the various capacity enhancements.

Emissions data are normalized based on the number of border crossings, and are presented per 1,000 border crossings. This emphasizes the combined effect of reduced delay and queuing plus cleaner, more efficient, vehicles.

For POVs, the emissions per border crossing are reduced by capacity enhancement scenarios (including transit and active transportation improvements) through 2035. Commercial vehicle emissions per border crossing drop through 2035 as well. Capacity enhancements reduce delay, and improvements in vehicle technology combine to produce these benefits. Overall, the largest proportion of emission reductions is anticipated to occur by 2025. Emissions per crossing continue to be reduced through 2035 but those reductions are modest as there are fewer benefits from ongoing turnover of the vehicle fleet replacing older high polluting vehicles with newer cleaner vehicles and fuels.

Adjustments for ROG emissions, based on Table 10, and the proportion of Mexican fuel at each POE, account for effect that Mexican gasoline has ROG emissions: CO_2 emissions reflect tailpipe CO_2, and are not corrected to account for low carbon fuel standards (LCFS) per EMFAC2017 guidance. The LCFS regulation is excluded from EMFAC2017 because most of the emissions benefits due to the LCFS come from the production cycle (upstream emissions) of the fuel rather than the combustion cycle (tailpipe). As a result, LCFS is assumed to not have a significant impact on CO_2 emissions from EMFAC's tailpipe emission estimates and adjustments for vehicles running Mexican fuels are no longer necessary.

Sections 6.1 and 6.2 below present the POV border crossing volumes and emissions, respectively. Sections 6.3 and 6.4 present the corresponding commercial vehicle volumes and emissions.

6.1 Imperial County Annual Northbound and Southbound POV Border Crossings

Figure 49 through Figure 53 show Imperial County POV volumes for each of the five county-wide scenarios. Volumes for each POEs that process POVs are presented, along with the county-wide totals. Volume 1 details the sources of existing and forecast traffic volumes[43].

[43] Note that Volumes reported herein add annual bus trips to the POV values reported in Volume 1.

To understand how volumes and emissions change between scenarios for POVs, note that:

- POV border crossings are anticipated to increase by about 14% from 2016 to 2025 without the bridge expansion at Calexico East. Induced demand with those improvements and Calexico West improvements results in an additional 2% increase in border traffic relative to 2016, for overall volume growth of about 16%.
- Across all Imperial County POEs, growth in POV volume from 2025 to 2035 declines slightly, reflecting the elasticities derived from San Diego County forecasting and growth in non-POV mode share at Calexico West.

The annual northbound volume for each POE was scaled to represent seasonal weekdays and weekend-days, and split into Regular lane, Ready Lane, and SENTRI lane volumes based on information from the Bureau of Transportation Statistics[44], data from prior studies[45], and data collected for this study. Southbound flows were also adjusted for seasonality and day of the week. Weekdays represent Tuesday through Thursday, while weekends reflect Saturday and Sunday Conditions. Seasonal and weekday/weekend adjustments are provided in Table 37. The breakout of traffic by Regular lane, Ready Lane, and SENTRI lane for each POE is provided in Table 38.

[44] BTS (2018) Bureau of Transportation Statistics, www.bts.gov/content/border-crossingentry-data.
[45] Imperial County APCD (2015) Vehicle Idling Emissions Study at Calexico East and Calexico West Ports-of-Entry, www.co.imperial.ca.us/airpollution/Forms%20&%20Documents/BORDER/Calexico%20POEs%20Final%20November%202,%202015.pdf.

Table 37. Northbound Imperial County POV seasonal weekday and weekend adjustments to annualized daily border crossing data.

POE	Winter Weekday	Winter Weekend	Summer Weekday	Summer Weekend
Calexico West				
Regular lane	99%	98%	99%	98%
Ready Lane (2025 & 2035 only)	99%	98%	99%	98%
SENTRI lane	99%	98%	99%	98%
Southbound	94%	107%	94%	107%
Calexico East				
Regular lane	106%	94%	102%	91%
Ready Lane	106%	94%	102%	91%
SENTRI lane	106%	94%	102%	91%
Southbound	102%	104%	98%	101%
Andrade				
Regular lane	103%	102%	95%	95%
Southbound				

Table 38. Northbound Imperial County POV lane utilization

POE	Regular Lane	Ready Lane	SENTRI Lane
Calexico West (2016)	55%		44%
Calexico West (2025 and 2035)	22%	39%	39%
Calexico East	27%	56%	17%
Andrade	100%		

Southbound POV travel, through Calexico West, and Calexico East POEs are assumed to operate as if the POEs share capacity across a single system, with about 72% of the southbound POVs using Calexico West and 28% using Calexico East.

Figure 49. Baseline 2016 Imperial County POV Border Crossing Volume by POE

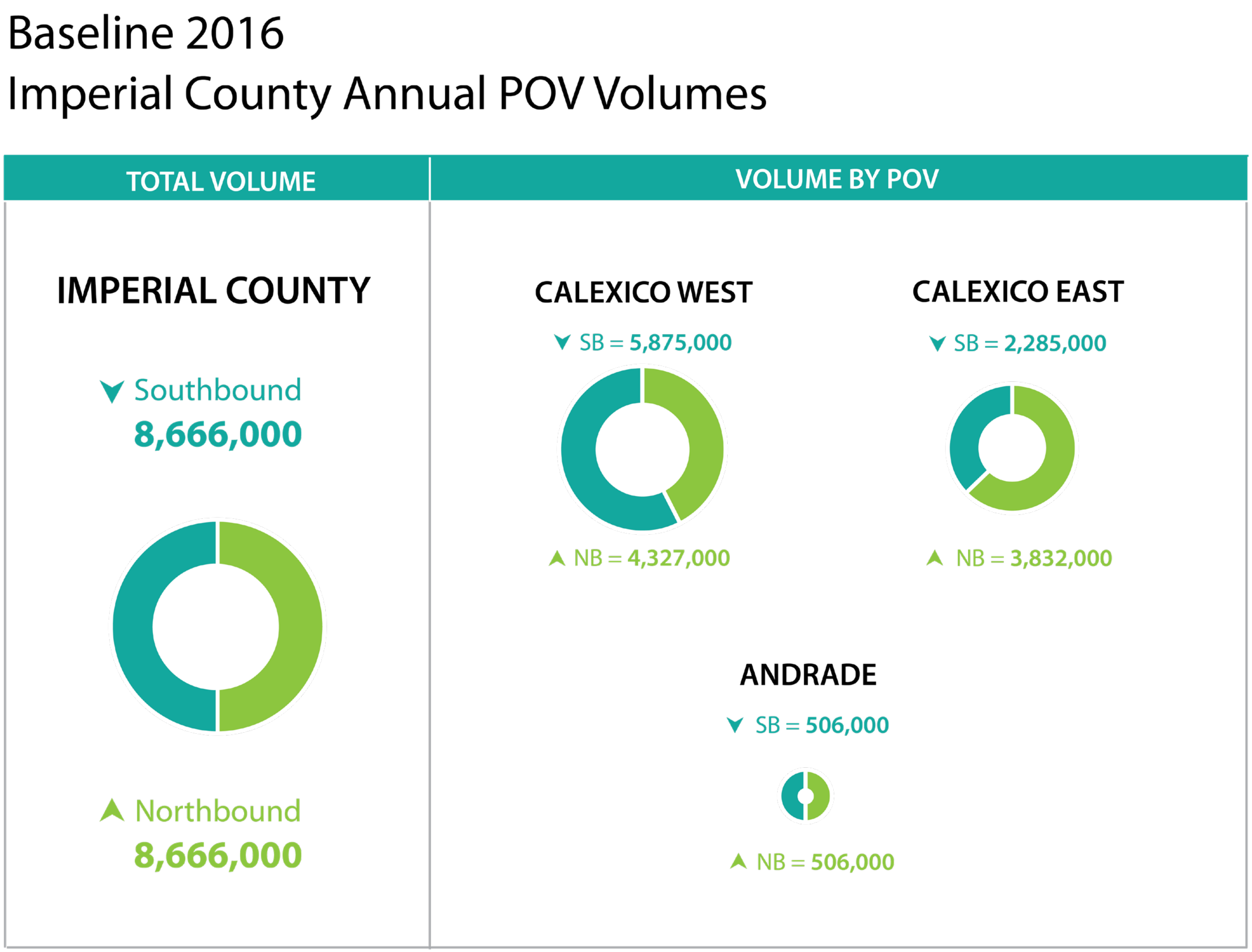


Figure 50. Baseline 2025 Imperial County POV Border Crossing Volume by POE

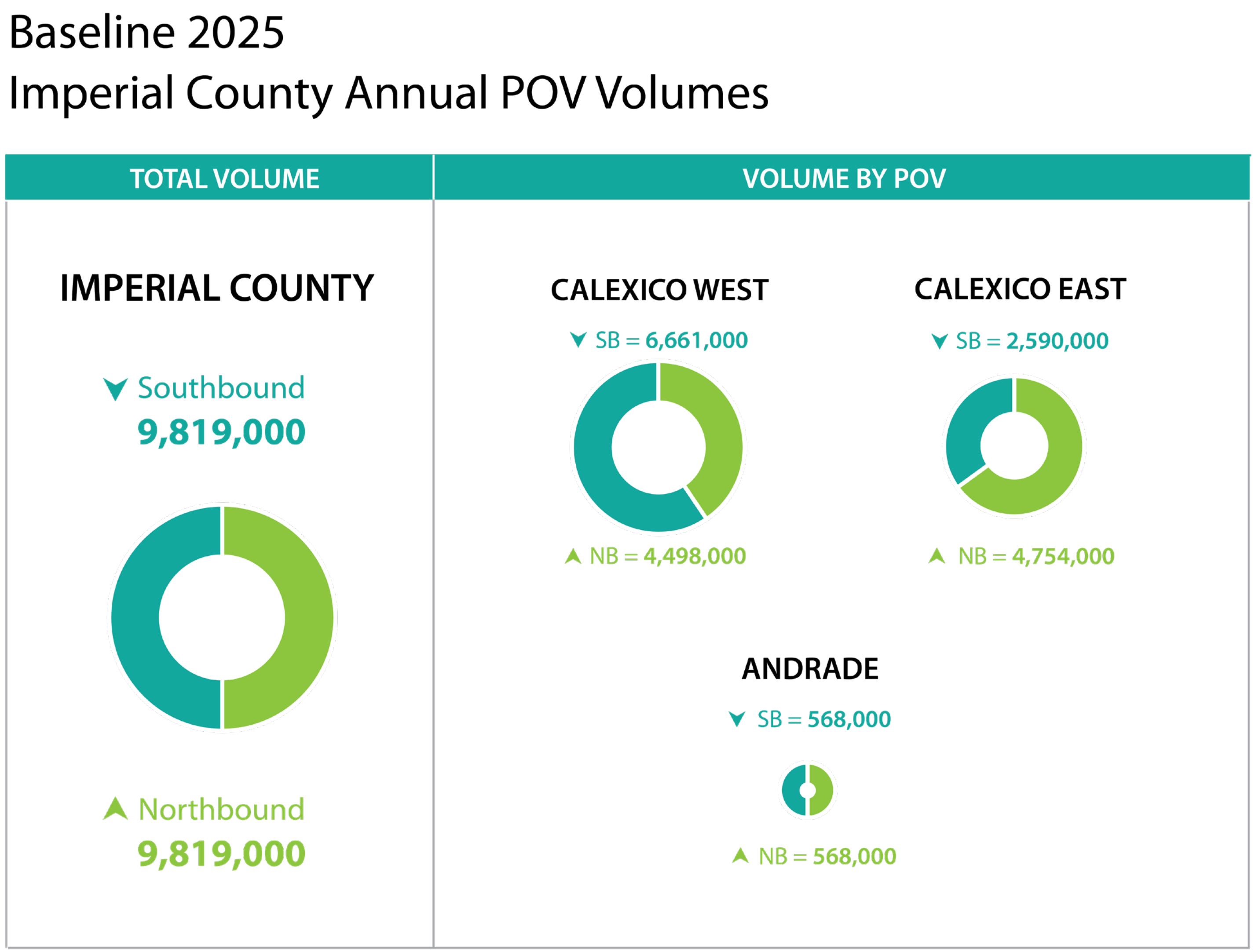


Figure 51. 2025 Imperial County POV Border Crossing Volume by POE with the All American Canal Improvements (OME 5x5)

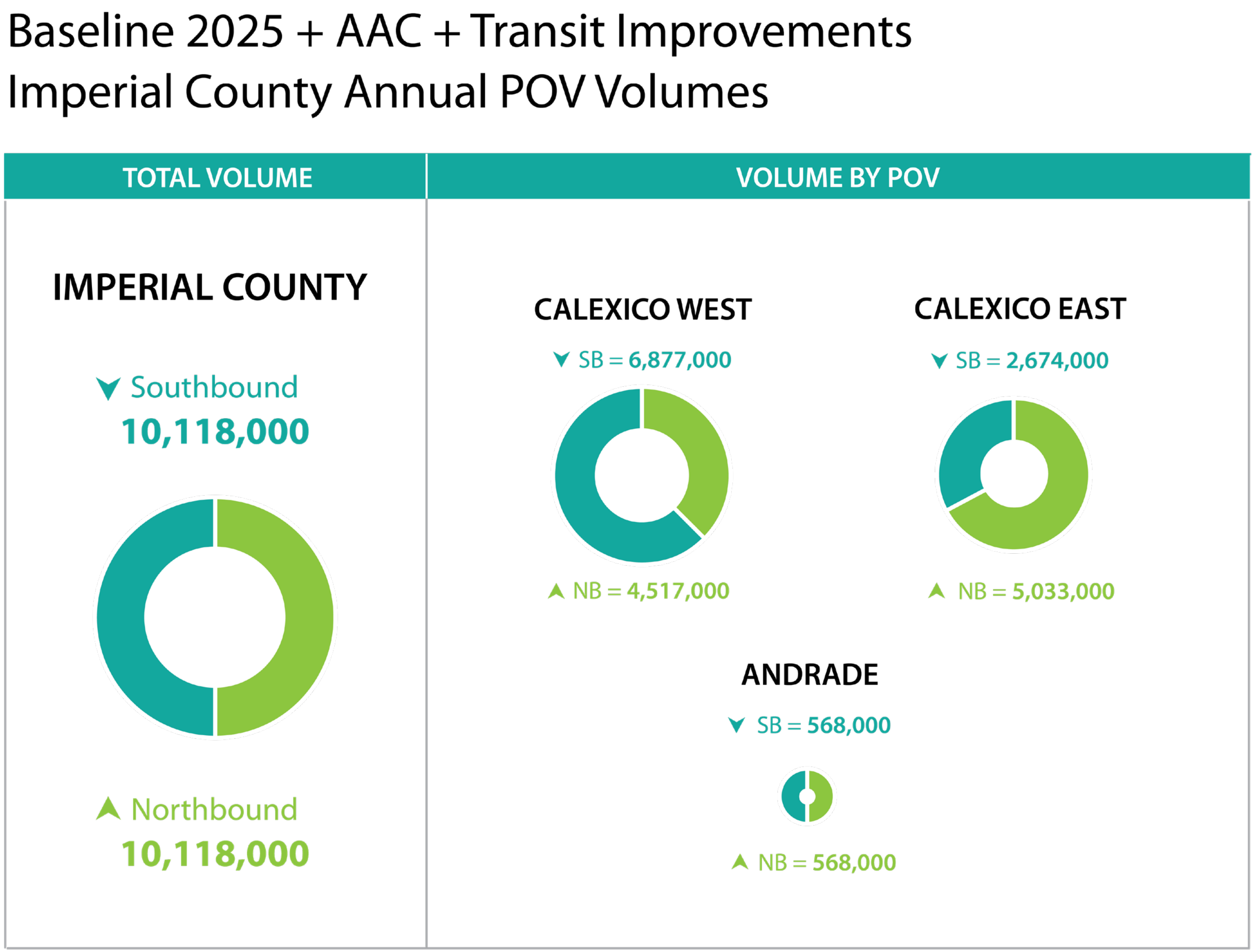


Figure 52. 2035 Imperial County POV Border Crossing Volume by POE with the All American Canal Improvements (OME 5x5)

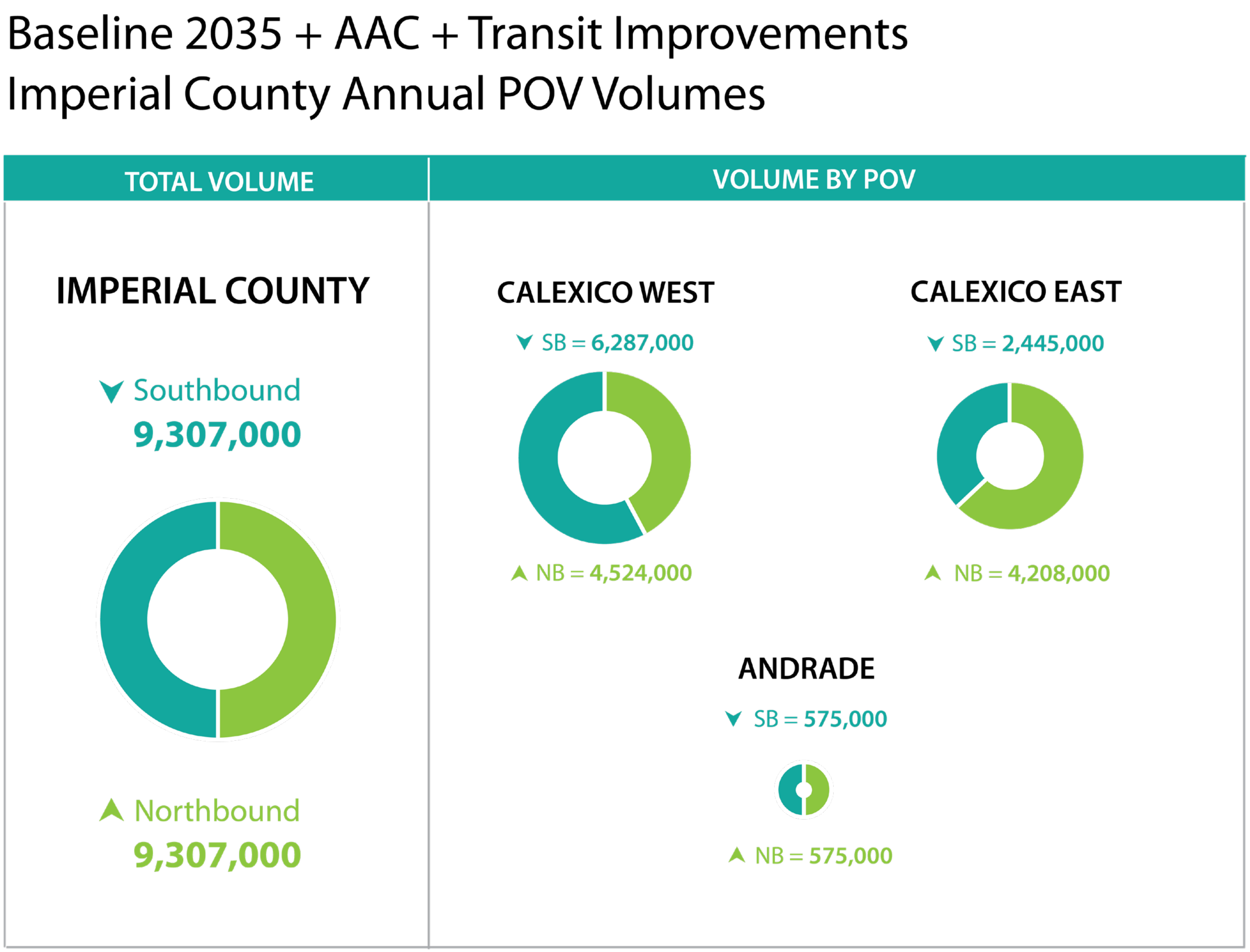
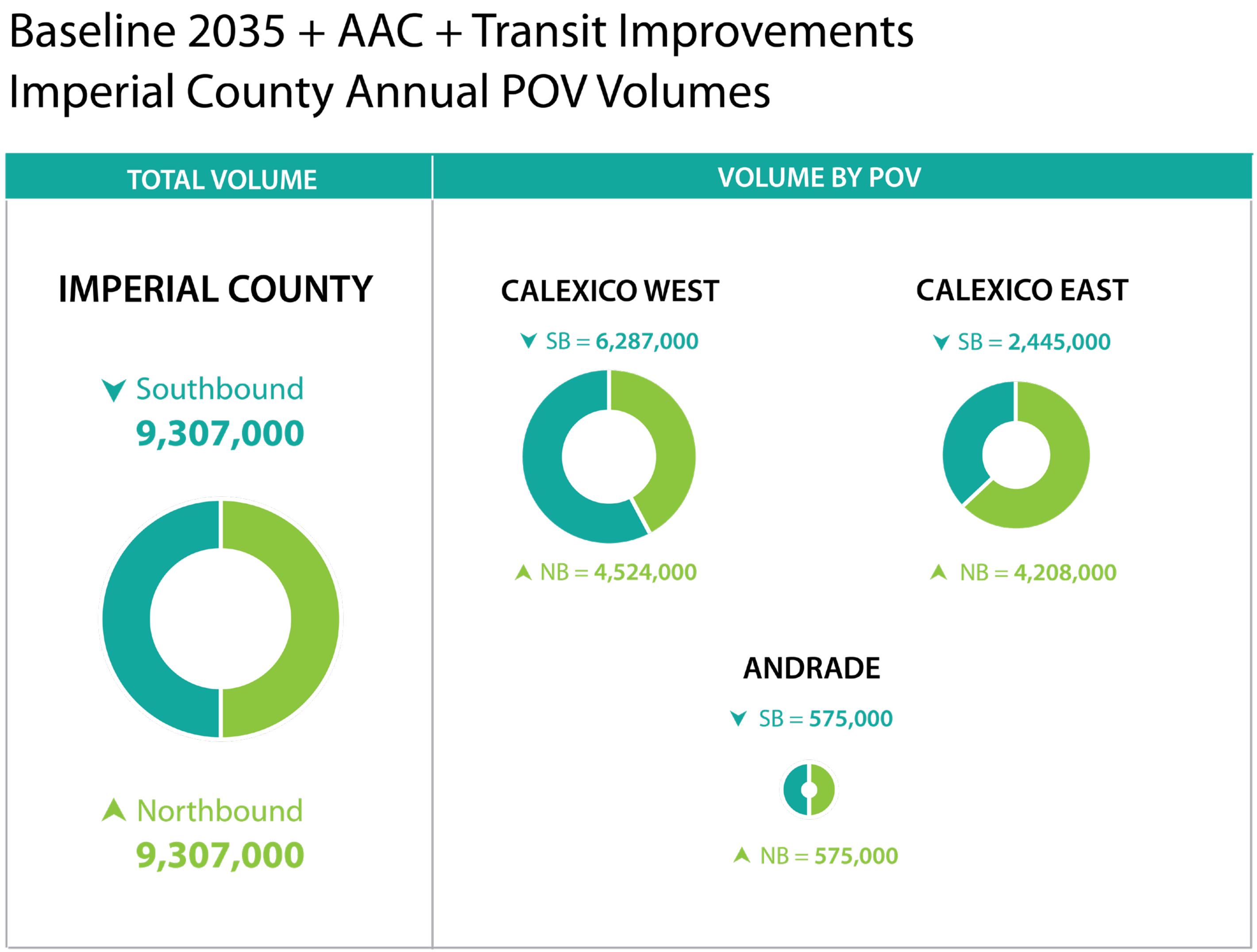


Figure 53. 2035 Imperial County POV Border Crossing Volume by POE with the All American Canal Improvements (OME 10x10)



6.2 Imperial County Annual Northbound and Southbound POV Emissions

Similar to the San Diego County results, average seasonal day emissions for Imperial County are reported for winter and summer "design days". The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all POE emissions for that season). Emissions are reported in units of grams per day, except for CO_2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

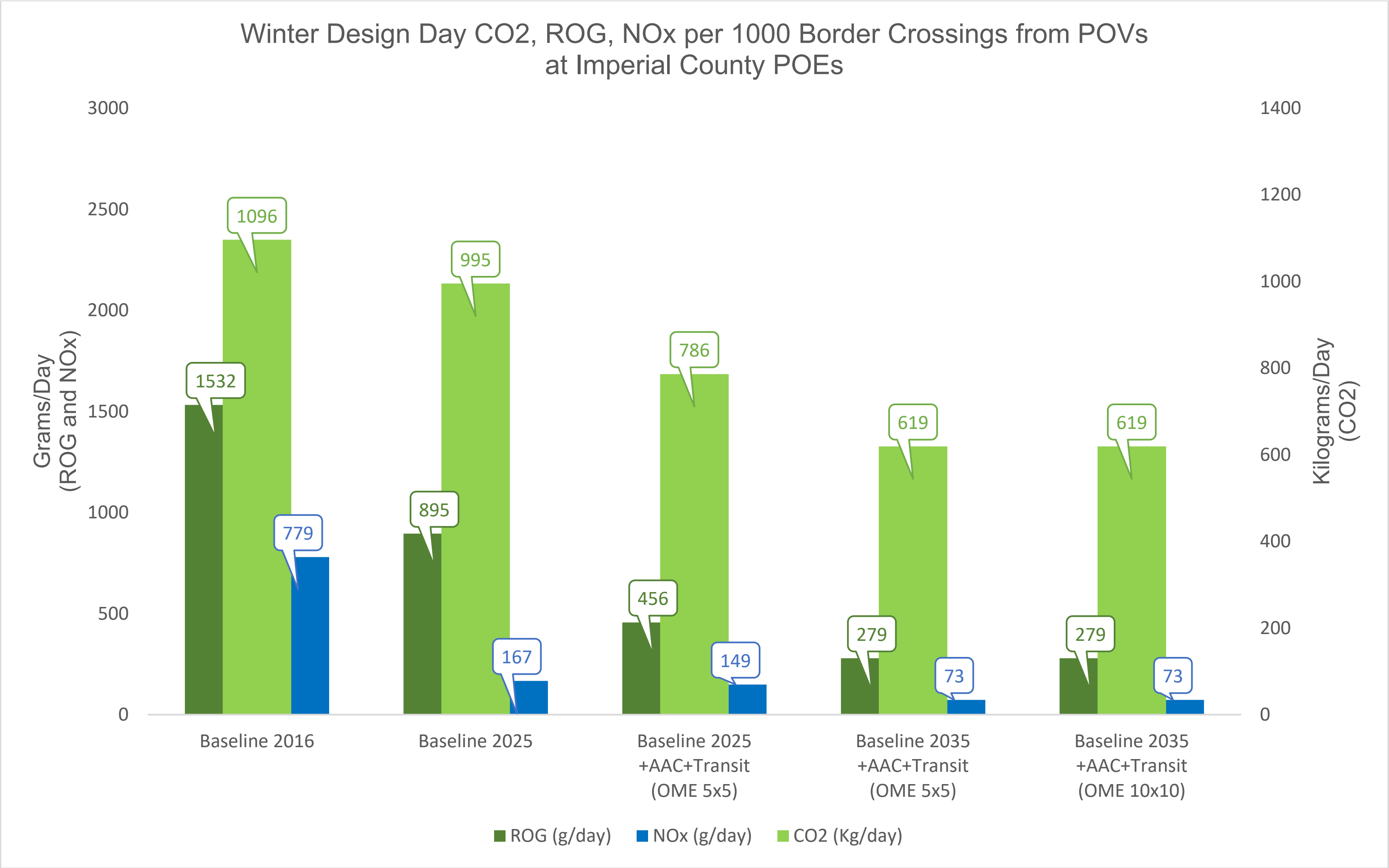
Figure 54 and Figure 55 report emissions for ROG, NOx, and CO_2 per 1,000 POVs crossing through the POEs between Imperial County and the state of Baja California. The results show emission reductions from the 2016 through 2035 baseline scenarios. This result reflects reduced crossing times associated with improvements at Calexico West and Calexico East, a less polluting vehicle fleet over time as older vehicles age out of the fleet, and the active transportation and transit enhancements.

PM10, PM2.5, and CO emission results are reported separately for each Imperial County POE in Figure 56 through Figure 61. There are two figures for each POE providing winter design day and summer design day results for all five analysis scenarios. Trends for each POE are similar to one another depending on where capacity improvements are built, and mode shift is anticipated to occur due to the active transportation and transit enhancements.

- At Calexico West emissions per POV crossing the border for all three pollutants drop rapidly from 2016 to 2025. A cleaner vehicle fleet and capacity added by the new northbound and southbound lanes in the Phase 1 improvements offset growth in the number of POVs crossing the border. Emission reductions from 2025 through 2035 are dominated by turnover of the vehicle fleet reducing overall emissions.
- At Calexico East emissions per border crossing are also anticipated to drop rapidly from 2016 to 2025. Capacity enhancements from the proposed AAC bridge expansion, and turnover of the vehicle fleet lead to the decline. From 2025 to 2035 emission reductions continue at a slower pace and result primarily from turnover of the vehicle fleet replacing older high-polluting vehicles with newer clean technology vehicles.
- The Andrade POE is not affected by capacity enhancements or active transportation and transit improvements that occur at Calexico West and Calexico East. Therefore, emissions from the two 2025 scenarios, and emissions from the two 2035 scenarios are identical at Andrade. Per POV border crossing, emissions of PM10 and PM2.5 decline through 2035 due to turnover of the vehicle fleet replacing older high-polluting vehicles with newer clean technology vehicles.

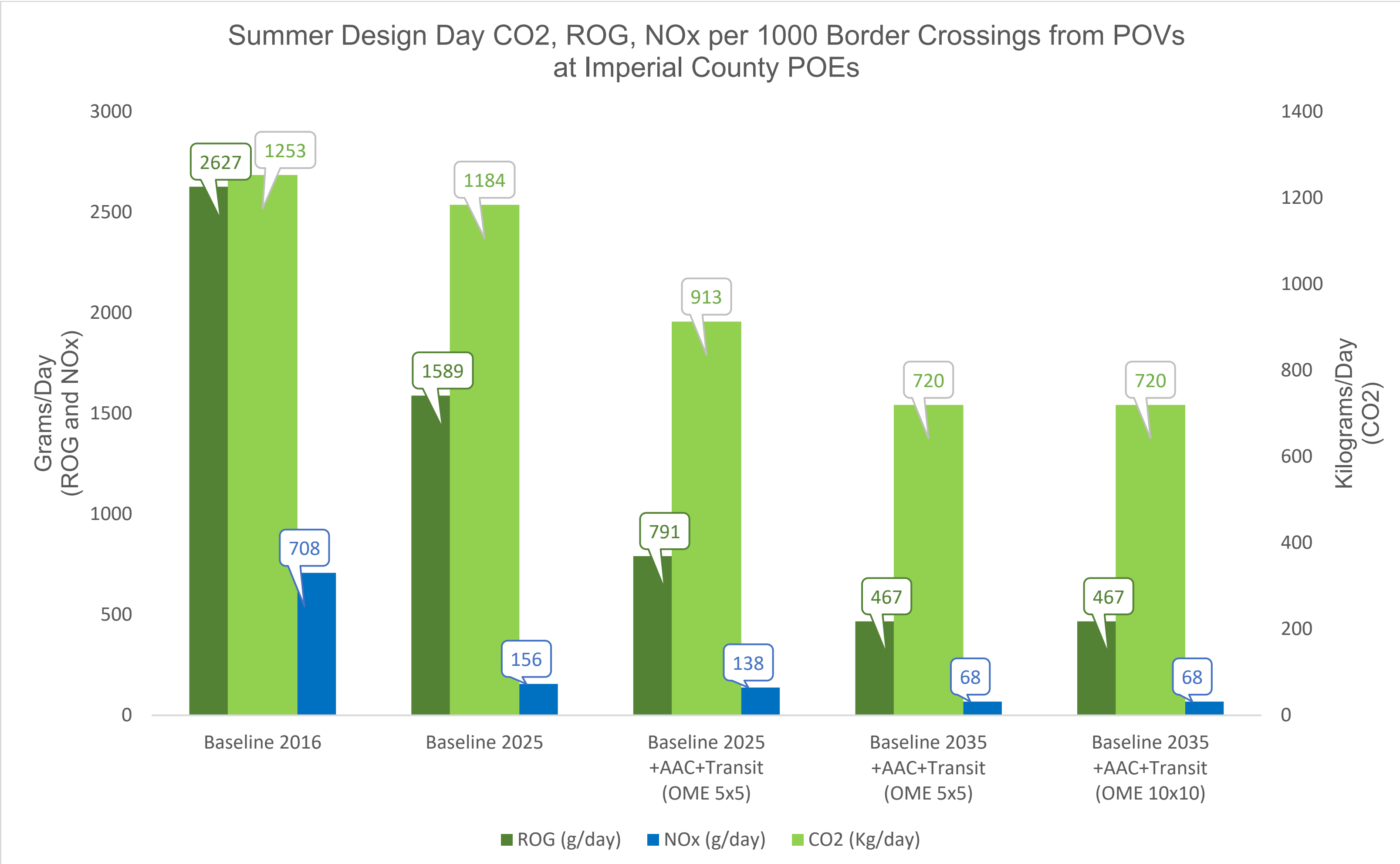
The trends for both the winter and summer design days are similar, with minor variations in emissions resulting from the seasonal traffic differences, and temperature effects on emissions.

Figure 54. Winter Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at Imperial County POEs



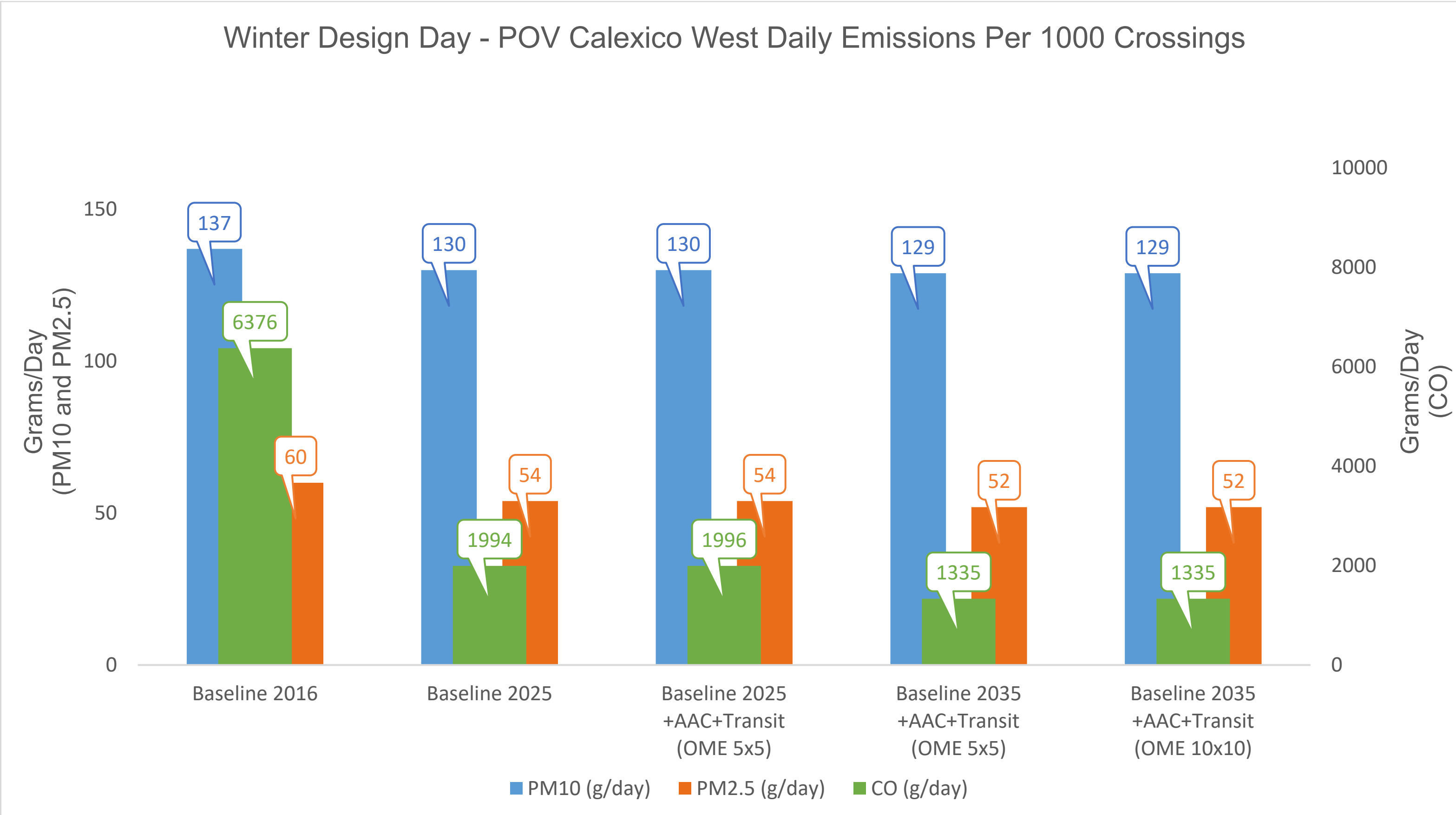
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 55. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from POVs at Imperial County POEs



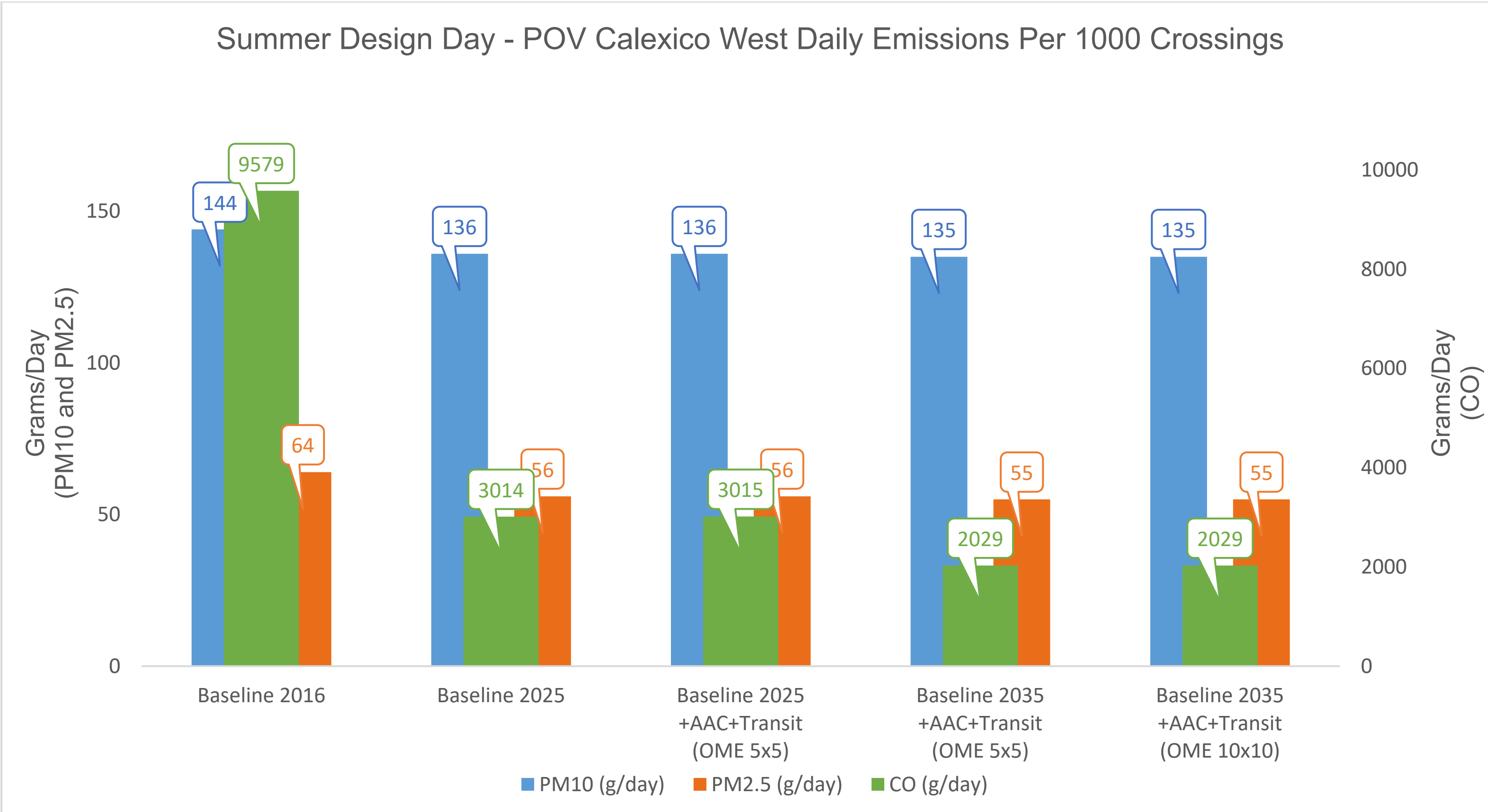
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 56. Winter Design Day PM10, PM2.5, and CO from POVs at the Calexico West POE



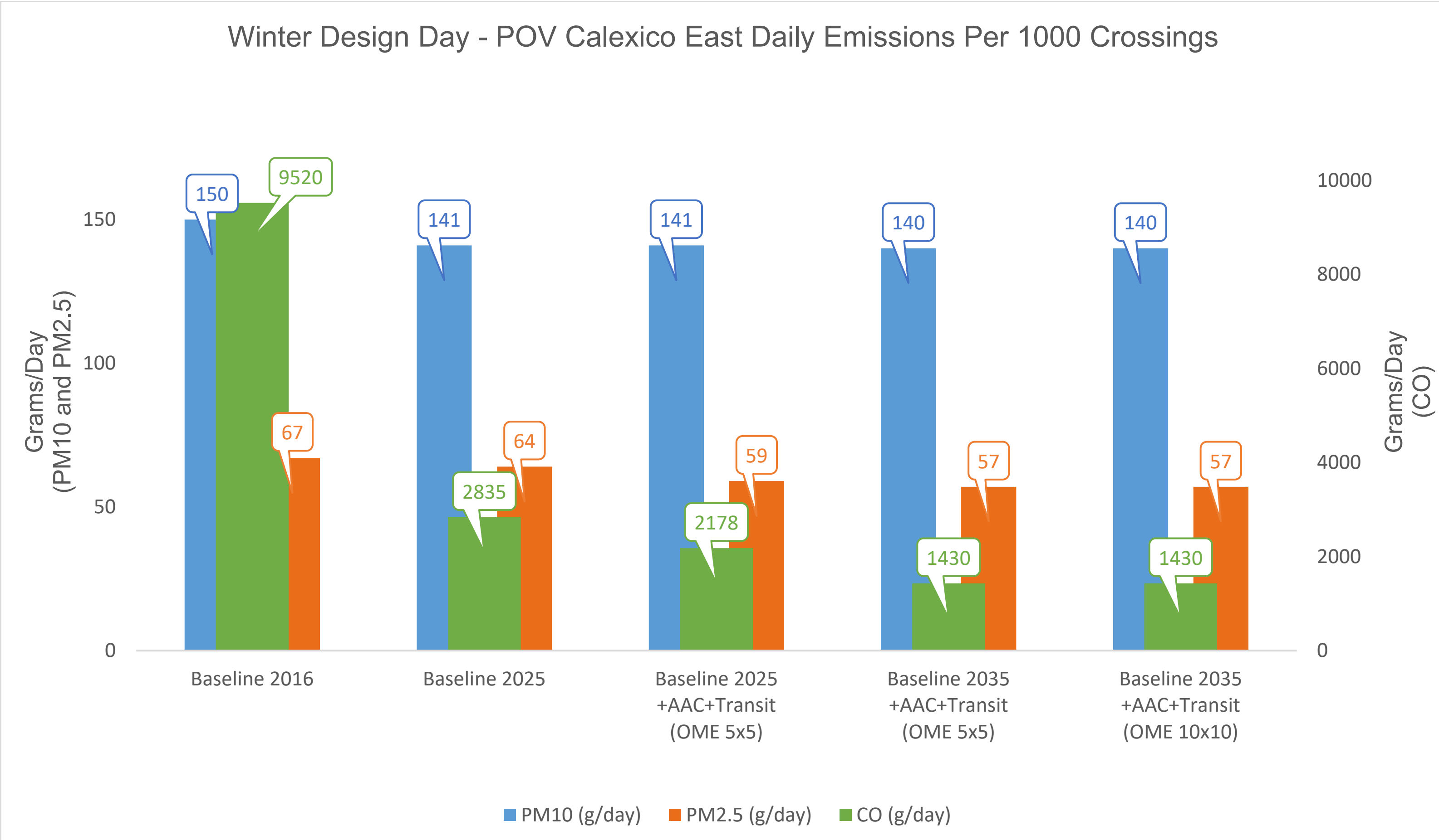
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 57. Summer Design Day PM10, PM2.5, and CO from POVs at the Calexico West POE



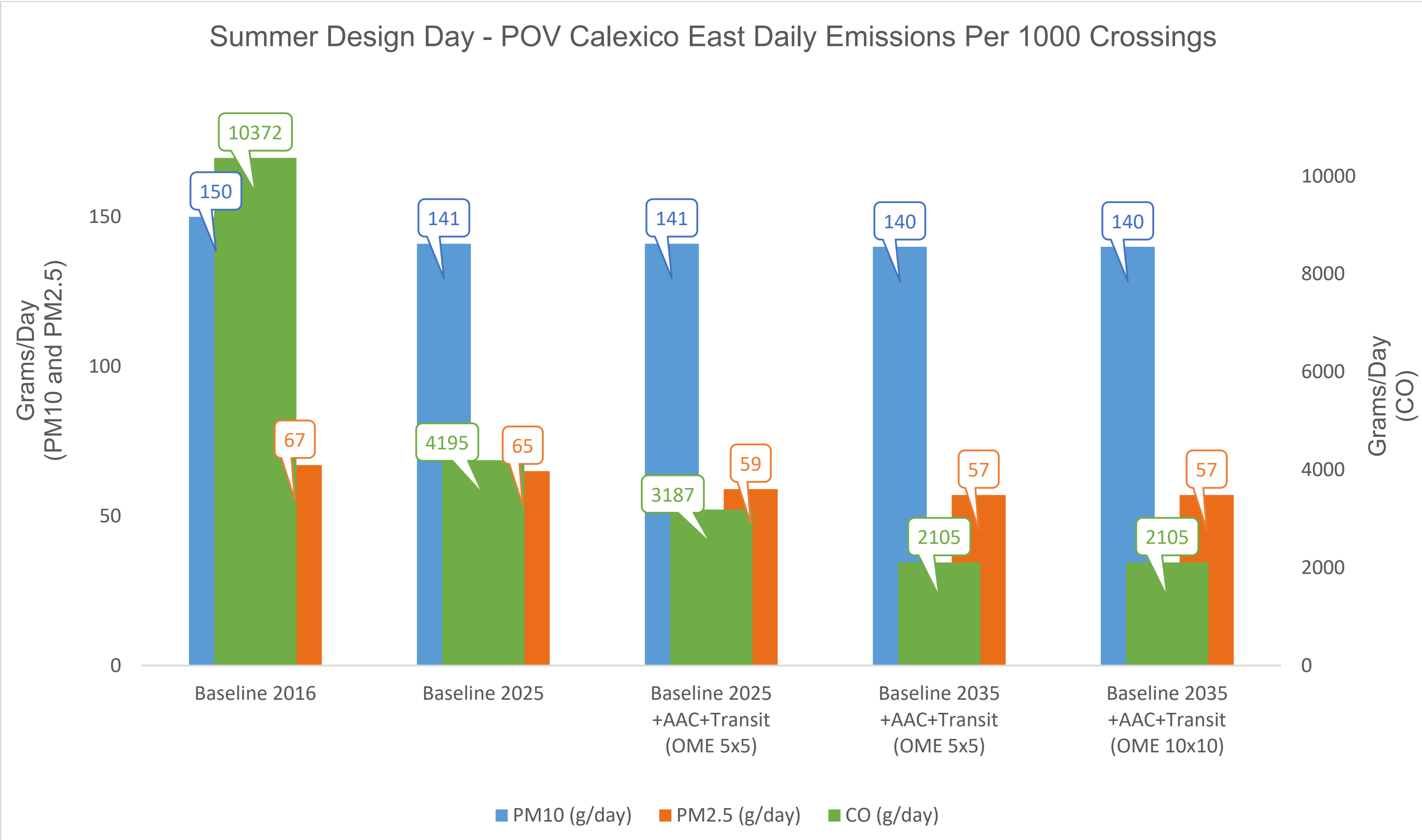
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 58. Winter Design Day PM10, PM2.5, and CO from POVs at the Calexico East POE



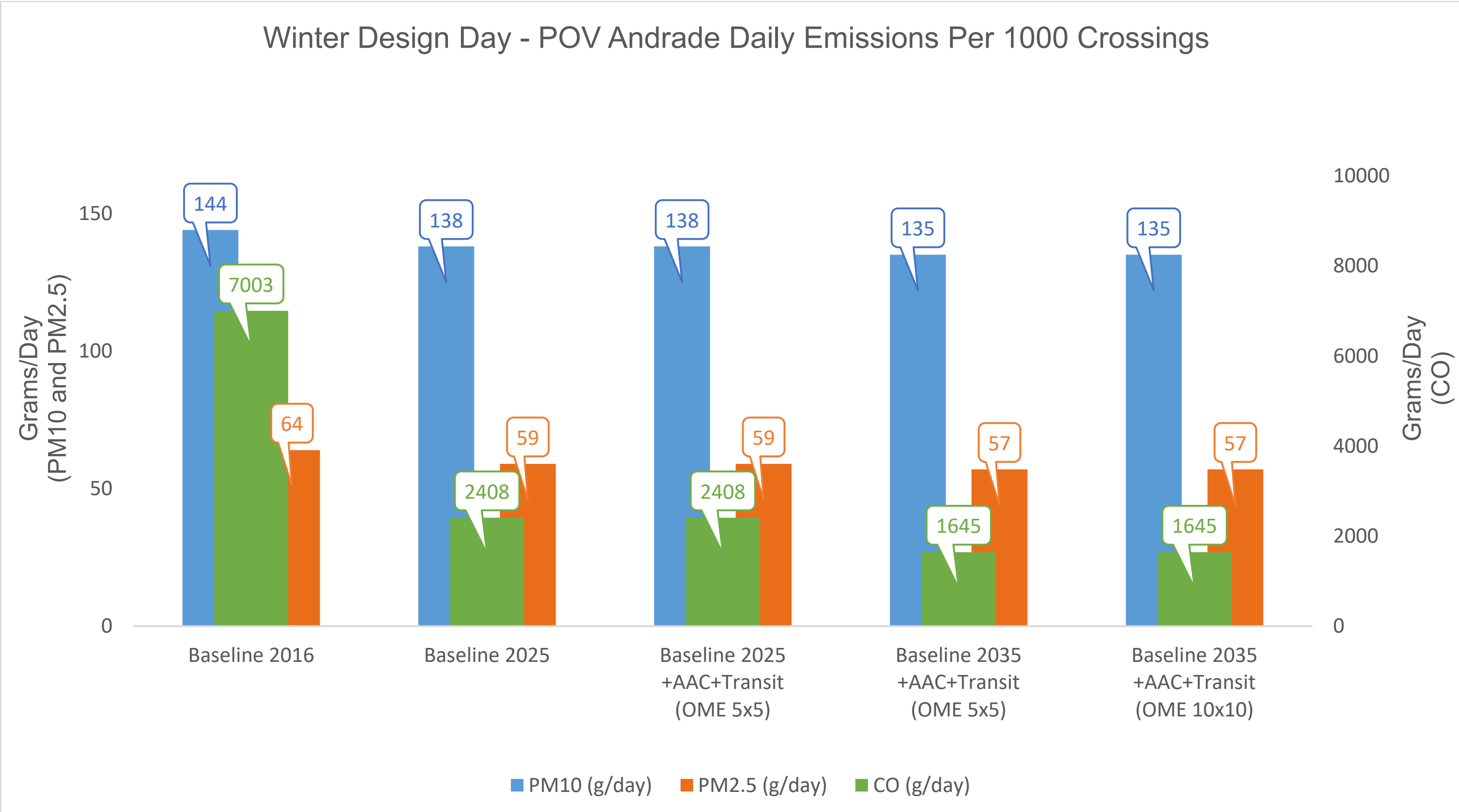
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 59. Summer Design Day PM10, PM2.5, and CO from POVs at the Calexico East POE



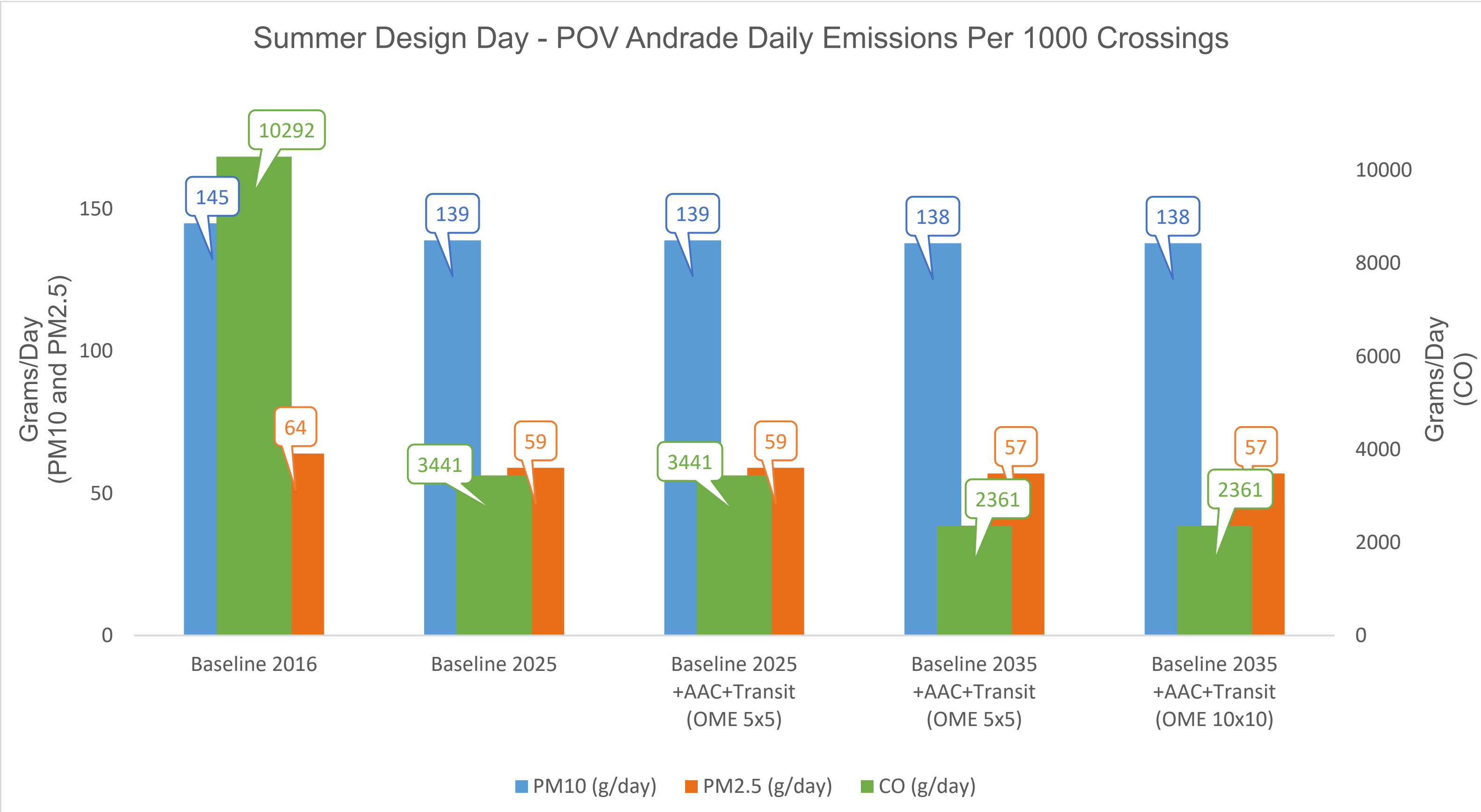
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 60. Winter Design Day PM10, PM2.5, and CO from POVs at the Andrade POE



Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

Figure 61. Summer Design Day PM10, PM2.5, and CO from POVs at the Andrade POE



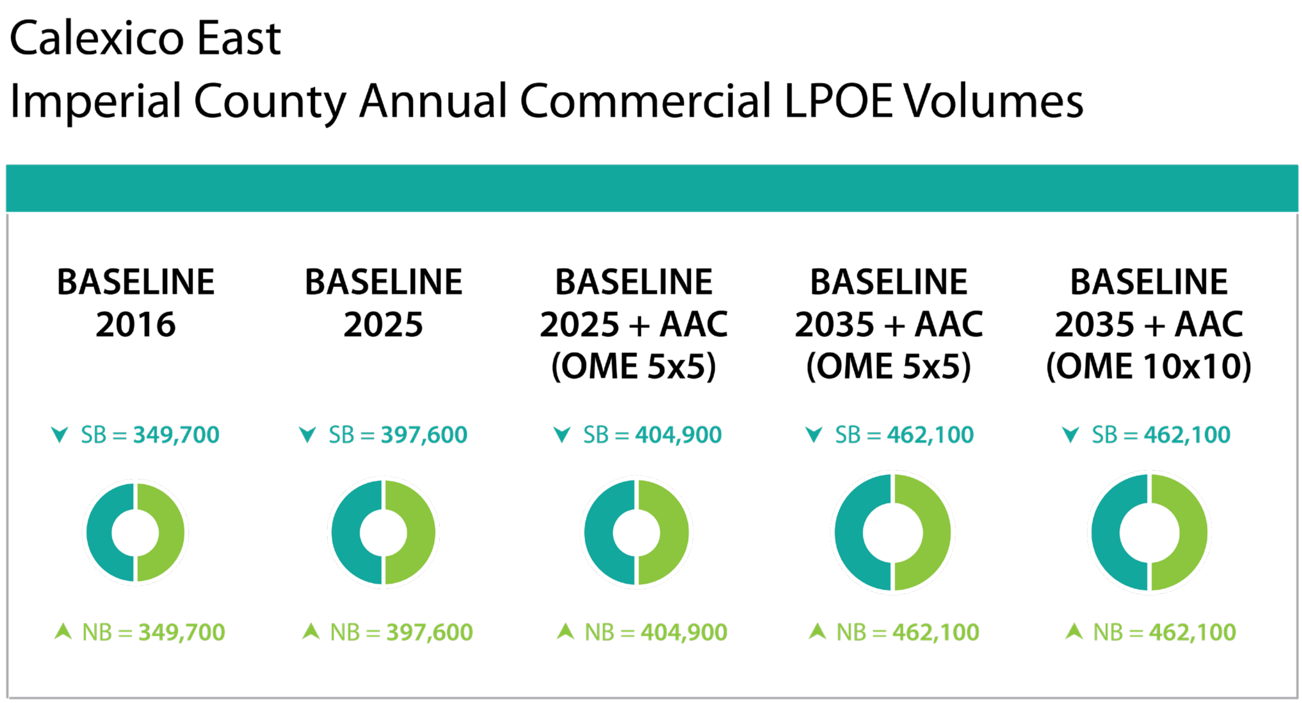
Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities.

6.3 Imperial County Annual Northbound and Southbound Commercial Vehicle Border Crossings

Imperial County commercial vehicle traffic is shown in Figure 62. Calexico East is the only Imperial County POE that serves commercial vehicles. Note that the 2035 crossing volume is not affected by the size of the OME facility in San Diego County.

From 2016 to 2025, commercial border crossings in Imperial County are anticipated to increase by 14%. The three additional northbound primary booths under the 2025 scenario with the AAC improvements, are anticipated to increase traffic by another two percentage points, to 16% above 2016 commercial vehicle border crossings. Through 2035, commercial border crossings are anticipated to increase by 32% relative to 2016.

Figure 62. Imperial County Commercial Vehicle Border Crossing Volume by POE for all Scenarios



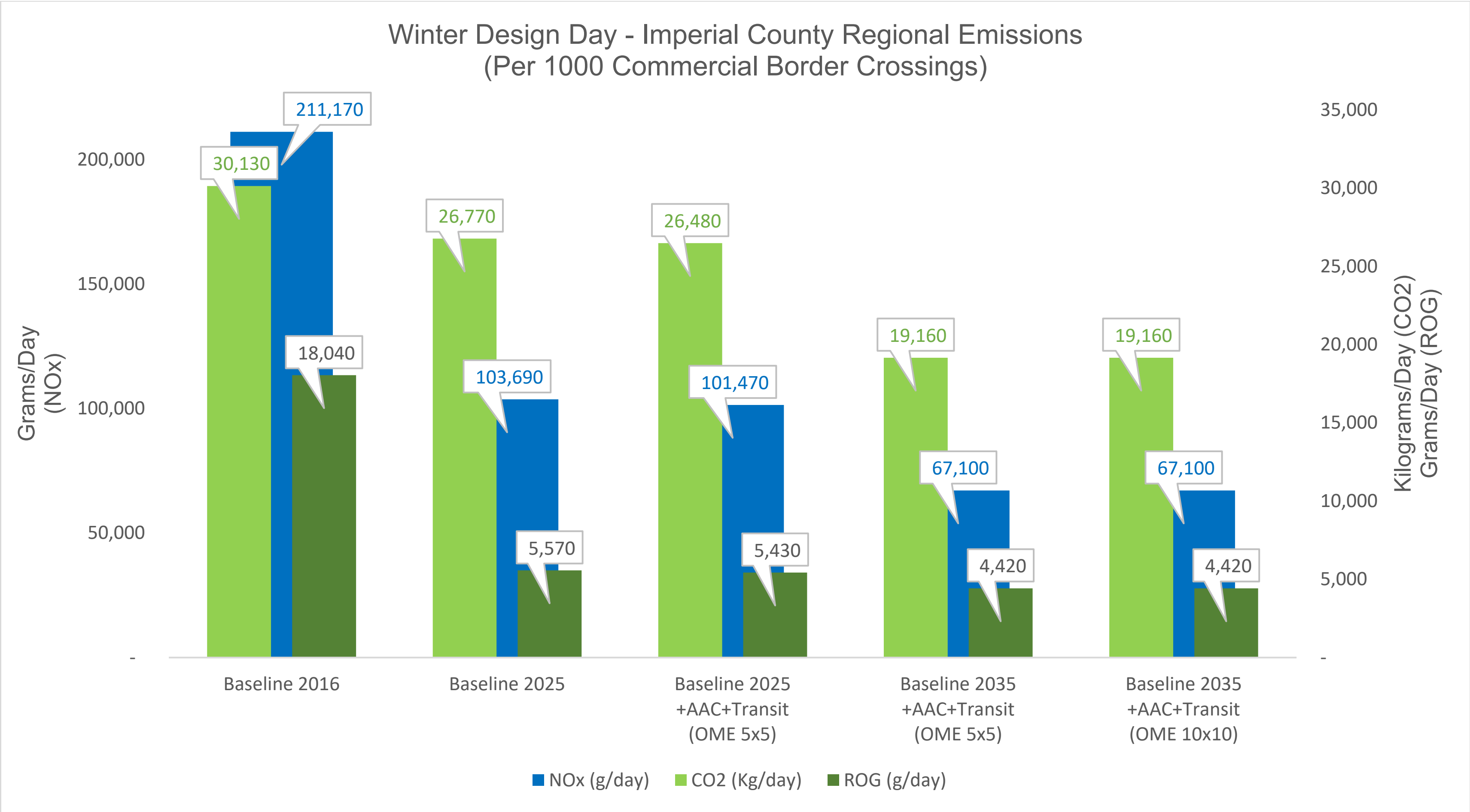
6.4 Imperial County Annual Northbound and Southbound Commercial Vehicle Emissions

Following the same pattern as commercial vehicle results for San Diego County, average daily seasonal emissions are reported for winter and summer "design days". The averages weigh together both weekday and weekend results to report values that represent a typical day (i.e. that if multiplied by 90 would reflect all POE emissions for that season). Emissions are reported in units of grams per day, except for CO_2 which is reported in units of kilograms per day. More detailed results and calculations are available as Excel spreadsheets in the electronic appendices.

Figure 63 and Figure 64 report emissions for ROG, NOx, and CO_2 per 1,000 commercial vehicles crossing the through the POEs between Imperial County, and the state of Baja California. The results show emission reductions from the 2016 to 2025 baseline scenarios, reflecting the less polluting, more efficient, commercial vehicle fleet in 2025. These emission reductions occur even though delays are growing with the increasing commercial vehicle volumes and the lack of additional capacity. The addition of three additional northbound primary inspection booths with the AAC improvements reduces delay but induces additional commercial vehicle border crossings. This results in slightly reduced ROG NOx and CO_2 emissions as the additional demand offsets the added capacity. Emissions per vehicle crossing continue to decline between 2025 and 2035 due to ongoing modernization of the commercial truck fleet.

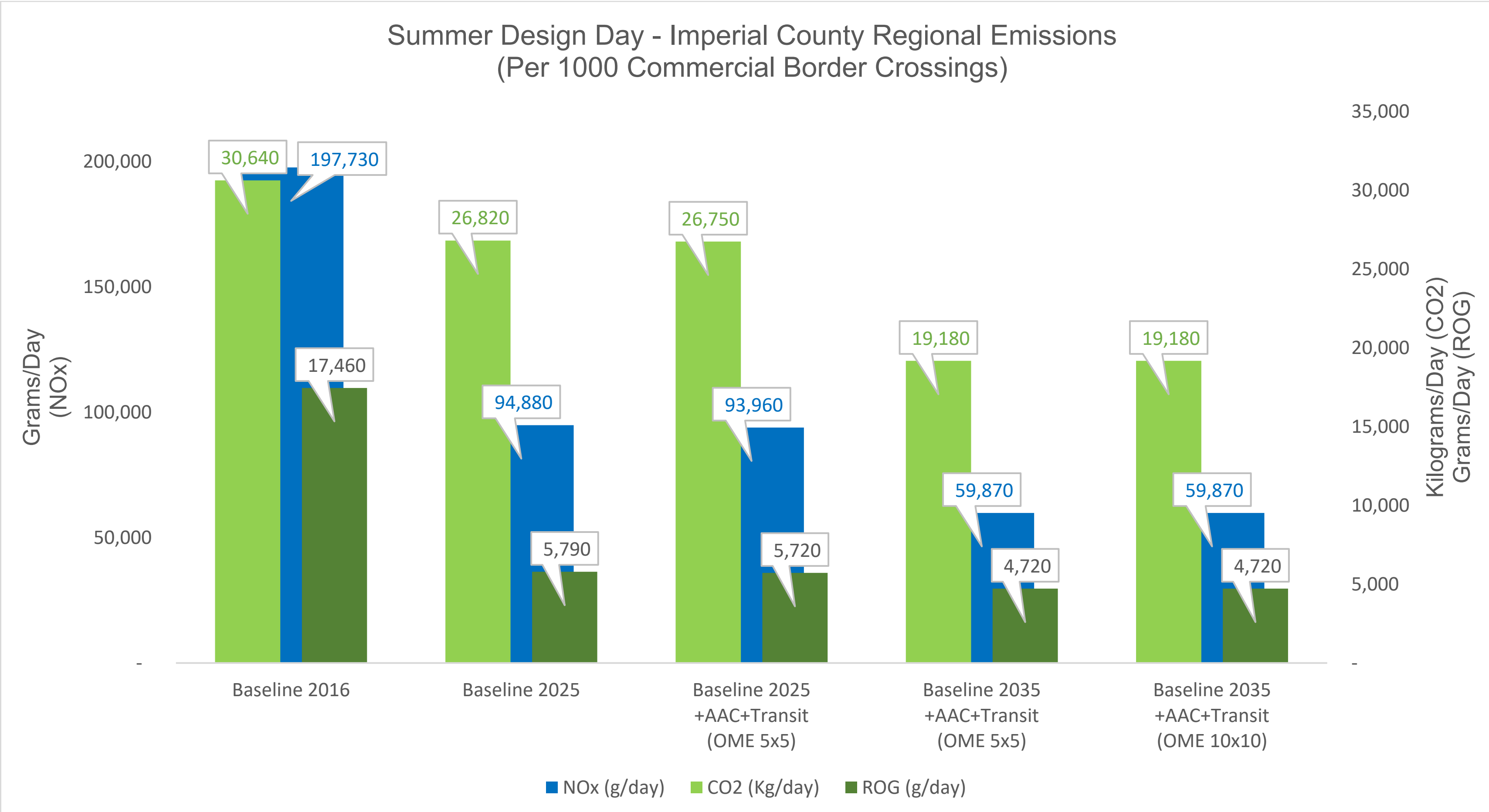
PM10, PM2.5, and CO emission results are reported in Figure 65 and Figure 66. There are two figures providing winter design day and summer design day results for all five analysis scenarios. Emissions drop from 2016 to 2025. Addition of the All American Canal improvements in 2025 has only a minor effect on emissions with slight decreases or increases in emissions as the added capacity is offset by additional demand. Between 2025 and 2035 there is again little change in emissions per vehicle crossing because impact of additional congestion is offset by the ongoing modernization of the commercial truck fleet.

Figure 63. Winter Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at Imperial County POEs



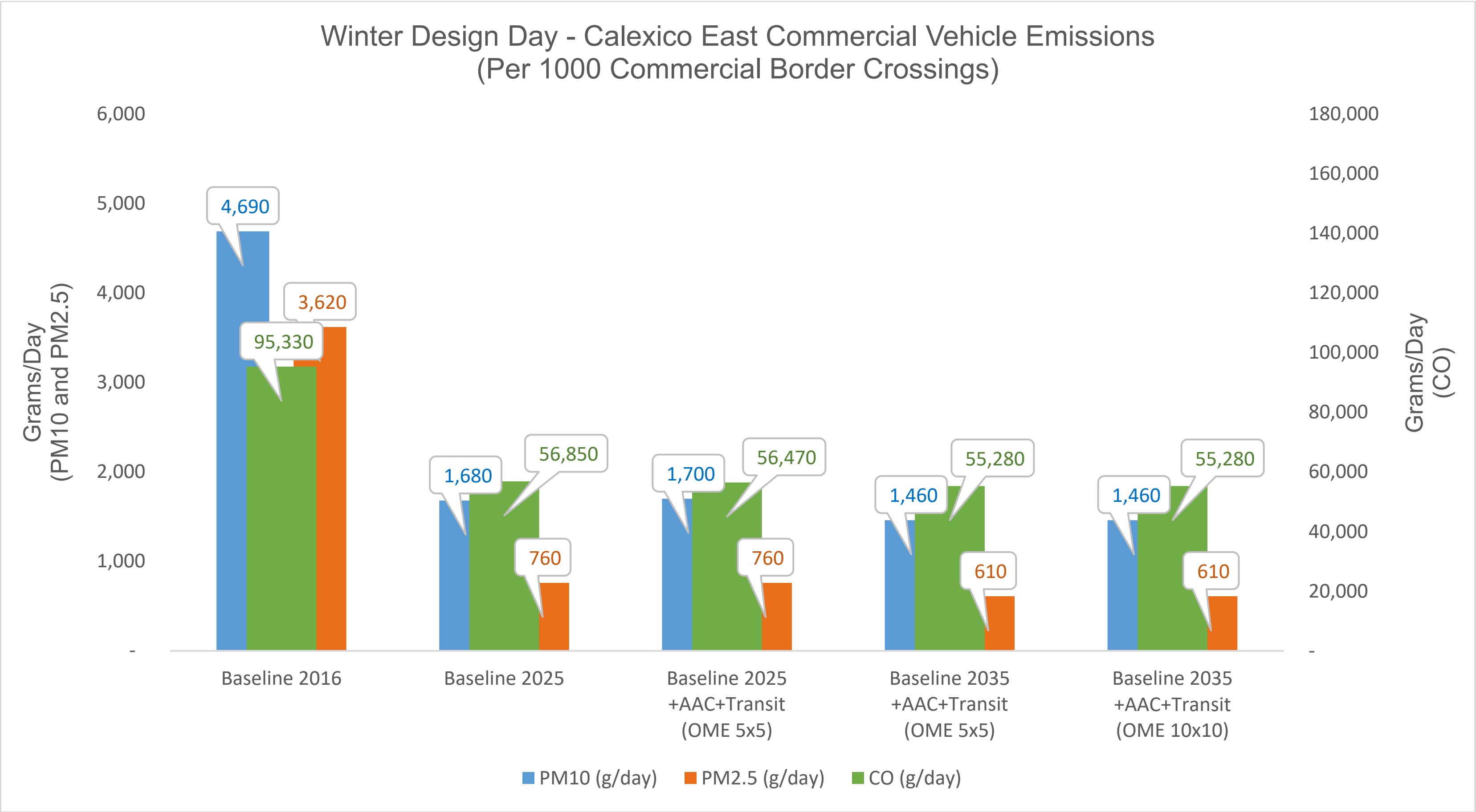
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 64. Summer Design Day CO_2, ROG, NOx per 1000 Border Crossings from Commercial Vehicles at Imperial County POEs



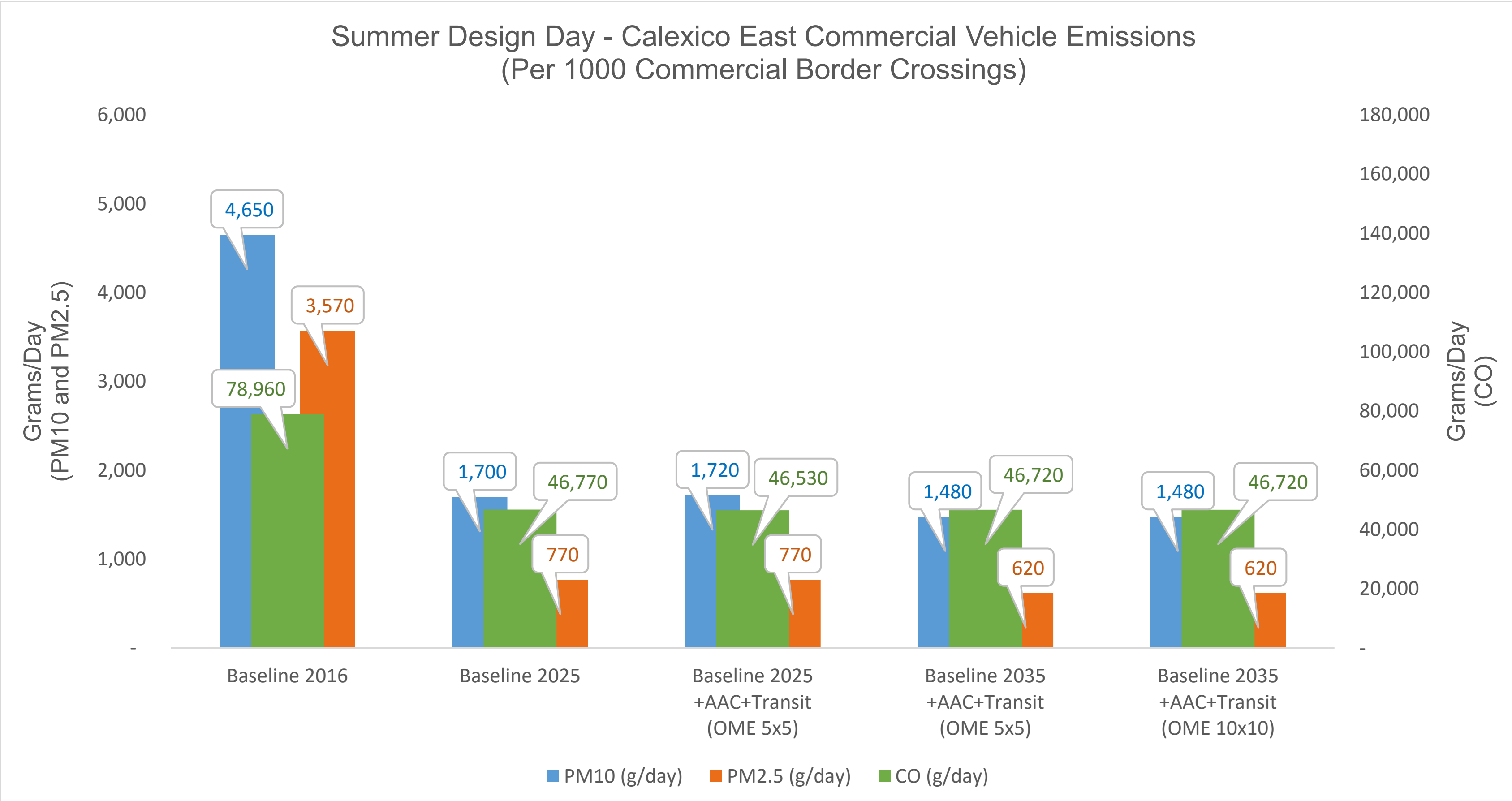
Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 65. Winter Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Calexico East POE



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

Figure 66. Summer Design Day PM10, PM2.5, and CO from Commercial Vehicles at the Calexico East POE



Note: Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

7 Discussion

Results in this report emphasize that POE emissions per border crossing are anticipated to drop rapidly from 2016 to 2025 due to:

- Reduced delay resulting from capacity enhancements, active transportation, and transit enhancements; and
- Lower polluting, more efficient, vehicles.

The biggest contributor to the emission reductions per vehicle crossing is ongoing turnover of the vehicle fleet which replaces older technology, higher polluting, vehicles with newer technology, less polluting vehicles. The capacity enhancements between 2016 and 2025 make a noticeable contribution to the 2025 emission reductions on a per vehicle crossing basis.

Between 2025 and 2035, increasing congestion is offset by continued fleet turnover such that while emissions per vehicle crossing continue to decline, emission reductions are not as substantial as those that occur between 2016 and 2025. Facility components of POEs are anticipated to be operating near to or at the point where small volume increases result in exponential increases in delay. There are noteworthy capacity constraints identified through the POE queue models:

- Under 2016 conditions at Otay Mesa, northbound CBP primary booths and the CBP cargo inspection area (specifically the VACIS non-intrusive inspections), appear to be bottlenecks. After implementation of the Otay Mesa cargo modernization project, the cargo inspection area is anticipated to constrain the throughput in 2025. Queues are anticipated to back up from the cargo inspection area into Mexico. If capacity were added to clear the cargo inspection bottleneck, the size of the downstream CHP inspection facility may become a bottleneck. Diversion of traffic to Otay Mesa East helps to mitigate this bottleneck.

- By 2035 at the Otay Mesa commercial POE, the existing CHP scales are anticipated to be over capacity.

- At the Calexico East Commercial POE, the northbound CBP primary inspection is the current bottleneck; however, the VACIS non-intrusive inspections in the cargo area are near capacity during peak periods. After the addition of three more northbound primary commercial inspection booths, the VACIS scanners act as the bottleneck in 2025 and 2035. Though overall delays are greatly reduced.

- For POVs, planned capacity expansions at San Ysidro, Otay Mesa, Otay Mesa East, Calexico West, and Calexico East can accommodate the expected northbound traffic through those POEs. The planned improvements are anticipated to accommodate southbound POV flows. However, CBP southbound POV inspection capacity is lower than Aduanas, and if CBP implemented more stringent southbound inspections, the southbound delay and queues at San Ysidro, Otay Mesa, and Calexico West could warrant additional study.

- Delay and queuing at Tecate and Andrade are anticipated to roughly double by 2035 due to growth in border crossing traffic and an absence of additional POE capacity.

Results reported in this volume are in units of grams (or kilograms) of pollutant per 1,000 vehicle crossings. Table 39 shows total emissions of CO_2, broken out by county and for all California-Baja California border crossings. These values are not per 1,000 crossings but rather reflect total anticipated emissions. These results show total emissions from POV and commercial crossings are anticipated to be lower in 2035 than during any other analysis year, despite substantial increases in border crossing volume. Total California-Baja California CO2 emissions peak in 2025 and are then anticipated to decline slowly through 2035. Commercial vehicle crossings are the largest source of border crossing emissions in both San Diego and Imperial Counties. For perspective, the emissions shown in Table 39 reflect only about 1% of the on-road CO_2 emissions in San Diego County, and 2% to 3% of the on-road emissions in Imperial County.

Table 39. Estimated Annual Average Day CO_2 Emissions across all California-Baja California POEs

Scenario	San Diego County POV (kg/day)	San Diego County Commercial (kg/day)	Imperial County POV (kg/day)	Imperial County Commercial (kg/day)	California-Baja California Total (kg/day)
Baseline 2016	153,700	181,800	54,700	66,800	457,100
Baseline 2025	200,300	210,000	57,900	67,200	535,400
2025 with Capacity Enhancements Transit and Active Transportation (OME 5x5)	176,100	198,200	46,500	68,000	488,700
2035 with Capacity Enhancements Transit and Active Transportation (OME 5x5)	175,700	178,300	33,700	55,900	443,600
2035 with Capacity Enhancements Transit and Active Transportation (OME 10x10)	160,500	179,300	33,700	55,900	429,300

Note: Emissions for POVs reflect a 3-mile approach to the POE and transit through the CBP and Aduanas facilities. Emissions for commercial vehicles reflect a 5-mile approach to the POE and transit through the Aduanas, CBP, and CHP facilities.

8 Emission Reduction Policies, Strategies, and Project Recommendations

Policy, strategy and project recommendations need to be considered within the overall hierarchy of the emission reduction strategies pyramid (Figure 67).[46] The base of the pyramid (cleaner, more efficient vehicles and better fuels) includes strategies that are implemented at regional, state and national scales. These emission reductions result from ever more stringent vehicle and engine emission certification standards and fuel economy standards, including increased penetration of hybrid and electric vehicle technologies. Benefits can take decades to be fully realized as newer, “cleaner” vehicles need to fully penetrate the fleet, replacing older vehicles as their useful life ends.

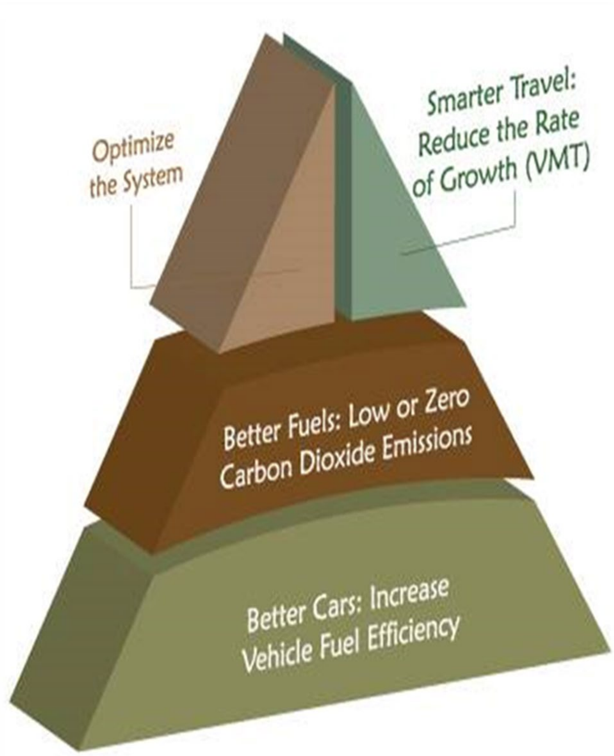


Figure 67. Emission Reduction Strategy Pyramid

Higher fuel economy standards, hybrid vehicles, and low carbon fuels result in more than a 30% drop in POV greenhouse gas emissions per mile of queuing between 2016 and 2035. Even greater emission reductions are anticipated for NOx, ROG, and CO from POVs. However, PM10 and PM2.5 emissions reductions are limited because of the effect of break and tire wear.

For commercial vehicles, California’s in-use commercial truck rules will require 2010 or newer engines on all heavy-duty commercial vehicles by 2025[47], including those entering through the POEs. Relative to 2016, recently implemented standards, coupled with the requirement to retire older engines, significantly reduce exhaust PM10, exhaust PM2.5, ROG, NOx and CO emissions by 2025; followed by only minor emission reduction benefits from 2025 to 2035. Greenhouse gas emissions from commercial vehicles are anticipated to decline by approximately 30% from 2025 to 2035. With California’s in use truck rules managing the age of the vehicle fleet and ultra-low sulfur diesel fuel available on both sides of the border, the best way to manage emissions at the POEs are through measures at the top of the emission reduction strategy pyramid, specifically through infrastructure investments (and staffing) that minimize commercial vehicle delay.

[46] CEC (2016) Reducing Air Pollution at Land Ports of Entry: Recommendations for Canada, Mexico and the United States, Montreal, Canada: Commission for Environmental Cooperation.
[47] CARB (2014) https://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm (and 13 CCR § 2025).

These improvements include construction of the planned commercial POE improvements identified in Section 3:

- Otay Mesa Commercial Modernization,
- Otay Mesa East, and
- Expansion of All-American Canal Bridge at Calexico East.

POV POE improvements, including San Ysidro Phase 3, Calexico West Phase 1 (constructed as of 2018) and Phase 2, and the Calexico East All-American Canal bridge expansion allow the POEs to keep pace, or at least mitigate, the effect of growing traffic on delays. Those delays contribute to emissions, but as shown in Sections 5 and 6, it will likely be after 2035 before increases in demand begin to overwhelm the benefits realized from a lower polluting, more efficient vehicle fleet. By that time additional infrastructure and vehicle technology measures will be needed to offset the negative air quality impacts of higher demand. Strategies that encourage hybrid, electric, and other vehicle technologies from the base of the Emission Reduction Strategy Pyramid (Figure 67) may provide substantial benefits by 2035.[48] Without additional vehicle technology measures, SANDAG, ICTC, and Caltrans should collaborate with CBP on opportunities to minimize border delay beyond 2035.

For commercial vehicles, the queue models used to estimate emissions indicate that the planned investments in northbound primary booth capacity would likely move bottlenecks to the CBP cargo inspection area in 2025; and at Otay Mesa to the CHP scales by 2035. CBP should further study operations in the commercial vehicle cargo inspection area, assuming significant growth in demand by 2035. California should consider additional commercial truck scales to the CHP facility at Otay Mesa before 2035.

Specific recommendations that help reduce emissions by managing demand, minimizing delay, and promoting lower polluting, more efficient vehicles are described in Table 40 through Table 44 below.

8.1 Recommendations: Improvements to Consider

The Project Team developed several recommendations to improve conditions at the border. The recommended strategies may have significant impacts on border crossers and businesses that utilize crossings in the California-Baja California border region. Potential impacts include reductions in delays, changes in modal split, and air quality improvement. Broadly, the types of recommended improvements can be summarized in the following categories:

- Investment in POE Infrastructure and Physical Capacity
- Improved Operations at POEs
- Improved Access to POEs
- Corridor-Wide Improvements

[48] The Governor's recent executive order, EO N-79-20, has goals for the State of California for sales of new passenger cars and trucks and for drayage trucks to be zero-emission by 2035. For medium- and heavy-duty vehicles the goal for zero-emission is by 2045 for all operations where feasible. CARB is tasked to develop regulations. https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf. This analysis does not account for the anticipated but unquantified benefits of EO N-79-20.

- Support for Coordination on Long-Term Strategies

Specific improvements considered under each category are listed in Table 40 through Table 44, as well as the impact they are anticipated to have in either border-crossing wait times/delay or modal splits between motorized vehicles and pedestrians.

In terms of capacity expansions at POEs, the Project Team recommends that additional lanes and booths be added for motorized vehicles. These improvements are expected to reduce delays for motorized crossers in the binational region, saving time and money of individual crossers (see Table 40).

Table 40. Investment in POE Infrastructure and Physical Capacity

Improvement	Impact on Wait-Times	Impact on Modal Split
Additional lanes and booths for motorized vehicles • Phase 3 Improvements at San Ysidro (complete)[49] • Phase 1 (complete) and Phase 2 Improvements at Calexico West[50] • Bridge Expansion over All-American Canal at Calexico East[51] • Otay Mesa Commercial Modernization[52]	Reduces wait-times for motorized crossers in binational region	Minimal, but may increase share of motorized crossers
Additional lanes and booths for pedestrian crossers • Phase 2 Improvements at Calexico West • Otay Mesa Pedestrian Modernization[53]	Reduces wait-times for pedestrian crossers in binational region	Minimal, but may increase share of pedestrian users
New POE facilities • Otay Mesa East Port of Entry	Reduces wait-times for motorized crossers across the San Diego-Tijuana region	Minimal, but may increase share of motorized crossers

[49] Phase 3 improvements at San Ysidro include the addition of 10 southbound POV lanes with additional southbound primary inspection booths and 8 northbound POV lanes with 15 additional northbound inspection booths. This project was completed in 2019. *Source: General Services Administration*

[50] Phase 1 improvements at Calexico West include the addition of 5 southbound POV lanes and a southbound bridge over the New River as well as 10 northbound POV lanes. This project was completed in 2018. *Source: General Services Administration.* Phase 2 improvements at Calexico West include a new pedestrian processing facility, 5 additional southbound POV lanes and 6 additional northbound POV lanes. This phase is currently unfunded but expected to be constructed by the corresponding analysis year (2025). *Source: General Services Administration.*

[51] "Expanded bridge over the All-American Canal" is part of proposed improvements to increase capacity at the Calexico East POE. Envisioned expansion comprises 2 additional northbound POV lanes and 2 additional northbound commercial lanes. The bridge expansion component is proposed to address the current bottleneck observed over this section of the approach road. These improvements are expected to be constructed before 2025. *Source: California Transportation Commission*

[52] Otay Mesa Commercial Modernization refers to a General Services Administration (GSA) led effort to renovate and expand commercial facilities at the Otay Mesa POE, including 6 additional commercial processing booths and other related improvements. *Source: General Services Administration*

[53] Otay Mesa Pedestrian Modernization refers to a GSA led effort to renovate and expand pedestrian facilities at the Otay Mesa POE. The construction is expected to include 6 additional pedestrian processing lanes and other related improvements. *Source: General Services Administration*

There are several improvements recommended under the Improved Operations at POEs category, more than half of which are related to truck crossings. In particular, interchangeable lanes, reversible lanes, and other innovative lane management operations are recommended to reduce delays for all POE crossers; however, this may also increase the share of motorized personal trips (see Table 41.).

Table 41. Improved Operations at POEs

Improvement	Impact on Wait Times	Impact on Modal Split
Southbound Electronic Commercial Clearance (Aduanas PITA program)	Marginal, but reduces total crossing and idling time for truck crossers at POE	-
Unified Cargo Processing	Marginal, but potentially reduces total crossing and idling time for truck crossers at POE	-
Joint Inspection Facility	Marginal, but reduces total crossing and idling time for truck crossers at POE	-
Interchangeable Lanes	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Reversible Lanes	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Lane Management	Reduces wait-times for crossers at POE	Minimal, but may increase share of motorized crossers
Appointment Time for Truck Crossers	Potential to reduce wait-times for truck crossers at POE	-
Extended Hours of Operations	Potential to reduce wait-times for crossers at POE	-
Variable tolls at OME	Potential to reduce wait-times for truck crossers at Otay Mesa	-

Strategies to improve access to POEs include improved bike and pedestrian access to POEs, enhanced transit services at the border, the deployment of an advanced traffic management and traveler information system and the prioritization of zero / near-zero emission trucks, with their different impacts are listed in Table 42. There are several improvements being advanced by border agencies. For example, Caltrans and SANDAG are pursuing a border wait time measurement system using ITS technologies. The system completed a successful pilot phase for southbound POV wait time measurements at San Ysidro, and the agencies are advancing the system at all ports of entry and in both the northbound and southbound direction. This effort corresponds to the Advanced Traffic Management and Advanced Traveler Information System and Regional Border Management System improvement concepts mentioned in Table 42.

Table 42. Improved Access to POEs

Improvement	Impact on Wait Times	Impact on Modal Split
Bike and pedestrian access improvements	-	Potential shift to pedestrian mode from motorized mode
Enhanced transit services (including: Tijuana BRT and higher frequency of transit service at San Ysidro and Otay Mesa), completion of Calexico West Intermodal Transit Center, and completion of Transit Center/Cell Phone Lot at Calexico East.	-	Potential shift to pedestrian mode from motorized mode
Advanced Traffic Management and Advanced Traveler Information System, including RFID and Wi-Fi readers on Mexico's northbound lanes to capture commercial and POV vehicle wait-time data	Potential reduction in NB wait times for trucks and POVs due to planning and routing to faster POE	-
Zero/Near-Zero Emission Truck Prioritization at POEs	Potential to reduce wait times for truck crossers at POE (and reduce emissions from using zero/near-zero emission trucks)	-

A recommendation for corridor-wide improvements consisted of the deployment of a Regional Border Management System (RBMS) and subcomponents. The individual components have the potential to reduce northbound and southbound delays for commercial and passenger vehicles due to efficient re-routing with advanced travel information (see Table 43).

Table 43. Corridor-Wide Improvements

Improvement	Impact on Wait Times	Impact on Modal Split
Regional Border Management System (RBMS) and Subcomponents - • Southbound Congestion Management and ITS Infrastructure Improvements • Freight Advanced Traveler Information System (FRATIS), including Information Dissemination Process • Integrated Corridor Management (ICM) and Active Traffic Management (ATM)	Potential reduction in NB and SB wait-times due to improved POE choice and trip routing could be realized for commercial and passenger vehicles with advanced travel information	Minimal, but may increase share of motorized crossers

A final recommendation (see Table 44) is that local planning agencies support binational planning processes and foster collaboration efforts for POE operations and transportation infrastructure. This cooperation is essential for the successful implementation of several of the recommended strategies identified above.

Table 44. Support for Coordination on Long-Term Strategies

Improvement or Strategy	Impact on Wait Times	Impact on Modal Split
Support Binational Planning Process for POEs and Transportation Infrastructure	Potential reductions to NB and SB wait-times	Potential shift to pedestrian mode from motorized mode

These recommendations also align with State of California goals and objectives noted in existing planning documents and efforts currently underway. Key examples of planning efforts that include border improvement strategies, projects and policies include the 2016 California Sustainable Freight Action Plan (CSFAP), which includes a work plan to implement pilot projects for "Advanced Technology Corridors at Border Ports of Entry". The series of pilot projects are currently being implemented and include elements such as deployment of technology to dynamically manage border infrastructure to reduce wait times. Currently, Caltrans is developing the 2020 California Freight Mobility Plan (CFMP) which is anticipated to include many of the same border improvement elements.[54]

Another example of planning work aligned with the study recommendations is the 2021 California-Baja California Border Master Plan (BMP) effort. This ongoing effort involves participation from more than 30 U.S. and Mexican agencies at the local, state and federal levels to coordinate on border infrastructure projects and improvement strategies. As part of the 2021 BMP, a comprehensive list of innovative border improvement strategies documents various approaches to help manage the binational transportation system in the California-Baja California region. The goal of developing innovative strategies is to optimize the use of existing infrastructure and projects under development with a focus on innovative and multimodal strategies and to leverage technology where possible. Some of the objectives in the 2021 BMP innovative strategies that overlap with the improvement categories listed above include:

- Promote a mode shift from single occupant vehicles (SOV) to active transportation and transit;
- Provide safe and secure processing at the border and reduce wait times for all modes of border crossings;
- Improve the air quality in and around the border region;
- Coordinate binational operations and shared data;
- Provide accurate and timely information to the traveling public;
- Provide high-speed connections to and from the border

[54] https://dot.ca.gov/programs/transportation-planning/freight-planning/strategic-planning