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Estimating Air Pollution Concentrations Using MOVES-Generated Site-Specific Traffic Emissions

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Abstract

The research presented here attempts to estimate air pollution concentrations using MOVES and site-specific traffic emissions particularly those emissions surrounding three different air-monitoring stations. The objectives of this research include using MOVES capability to conduct project-level analyses, choosing impact zones to create emissions inventories. Emissions inventories provided by the MOVES model for impact zones within the El Paso county area were used to identify a relationship between air monitoring stations' measured results and emission estimates from a project-level analysis. The research hopes to identify an optimum zone radius that can be used to compare MOVES estimates with air monitoring stations reported data. Air concentration estimations were found using a simple Fixed-Box Model. Modeled emissions were then compared to concentrations from air monitoring stations in El Paso. Air concentrations were found to vary greatly between measured concentrations and the predicted concentrations using MOVES and the Fixed-Box Model. While the correlation is stronger when comparing CO and NO_x measured concentrations to observed concentrations, there still appears to be a great discrepancy between values. Measured PM_{10} and $PM_{2.5}$ values at air monitoring stations were substantially greater than concentrations measured through MOVES and the box model. This suggests that PM_{10} and $PM_{2.5}$ concentrations at these sites can be caused by factors other than and in addition to traffic emissions. Additionally, this research validated emission estimates from the impact zones using VMT estimates and comparison to emissions values obtained from previous studies.

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Chapter 1: Introduction

Traffic-related air pollution can be a major public health concern in any urban area. This problem is compounded in the Paso del Norte region (PdN) border region, which comprises the cities of El Paso, Texas, Ciudad Juarez, Chihuahua, and Sunland Park, New Mexico where there is rapid economic growth, and a substantial number of people living in close vicinity of major roadways (Raysoni et al., 2011). The desert surroundings, arid weather, frequent temperature inversions, heavy border traffic at the international ports of entry between El Paso and Ciudad Juarez, and poorly maintained vehicle fleet further exacerbates this problem. The rapidly worsening air quality seen in populations along the U.S.–Mexico border is partly due to high rates of urbanization and industrial development (Pennington et al., 2004). The problems persist in El Paso due to the topographic situation. El Paso, as its name implies, is located in a pass. The city is built around the southern end of the Franklin Mountains and goes northward along both the east and west edges of the range (Applegate, 1982). It is necessary to quantify the amounts and kinds of vehicular emissions in the region and assess the impacts to the population.

The development of mobile source emission models was necessary in order to provide emissions inventories for on-road mobile sources (McCarthy et al., 2011). The U.S. Environmental Protection Agency (EPA) continuously collects data and measures vehicle emissions to make sure the best possible understanding of mobile source emissions is obtained. The first model, named MOBILE1, was released in the 1970s, and was recurrently updated with more accurate data, updates in technologies, changes in regulations and standards, and general improved understanding of emission levels and the factors that affect those emissions (EPA, 2016). The newest model, EPA's MOtor Vehicle Emission Simulator (MOVES), replaced EPA's previous mobile source emissions model and was released in 2004. It was created to replace

MOBILE6 and NONROAD, official models for estimating mobile source emissions at the time. With the use of the mobile source emissions models, emissions can easily be enumerated, estimated, or predicted using traffic information.

Considering the adverse health risks to the human population of an urban area, it is an important task in finding correlations between air concentrations and traffic emissions in order to assess the impact of traffic on air quality and the surrounding population, especially those near highways and areas of denser traffic (Lipfertet al., 2008).

1.1. Problem Statement

Air pollution near highways is primarily caused by traffic emissions and there is likely a direct relationship between the emissions from mobile sources and air pollution measurements at locations near the highways. This research attempts to find a relationship between ambient air concentrations and mobile emissions for the communities located in the vicinity of a busy highway. Emissions inventories generated by the MOVES model for localized zones within the El Paso county area can be used to develop a relationship between air monitoring stations' measured results and the emission estimates using a project-level analysis. Furthermore, identifying an optimum radius of the impact zones is necessary to compare MOVES estimates with air monitoring stations' reported data and validate the correlation between mobile emissions and ambient air concentrations.

1.2.Objectives

This research attempts to find a relationship between ambient air concentrations and mobile emissions. The objective is to use emissions inventories provided by the MOVES model for small areas within the El Paso county area to determine whether a relationship exists between

air monitoring stations' measured results and emission estimates from a project-level analysis. The tasks of this research include:

1) Selecting locations and defining zones of impact based on existing air monitoring stations
2) Estimating traffic emission using EPA-approved MOVES model to conduct project-level analyses using local traffic information
3) Evaluating the relationships between the air pollution measurements and traffic emissions within several selected zones

The emissions estimates developed in this study are compared to those estimated for a larger area by the El Paso MPO for data validation.

1.3. Significance of the Work

Identifying correlations between traffic emissions and air concentrations of pollutants in an optimal zone can provide further insight into the effect of traffic patterns on air quality in the region. By extrapolating results from these air-monitoring stations, a comprehensive map of the entire county can be further considered to show air concentrations distribution spatially.

Chapter 2: Literature Review

2.1. Air Pollution in El Paso

Motor vehicles are major contributors to air pollution by directly emitting significant amounts of pollutants. Motor vehicle engines emit various types of pollutants including nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), particulates, among others. Many of these emissions also contribute to the formation of secondary pollutants such as ozone and secondary particulate matter (Abu-Allaban et al., 2006). In cities where high levels of human activities are around transportation corridors, there exists a high incidence of people having health problems (Sharma et al., 2009; Cyrys et al., 2003). Numerous epidemiologic studies have shown an association between ambient air particulates and increased illness and mortality (Du et al., 2016). Exposure to traffic-related air pollutants near highways is associated with adverse health effects including cardiopulmonary disease, asthma and reduced lung function (Brugge et al., 2007; Janssen et al., 2003; Gauderman et al., 2007; McConnell et al., 2006; Van Vliet et al., 1997; Krzyżanowski et al., 2005). These conclusions have motivated research to understand and quantify the types and amounts of pollutants in near-highway environments.

The PdN border region has experienced significant population and economic growth since the passage of the North American Free Trade Agreement (NAFTA) in 1994, which accelerated binational commerce between the U.S. and Mexico. This region has also seen an increase in the overall number of motor vehicles in the cities as well as at the international border crossings including passenger cars and commercial vehicles across the four international ports of entry between El Paso and Ciudad Juarez each year. The PdN region is an area heavily impacted by traffic emissions from one of the busiest US–Mexico border crossings as well as high local vehicle usage (Sarnat et al., 2011). El Paso fails to meet U.S. federal air quality standards and is

therefore designated as a federal nonattainment area for particulate matter greater than 10 micrometers in aerodynamic diameter (EPA, 2016).

The PdN region is subject to air pollutants from both El Paso and Juarez caused by vehicle emissions, open burning of garbage and tires, dust from miles of unpaved roads, and emissions from industrial plants. These sources are known to produce material mixtures of thousands of organic compounds, many of which are highly toxic and carcinogenic.

However, motor vehicle emissions are a major source of urban air pollution. This is true for the greatest contributors to poor air quality in the El Paso region, which are mobile sources such as automobiles and trucks. The poor enforcement of vehicular registration and inspection laws in El Paso and the inadequate laws of Juarez hinder any attempts at regulating older vehicles and ensuring the reduction of the harmful emissions into the air. Emissions are particularly high in the air shed because of the high percentage of older vehicles, many without proper exhaust emission control devices that convert toxic chemicals in the exhaust of an internal combustion engine into less noxious substances, which produce a significant amount of diesel exhaust. Inadequate local actions to handle increased congestion from border crossings, and the lack of options for diverting large truck traffic, only exacerbate the release of toxins. Higher concentrations of pollutants take place mainly on national highways and major connecting roads of cities where vehicular traffic is high. It is thus observed that urban residents living near a roadway experience higher exposure to motor vehicle emissions compared to those living farther away, thereby experiencing a higher health risk. A number of studies have shown correlations between decay relationships of pollutants near busy roadways. (Beckerman et al., 2007, Durant et al., 2010, Padró-Martínez et al., 2012). These studies observe the associations between distance, from highways or high traffic areas, and ambient concentrations of pollutants. These

studies show that various pollutant concentrations are elevated near highways and the decrease within certain distances as a result of dilution. Therefore, it is necessary to research the amounts and kind of pollutants created from mobile sources, especially when traffic corridors are concurrent with areas of high human activity.

2.2. Overview of Mobile Source Emission Models

Emission estimation is typically done through emission models. A number of emission models were developed over the past decades to estimate emissions and energy consumption. Typically, all these models take into account the various factors affecting emissions, although they differ in their modeling approach, modeling structure, and in the data used to develop them (Boulter et al., 2007). This chapter presents a review of mobile source emission models used by the EPA. The MOBILE model was first developed as MOBILE1 in the 1970s, but has been intermittently updated with more accurate data, changes in technologies, changes in regulations and standards, and general improved understanding of emission levels and the factors that affect them (CRC, 2004).

The development of these models was due to the Clean Air Act, which requires the EPA to regularly update its mobile source emission models (McCarthy et al., 2011). EPA continuously collects data and measures vehicle emissions to make sure the best possible understanding of mobile source emissions is obtained. The newest model, EPA's MOtor Vehicle Emission Simulator (MOVES) replaces EPA's previous mobile source emissions model called MOBILE (EPA, 2009) . MOVES contains a significant expansion of capabilities compared to MOBILE.

MOVES is an emission modeling system that estimates total emissions and energy use from all on-road sources including cars, trucks, buses, and motorcycles. These emissions can be

measured at the national, county, and project level for criteria pollutants, greenhouse gases, and air toxics.

Additionally since MOVES' debut in 2010, there have been several improvements to the model. MOVES2014 is a major new revision to EPA's mobile source emission model and it replaces MOVES2010 and its minor revisions (MOVES2010a and MOVES2010b). MOVES2014a, released in December 2015, is the latest version of MOVES. It incorporates significant improvements in calculating onroad and nonroad equipment emissions. MOVES2014a does not significantly change the criteria pollutant emissions results of MOVES2014 and therefore is not considered a new model for SIP and transportation conformity purposes (EPA, 2015). However, MOVES2014a was used in this research because of its updated defaults and improvements in calculating emissions.

2.3. Comparing MOVES to MOBILE

The input structure MOVES provides is more flexible than its predecessor is. It includes a graphical user interface (GUI), while MOBILE required text input and output files. MOVES uses MySQL software and Java operating in Windows rather than MOBILE FORTRAN software and operating in DOS. MOVES has a relational database structure to store data in tables that allows updates without requiring changes to the model code (Vallamsundar & Lin 2011).

In terms of outputs, MOVES provides an estimate on a total emission inventory as well as emission rates, supplanting the need for extensive external post-processing. The output is also easily customizable with varying levels of aggregation and disaggregation.

The temporal and geographical reach of MOVES far exceeds the capabilities of MOBILE. MOVES can provide emission estimates at national, county, and project level, rather

than MOBILE's regional scale with no geographical specificity. MOVES can also generate estimates by hour, weekday, weekend, month or year. MOVES emissions are based on "operating modes" such as acceleration, cruising, and deceleration as well as average speed, but MOBILE was only based on aggregate driving cycles accounting only for differences in average speed.

MOVES includes the ability to estimate emissions from criteria pollutants, greenhouse gases and air toxics, while MOBILE only calculates emissions of hydrocarbons, oxides of nitrogen and carbon monoxide from passenger cars, motorcycles, light and heavy duty trucks (CRC, 2010).

MOVES consist of a larger data set including in-use data on light duty vehicles, PM data for light duty vehicles with temperature effects, data for heavy-duty vehicles including speed effects and crankcase, start, and extended idle emissions (Fujita, 2012). MOBILE used certification data rather than in-use and did not provide for various speed and temperature effects (Tang et al., 2003). MOVES adopts a much more sophisticated, modal-based estimation procedure than the simplistic fuel economy approach in MOBILE for computing transportation energy consumption and Green House Gas (GHG) emissions (Vallamsundar & Lin 2011).

Chapter 3: Emissions Modeling Using MOVES2014

The following chapter discusses the use and review of the emission model MOVES2014. The EPA's aforementioned MOVES is used as a post-processor to determine the air quality impact of transportation projects and their vehicular emissions. MOVES contains default values for many of the inputs required in the model including the transportation related ones. However, the EPA recommends the use of local information for transportation related inputs as a strategy to obtain better emission estimates. Using MOVES project-level simulation, a more detailed analysis can be performed for the emissions from traffic in the area and ultimately provide useful data for developing a correlation to ambient air concentrations.

3.1. Previous MOVES Versions

MOVES2004, released in 2004, was the first installment of the new generation of mobile source modeling framework that could be used to estimate and project national inventories at the county level for nitrous oxide, methane and carbon dioxide from highway vehicles.

MOVES-HVI, released in 2007 was a demonstration version of MOVES that is the Highway Vehicle Implementation of EPA's model. This version's only added features were to estimate criteria pollutant emissions such as gaseous hydrocarbons, carbon monoxide, oxides of nitrogen and particulate matter from highway vehicles, but results were not to be considered realistically (EPA, 2007).

A draft version of MOVES was released in 2009 to the public mainly for users' review and comments and was not intended for official use. The first emissions model was designed to work with databases to accommodate for newly available data. The model also included a "default" database that summarized emission relevant information for the United States. This

data comes from EPA research studies, Census Bureau vehicle surveys, Federal Highway Administration travel data, and other federal, state local, industry and academic sources. A finalized version was released in December 2009 as MOVES2010 (EPA, 2009).

Previous versions of official MOVES include MOVES2010, MOVES2010a, and MOVES2010b. MOVES2010 was the first of EPA's tool for estimating emissions from highway vehicles (EPA, 2009). MOVES2010a, released in August 2010, is a minor revision to MOVES2010. This version allows users to account for emissions under new car and light truck energy and greenhouse gas standards affecting model years for 2012 and later and updates effects. MOVES2010b includes corrections to database as well as several improvements to network operations.

MOVES2014 is the first major revision to the MOVES series since the original release of MOVES2010. MOVES2014 incorporates new emissions test data, the impacts of new emissions standards, new features, and other functional improvements, all of which contribute to improved estimates of criteria pollutant emissions compared to MOVES2010 (EPA, 2015).

MOVES2014 allows users to benefit from new regulations promulgated since the release of MOVES2010b and incorporates new and up-to-date emissions data, and has improved functionality compared to MOVES2010b. MOVES2014 also has added the capability to model non-highway mobile sources by incorporating EPA's NONROAD2008 model (EPA, 2015).

3.2. Review of MOVES2014

MOVES2014 is a computer model designed by the EPA to estimate emissions from cars, trucks, buses and motorcycles. This model can be used to estimate emissions from transportation projects that include roadways intersections, highways, transit projects and parking lots. MOVES is designed to allow for the estimation of motor vehicle emissions at multiple scales, from

national to county to project-level, using different levels of input data. Additionally, the model can be used to complete project-level hot-spot analyses for transportation conformity determinations, modeling project-level emissions for state implementation plans, and completing environmental assessments and environmental impact statements as required by the National Environmental Policy Act (NEPA).

There are several decisions to be made before conducting a project level analysis as required by this research. A general overview of the EPA's guidance manuals, "Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas" and "MOVES2014a User Guide" is intended to help evaluating and choosing models and the associated methods and assumptions before conducting the analysis (EPA, 2015).

3.3. RunSpec Parameters

This section describes the inputs necessary for the three different types of analysis. In order to process the RunSpec a description must be entered as well as a selection of the scale of the analysis. A time frame must be selected for the analysis to include the year, month, day, and hour. At the project level, each MOVES run represents one specific hour. The user may select either "weekday" or "weekend" but for most analytical purposes "weekday" is the appropriate choice. The project scale also allows the user to define the specific a single county where the project takes place. The user is able to specify the vehicle types that are included in the run, of which there are 13 "source use types" to select from. In addition to the vehicle type, the user must identify fuel/source type combinations. Fuel types Gasoline, diesel, ethanol, and compressed natural gas should always be selected. MOVES includes five different road types users can choose which include rural restricted access, rural unrestricted access, urban restricted

access, urban unrestricted access, and off-network. MOVES utilizes the road types to determine the default drive cycle on a particular link. Pollutants and processes are chosen at the same time due to some pollutants/processes being chained and calculated as ratios to others. Finally, output details must be selected to specify the level of detail desired in the output data

The MOVES model allows for three different levels of analysis. Using the national scale analysis the model can be used to model the entire country, one or more states, or one or more counties. This scale allows the user to use the information in the MOVES default database, but still provides the option to input local data and override the default data.

The county scale analysis can be used to model an individual county or a Custom Domain made up of several counties. This scale is required for use in State Implementation Plans and conformity analyses. The user must enter county-specific data for the input database. While there is some access to default data, local data is necessary for most inputs. The project scale analysis provides link level modeling of specific transportation projects including highways, intersections, interchanges, transit projects and parking lots. The user must enter project-specific data for the input database. For each of the three levels of analysis, a RunSpec must be created. The RunSpec specifies the scale, location, time period, alternate data, and output preference of the MOVES run. A description panel allows for the inclusion of details in the form of text. The scale panel indicates the scale of the analysis. Calculation type can be either Inventory or Emission Rates. Using both can give equivalent results but post-processing errors are more common if using emission rates calculation type.

Time spans panel allows a time aggregation to be chosen from year, month, day, or hour. National level allows for choosing multiple years, months, days, and hours. County level runs

can choose all hours and months but only a single year. Project level allows for choosing only one year, one month, one hour, and either weekend days or weekdays.

The geographic bounds panel allows the user to choose the county in which the analysis is in; this accesses the available default data stored for that county. The Vehicles/Equipment panel defines the types of vehicles to be analyzed. For most analyses, all valid gasoline, diesel, ethanol and CNG vehicle combinations are used. Table 3.1 displays the MOVES Source Types and HPMS Vehicle Types. The user can indicate which road type to include in the analysis. Table 3.2 provides descriptions for the available road types.

Table 3.1: Source Types

sourceTypeID	**sourceTypeName**	**HPMSVtypeID**	**HPMSVtypeName**
11	Motorcycle	10	Motorcycles
21	Passenger Car	25	Light Duty Vehicles
31	Passenger Truck	25	Light Duty Vehicles
32	Light Commercial Truck	25	Light Duty Vehicles
41	Intercity Bus	40	Buses
42	Transit Bus	40	Buses
43	School Bus	40	Buses
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck	50	Single Unit Trucks
53	Single Unit Long-haul Truck	50	Single Unit Trucks
54	Motor Home	50	Single Unit Trucks
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck	60	Combination Trucks

Table 3.2: Road Types

Road Type	Description
Off-Network	Captures emissions that occur while vehicles are not moving, i.e., start, extended idle (hoteling of long haul combination trucks), and resting evaporative emissions. Idle emissions that occur during normal running operation, such as at signalized intersections, is captured in the other road types.
Rural Restricted Access	Captures running emissions, including running evaporative emissions. Restricted indicates restricted vehicle access via ramps, such as freeways and interstates.
Rural Unrestricted Access	Captures running emissions, including running evaporative. Un-Restricted indicates all other rural roads not included in Restricted.
Urban Restricted Access	Captures running emissions, including running evaporative. Restricted indicates restricted vehicle access via ramps, such as freeways and interstates.
Urban Unrestricted Access	Captures running emissions, including running evaporative. Un-Restricted indicates all other urban roads not included in Restricted.

The pollutants and processes panel allows the choosing of the pollutant and process combinations required for the analysis. Some pollutants/processes are chained and are calculated as ratios to others. MOVES calculates emissions of criteria pollutants, greenhouse gases, and selected air toxics associated with motor vehicle operation (EPA, 2015). MOVES also calculates energy consumption for onroad and fuel consumption in terms of mass fuel per day (i.e., grams fuel per day) for nonroad. For many pollutants, the emissions calculation is based on the prior calculation of another pollutant emission. The Pollutant/Process will display an error message if the user selects a dependent pollutant but not the base pollutant. In MOVES2014, the option to automatically select all prerequisite pollutants is available. There are fewer pollutants available for nonroad equipment, but the prerequisites are the same as for onroad and all of the buttons in this window operate identically for nonroad.

In MOVES, Processes refers to the mechanism by which emissions are created. Engine operation creates Running Emissions Exhaust, Start Emissions Exhaust (the addition to running

emissions caused by the engine start), and Extended Idle Emissions Exhaust (i.e., hotelling emissions from a combination, long-haul truck). MOVES Onroad emission processes also distinguish Crankcase Running Exhaust, Crankcase Start Exhaust, and Crankcase Extended Idle Exhaust to describe the exhaust gases that escape around the piston rings and enter the crankcase during normal operation. For nonroad equipment, start and running emissions are both included in “Running Exhaust.” The Crankcase Running process is available in nonroad but only for the total hydrocarbon pollutant. Evaporative emissions occur when unburned fuel escapes the vehicle's fuel system. For onroad vehicles, MOVES models these emissions through the following processes: Evaporative Fuel Vapor Venting, Evaporative Permeation, Evaporative Fuel Leaks, Refueling Displacement Vapor Loss and Liquid Spillage Loss.

For nonroad equipment, MOVES models evaporative emissions separately by the following processes: Crankcase Running Exhaust (which is actually Evaporative, not Exhaust), Refueling Displacement Vapor Loss, Refueling Spillage Loss, Evap Tank Permeation, Evap Hose Permeation, Diurnal Fuel Vapor Venting, Hot Soak Fuel Vapor Venting, and Running Loss Fuel Vapor Venting.

For Onroad vehicles only, Brakewear and Tirewear describe the non-exhaust particulate emissions that result from brake use and tire wear.

In onroad, there are some Processes are dependent on other Processes or other conditions that apply to all pollutants that share the process association. Some dependencies are specific to Onroad and relate to required selections in the Time Spans or Road Type section of the Navigation Panel. If dependencies are included in any of the processes, there are associated requirements. Nonroad does not have any of these process prerequisite requirements.

In general, the MOVES data importers, such as the Data Importer, Nonroad Data Importer, County Domain Manager, and the Project Data Manager, should be used to enter data rather than the Manage Input Data Sets panel. It is highly recommended to use the MOVES data importers and managers because they provide advantages such as checking the data for errors, creating input templates, and exporting default data filtered to be consistent with other RunSpec settings. However, MOVES allows the user to select Manage Input Data Sets on the Navigation Panel to specify specialized user-supplied data to be read by the model during execution.

Output databases allow the user to choose what output data to be displayed and calculated for units, activity, and output emission details. The units available for the mass are kilograms, grams, pounds, or U.S. tons. Available energy units are joules, kilojoules, or million BTUs (British Thermal Units). The available distance units are miles or kilometers. Only one choice can be made for each unit. The activity that can be displayed in outputs includes distance traveled, source hours, hoteling hours, source hours operating, source hours parked, population, and starts.

3.4. Data Manager Inputs

Data is entered using the County Data Manager (CDM) or the Project Data Manager (PDM). Setting the descriptions for the RunSpec first allows the data manager to filter default data for relevant information. The data manager also conducts error-checks on the user imported data to make sure there are no conflicts with description entered in initial RunSpec.

The meteorology data importer allows the user to import temperature and humidity data for months, zones counties, and hours that are included in the RunSpec. The MOVES default database contains 10-year average temperature and humidity data for the period from 2001 to 2011 for each county, month, and hour.

The importer also allows for the specification of Source Type Population by inputting the number of onroad vehicles for each source type in the geographic area.

The user can also enter data that provides the distribution of vehicle counts by age for each calendar year and vehicle type as a fraction adding to one for each vehicle type and year.

The vehicle type VMT importer is used to enter vehicle miles traveled data and VMT time allocation fractions into MOVES. VMT may be entered by HPMS typed according to the Federal Highway administration or by MOVES source types as annual or daily VMT.

The user can input average speed data specific to vehicle type, road type, and time of day. MOVES defines 16 speed bins, which describe the average driving speed on a road type or link. The fraction of driving time in each speed bin for each hour/day type, vehicle type, road type, and average speed, must be entered, where the fractions sum to one for each combination of vehicle type, road type, and hour/day type specified in the RunSpec.

The ramp fraction allows the user to modify the fraction of time driving on ramps on selected road types.

The fuel tab of the importer includes four different aspects of fuel data that can be specified. The fuel formulation property allows the selection of an existing fuel in the MOVES database and the option to change its properties, or create a new fuel formulation with different fuel properties. Fuel supply assigns existing fuels to fuel regions, months and years and an associated market share for each fuel. Fuel usage refers to the fraction of E-85 capable vehicles using E-85 compared to conventional gasoline. The Alternative Vehicle and Fuel Technologies allows to specify the mix of fuel types in the model, specifically the fleet distribution fraction by fuel type, source type, model year, and engine technology.

The hotelling importer is used to import information on combination truck hotelling activity. In MOVES2014, hotelling can be divided into three operating modes: Extended Idle, Diesel Auxiliary power (APU), and APU-Off. Extended Idle is defined as long-duration idling with more load than standard idle and a different idle speed. It is used to account for emissions during hotelling operation when a truck's engine is used to support loads such as heaters, air conditioners, microwave ovens, etc. Diesel Auxiliary power refers to use of auxiliary power units that allow for heating/cooling/power for the cab without running the truck's engine. APU-Off refers to hotelling when the truck's engine is off and an APU is not being used. This could include hotelling resulting from truck-stop electrification. All hotelling processes only apply to long-haul combination trucks.

Specific to the Project Data Manager, the link source types importer is used to enter the fraction of the link traffic volume, which is driven by each source type. It is not used to enter off-network data, and is not required if the Project contains only an off-network link. For each link ID, the source type hour fraction must sum to one across all source types. If you enter data for source types that are not selected in the RunSpec, MOVES will ignore that data. The Project level calculator will not re-normalize the fractions to omit the contribution of source types that are not selected in the RunSpec.

Also specific to the PDM, the operating mode distribution importer allows the import of operating mode fraction data for source types, hour/day combinations, roadway links and pollutant/process combinations that are included in the RunSpec and Project domain. This data is entered as a distribution across operating modes. Operating modes are modes of vehicle activity that have a distinct emission rate. Running activity for light duty vehicles has modes that are distinguished by their Vehicle Specific Power and instantaneous speed. Start activity has modes

that are distinguished by the time the vehicle has been parked prior to the start. The start process has eight operating modes that require data and tire wear has sixteen operating modes. It is optional for modeling 'running emission' processes. However, if chosen, data for all twenty-three running exhaust operating modes must be entered.

The Link Drive Schedules Importer is used only in the PDM. It defines the precise speed and grade as a function of time, in seconds, on a particular roadway link. The time domain is entered in units of seconds, the speed variable in miles per hour and the grade variable in percent grade. This importer is used only when modeling 'running emission' processes when the Link Drive Schedules Importer is used. For a given roadway link, an operating mode distribution input will take calculation precedence over an imported drive schedule. An imported drive schedule will take calculation precedence over an average link speed input when more than one is entered for a given link. However, at least one of three, an operating mode distribution, a link drive schedule or a link average speed, must be entered for each of the defined roadway links.

The off-network importer used in project-level scales provides information about vehicles that are not driving on the project links, but still contribute to the project emissions. For each source type in the RunSpec, vehicle population is the average number of off-network vehicles during the hour being modeled. The start fraction field is a number from zero to 1.0, which specifies the fraction of this population that has a 'start' operation in the given hour.

Finally, the Inspection and Maintenance (I/M) programs importer specifies the level of compliance and general effectiveness of the I/M program design being used. The compliance factor input is a multiplicative factor that encompasses I/M program performance metrics such as waiver rates, exemptions, special training programs and general effectiveness. It can range from 0 percent (a program that has no effectiveness or merit) to 100 percent (highest possible success).

The compliance factor is entered as a function of pollutant-process, location, source type, model year range, fuel type and specific I/M test types. The lack of data in this importer will lead to the modeling of a no I/M scenario.

3.6. MOVES2014 Outputs

MOVES allows for two types of outputs, emission rates or inventory. Specifying for emissions rates provides output as a set of emission rates per mile or per vehicle. This output can be post-processed by multiplying rates by vehicle activity data to get inventory. MOVES produces three sets of rates: rate per distance, rate per vehicle, and rate per profile. The table of emission rates is further organized by varying temperature, speed, road type, and fuel type. Rates can be applied to multiple counties and multiple days with the same fuels and Inspection and Maintenance Programs. Emission rate output should be used when modeling many counties as well as to model a wide range of temperatures. The user can apply rates on a link basis for a link-based inventory.

The inventory output delivers emissions in units of mass in the form of grams, kilograms, pounds, and tons. MOVES processes results, rates multiplied by activity, to yield total mass of emissions. The results are specific to county and time. Inventory output can be used to model a small number of counties over a limited time period and when it is necessary to minimize post-processing and avoid calculation errors. This output format can be used to develop inventories for a single nonattainment area with a limited number of counties.

Chapter 4: Study Design

The El Paso Metropolitan Organization (MPO) provided El Paso traffic data used in the study. The data included the Travel Demand Model (TDM) studied by the MPO in the Horizon 2040 Metropolitan Transportation Plan, used for transportation conformity purpose (MPO, 2014). Three different monitoring stations in El Paso were chosen as the center of each impact zone. Zones with radiuses of 0.5km, 1km, and 2km were analyzed at each monitoring station, permitting geographical distance to the U.S.-Mexico border. Using the traffic network, data from roadway links was extracted from the areas chosen. Using MOVES, project-level runs were created for different times of day. The TDM provided roadway link data for the average hour/peak-hour traffic scenario. Using the traffic data corresponding for the time of days, four runs were created for each zone at the three stations. Pollutants analyzed were carbon monoxide, PM_{10}, $PM_{2.5}$ and oxides of nitrogen (NO_x). Post-processing of the data included finding daily inventories for each zone and normalizing data using a simplified box model.

4.1. Selection of CAM Stations

This study focuses on three different locations in the El Paso del Norte Area. Each site location was chosen among all available Texas Commission on Environmental Quality (TCEQ) Continuous Air Monitoring Stations (CAMS) in El Paso and New Mexico Environment Department (NMED) air monitoring stations in Dona Ana County for the ambient air monitoring station at the center of each zone. Criteria used during the selection of study locations included:

- Pollution data
- Distance to the highway
- Distance to the border

Each air monitoring station was chosen considering the pollutant data available for the study year as well as the pollutants monitored and their relevance to the study. This was a limiting factor, as many stations discontinued or had never monitored and reported the criteria pollutants in this study. The station's proximity to a highway to assess higher levels of traffic was the second step in selection of a station. Additionally, a station's distance to the U.S.- Mexico border was a criteria analyzed in the selection of the stations. Because of the limited availability of motor vehicle activity data from Ciudad Juarez as well as difficulty integrating traffic networks, stations with close proximity (less than 0.5 km) to the border were excluded from selection. The stations include two CAMS operated by the TCEQ and one station operated by the NMED.

The first station chosen is located on the University of Texas at El Paso campus, also named CAMS 12 UTEP. This station has been operational since 1996. The parameters currently monitored at the station include sulfur dioxide, nitric oxide, nitrogen dioxide, oxides of nitrogen, ozone, PM_{10} (at standard conditions) and $PM_{2.5}$ (at local conditions). The station also monitors various meteorological parameters including wind speed, wind direction, outdoor temperature, dew point temperature, relative humidity, precipitation, and solar and ultraviolet radiation. Carbon monoxide information is only available for dates from June 1998 to March 2015. PM_{10} at local conditions is available at this site from June 1998 to July 2000. $PM_{2.5}$ data at local conditions is available from November 1999 to January 2007. The $PM_{2.5}$ parameter available for the study year of 2010 is referred to as "$PM_{2.5}$ Acceptable" which is found from speciation mass. This parameter is utilized for mass concentration data produced from speciation networks. The location of this station, less than 1 km from the I-10 Highway as well as various urban arterial roads and the traffic experienced at this location can show how higher traffic activity can produce high levels of emissions.

The second station chosen is located on 320 Old Hueco Tanks Rd in the town of Socorro near the far east side of El Paso, labeled CAMS 49. This ambient air monitoring station has been operating since November 1999. Among the pollutants being currently monitored are PM_{10} (standard conditions) and $PM_{2.5}$ (local conditions). Carbon Monoxide data is available for this site from August 2004 to February 2012. Data for Oxides of Nitrogen is available from November 1999 to January 2008. This station is not located near any major highways but includes traffic patterns for residential roads and traffic provided by its proximity to an elementary school and a park. This station also allows for a higher radius impact zone of 2 km without encompassing areas in Ciudad Juarez.

The third monitoring station is located 5935 Valle Vista in Sunland Park labeled 6ZM Desert View operated by the New Mexico Environment Department. Of the pollutant parameters currently measured at this site PM_{10}, $PM_{2.5}$ and NO_x are the pollutants of interest for this study, which include data for the study time frame of July 2010. A map of the study area is shown in Figure 4.1 showing the locations of the three ambient air-monitoring stations. The impact zones chosen for this location include traffic patterns caused by the proximity of two elementary schools as well as McNutt Road, which includes higher traffic volumes.

These stations are chosen because of the pollutant data available for the study period as well as for their locations providing varying insight to traffic patterns and their correlations to measured ambient air concentrations by the air monitoring stations. Figure 4.1 below shows the locations of the three air monitoring stations within the study area. Included in the figure is the traffic network for El Paso county and Sunland Park provided by the El Paso MPO.

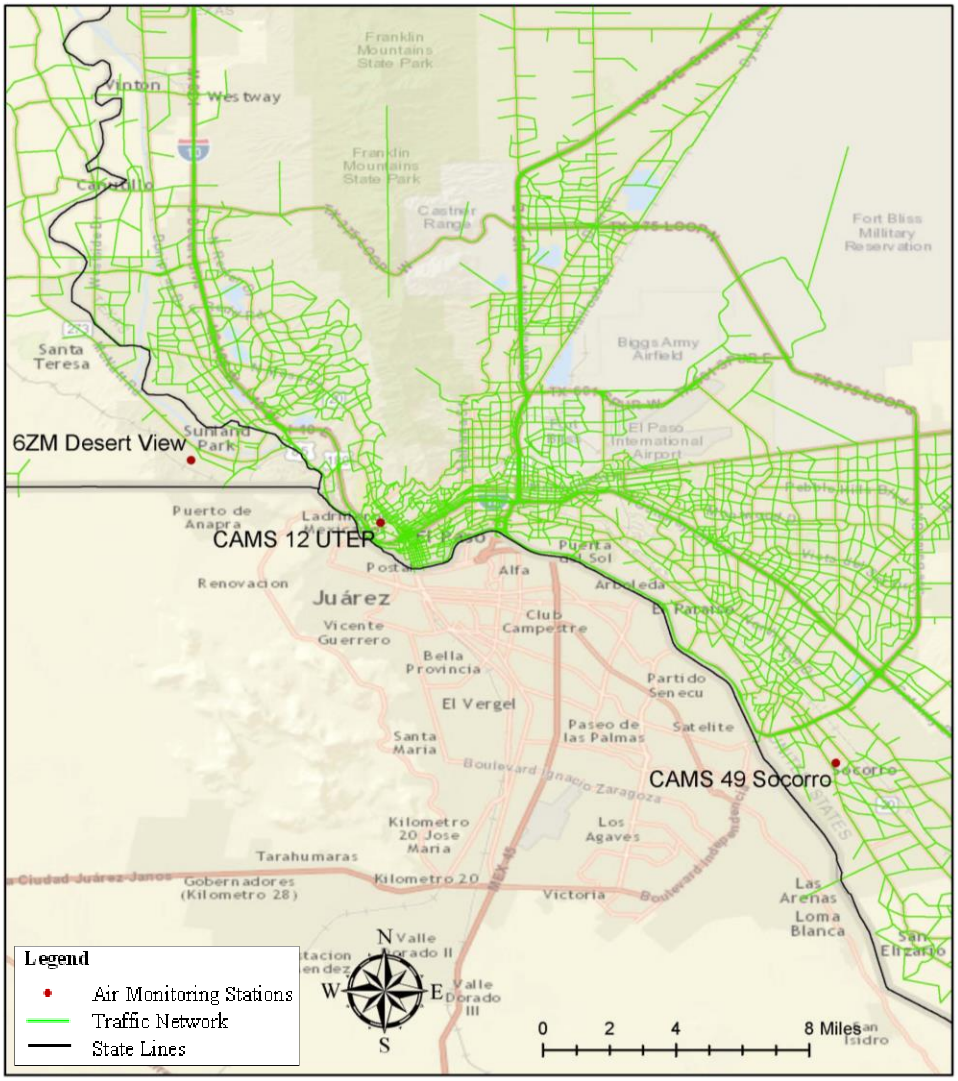

Figure 4.1: Map of Study Area

4.2. Definition of Zone

In order to identify an optimum zone that can be used to compare MOVES estimates with air monitoring stations reported data, varying size radius must be analyzed at the three locations. Each monitoring station was included in zones analyzing traffic information using three different sized radiuses. Three sizes of the zones (0.5, 1.0 and 2.0 km) were identified for use in the analysis. Because of the lower amount of arterial or highway roads at the stations

located at Sunland Park and Socorro, zones with a radiuses less than 0.5 km would result in narrow traffic data. At the monitoring station located on UTEP campus and the station located in Sunland Park at Desert View, a 2.0 km radius zone could not be used because of their proximities to the United States border with Mexico. These zones might be analyzed if traffic data from Ciudad Juarez is incorporated with the traffic network for the El Paso County area. Shown in Figure 4.2 are the links chosen to analyze the 0.5 km radius impact zone studied at the CAMS 12 UTEP location. Any links, or part of links contained in the different zone areas were included in each analysis. There are 48 links included in this analysis.

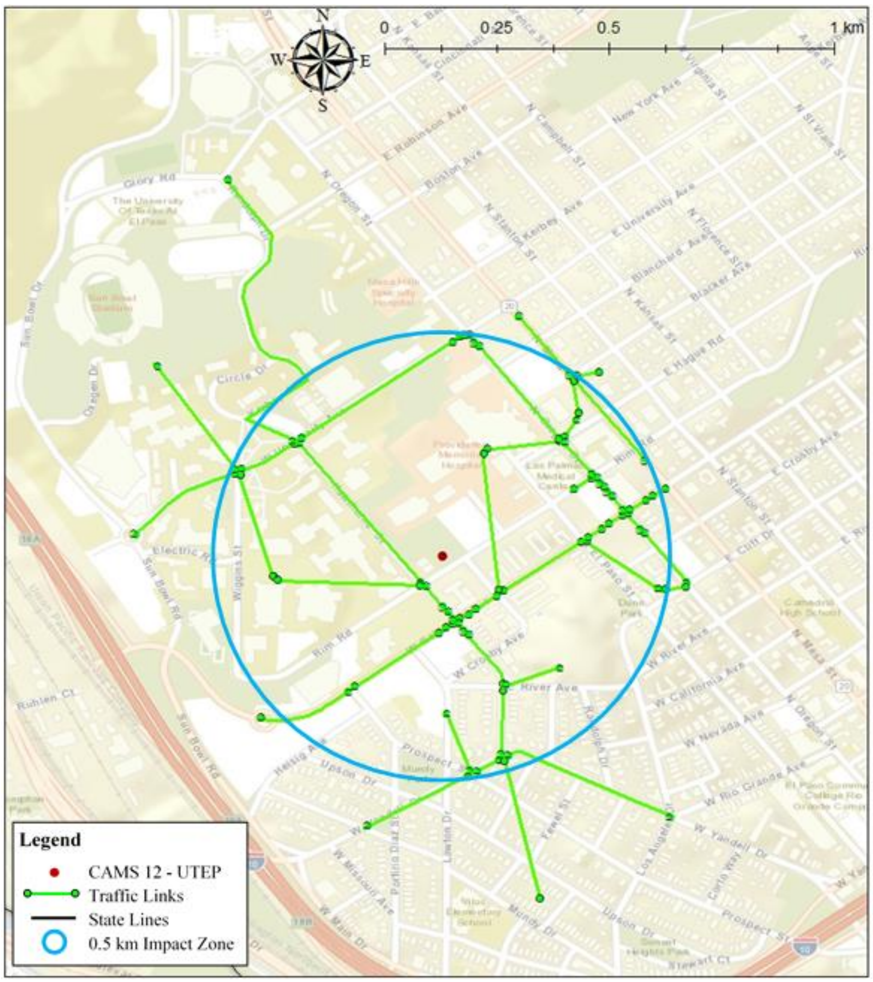

Figure 4.2: 0.5 km Radius Impact Zone at CAMS 12 UTEP

Figure 4.3 below shows the links chosen to analyze the 1 km radius impact zone at CAMS 12. The number of roadway links included in this analysis was 174.

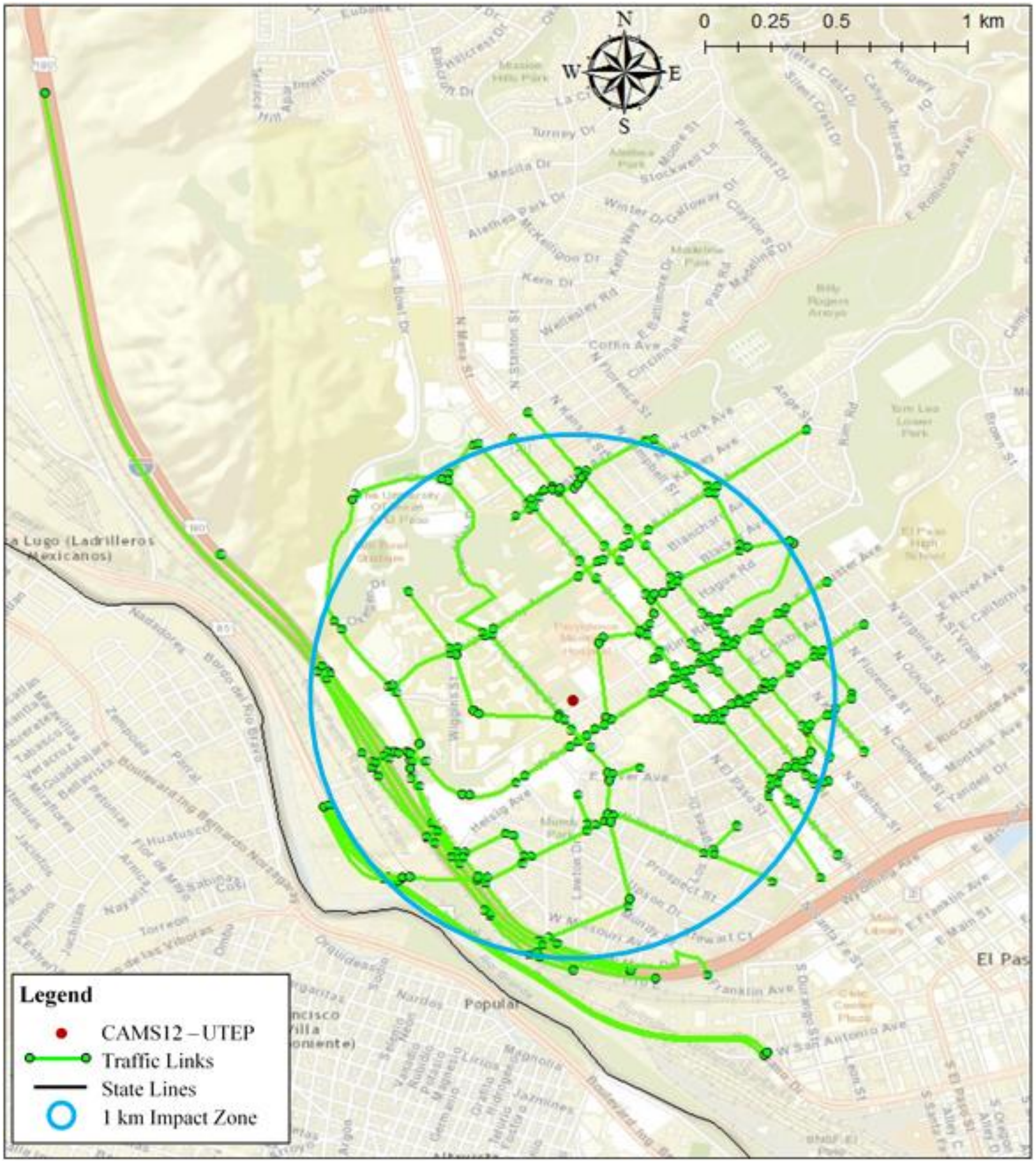

Figure 4.3: 1 km Radius Impact Zone at CAMS 12 UTEP

The second monitoring station located in Socorro allowed for the selection of three impact zones. Because of its distance from the border, this station supported using impact zones with 0.5 km, 1.0 km and 2.0 km radiuses. Figures 4.4 through 4.6 display the three impact zones of 0.5 km, 1.0 km, and 2.0 km radius around CAMS 49 highlighting the links chosen for each impact zone. Two roadway links were included in the 0.5 km radius analysis; 15 links were included in the 1.0 km radius analysis; 43 links were included in the 2.0 km radius analysis.

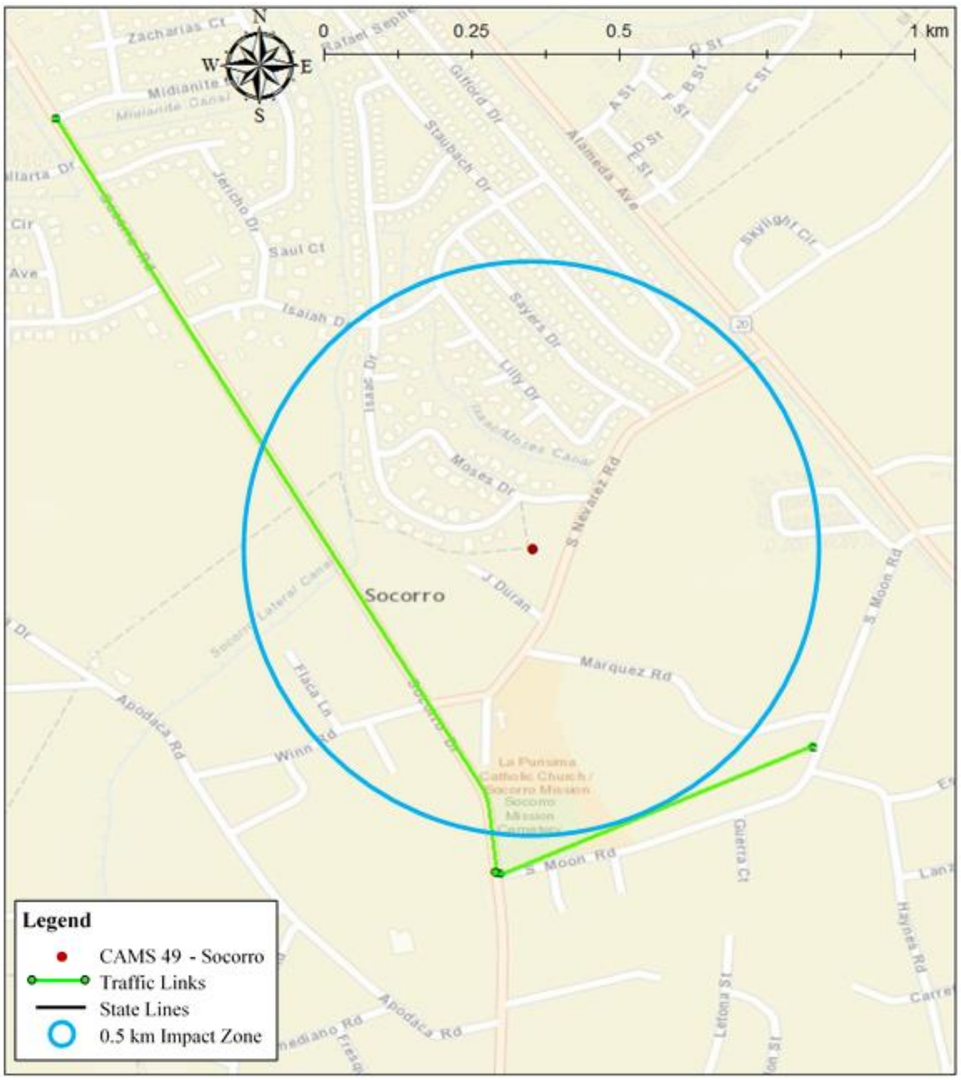

Figure 4.4: 0.5 km Radius Impact Zone at CAMS 49 Socorro

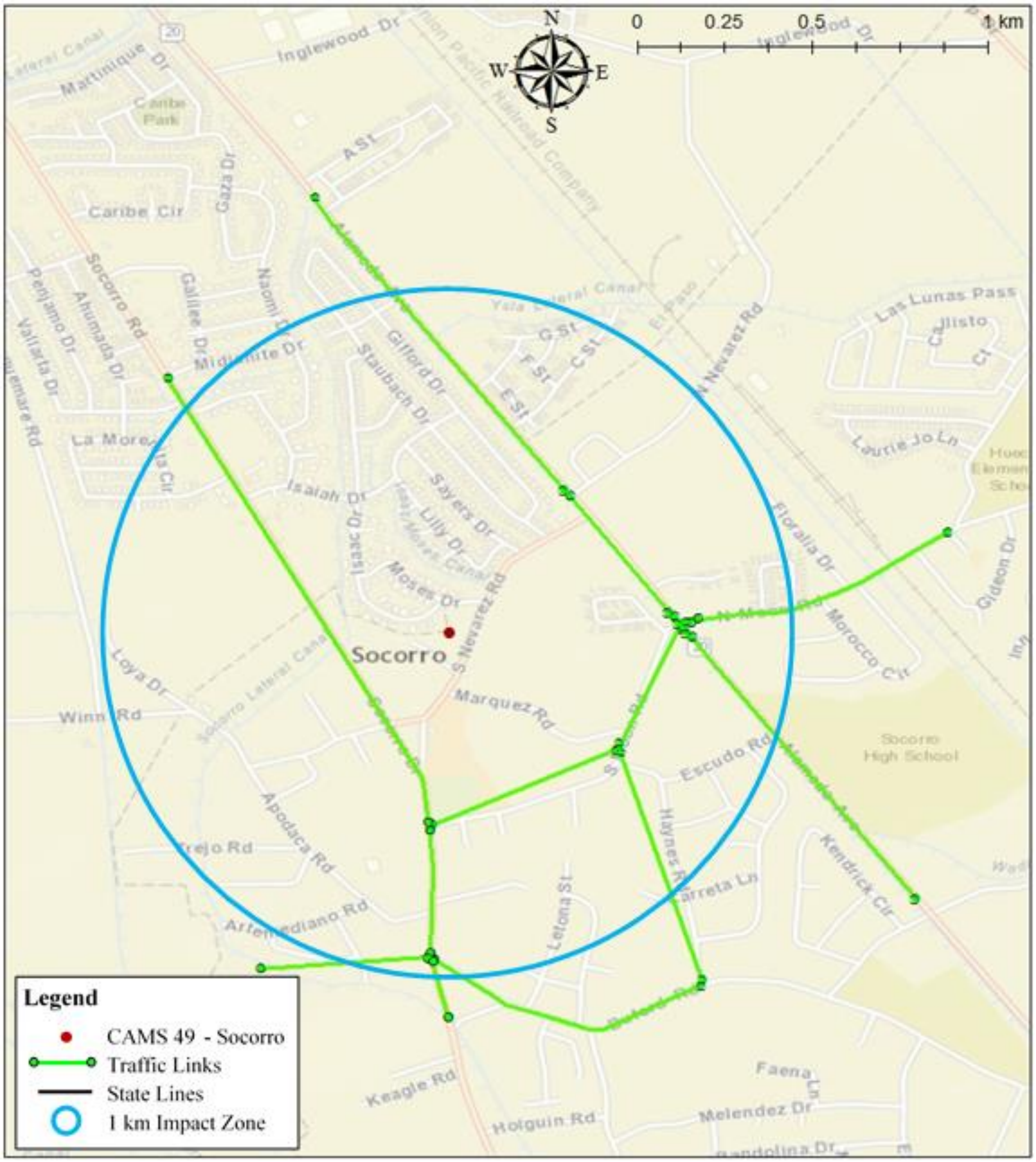

Figure 4.5: 1 km Radius Impact Zone at CAMS 49 Socorro

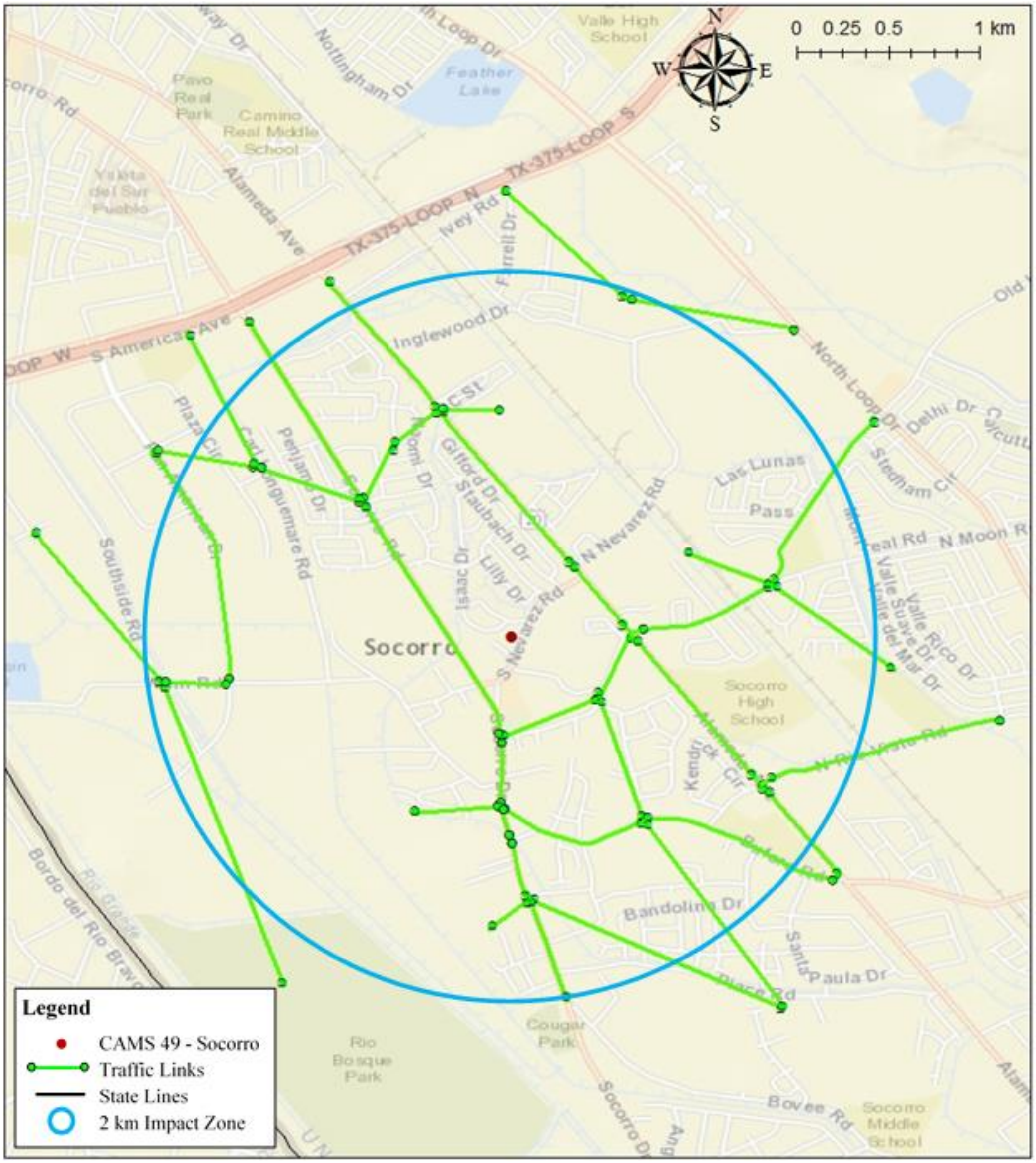

Figure 4.6: 2 km Radius Impact Zone at CAMS 49 Socorro

At the third station, the Desert View station, a radius of 2.0 km crosses the U.S.-Mexico and therefore two impact zones were selected at this location. Figure 4.7 shows the first impact zone of radius 0.5 km with only one link included for the analysis. Figure 4.8 displays the 1.0 km radius impact zone with the links studied in the analysis which were four roadway links. The number of links per impact zone and descriptions of links is discussed in the following section.

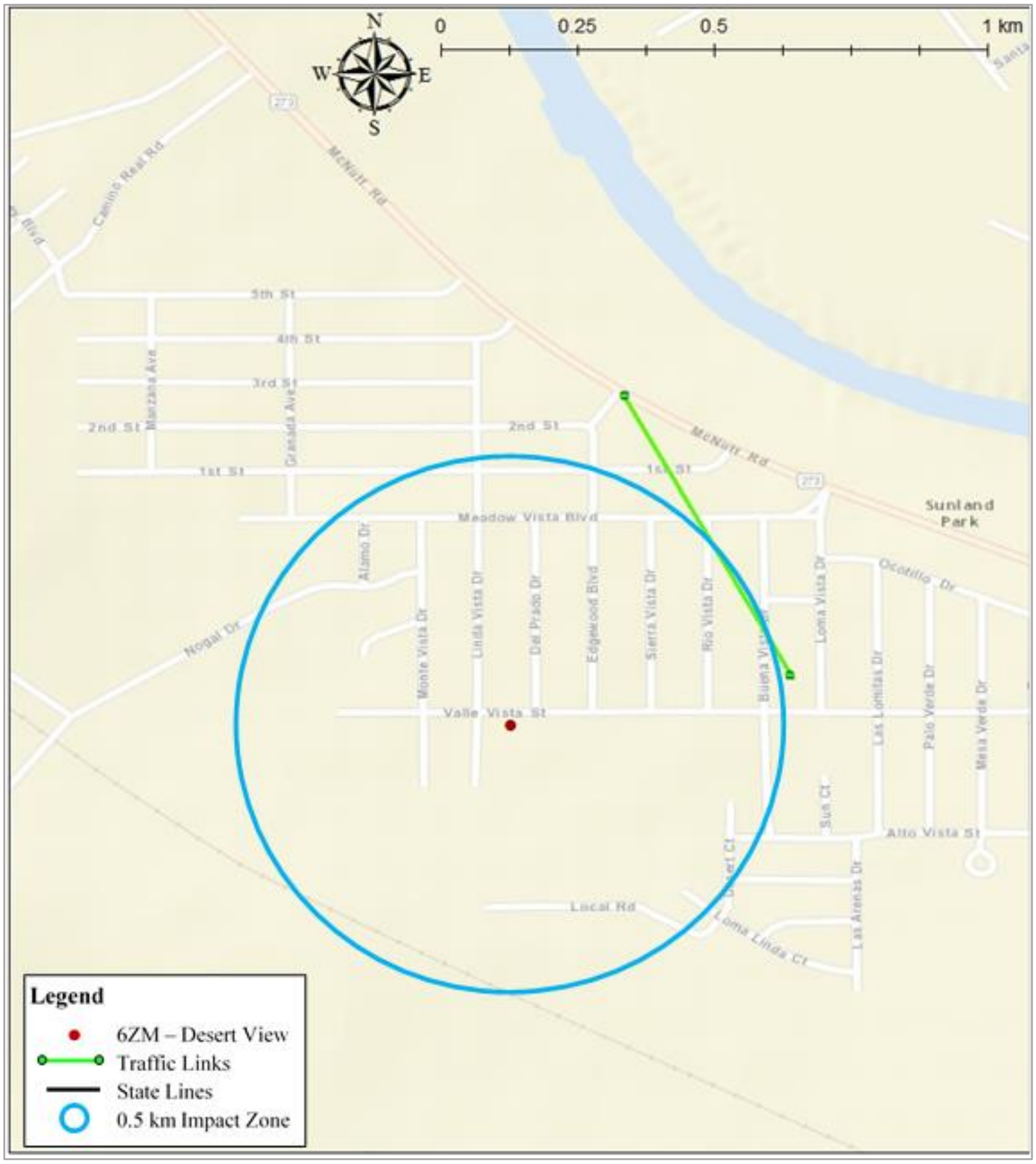

Figure 4.7: 0.5 km Radius Impact Zone at 6ZM Desert View

Figure 4.8: 1 km Radius Impact Zone at 6ZM Desert View

4.3. Definition of Links

This section describes the link data used as inputs for MOVES modeling software as provided by the TDM and approach used by MPO for development of the modeled volumes that are part of the air quality conformity process. For the development of the travel demand model, the MPO study area includes El Paso County in Texas and small portions of Dona Ana and Otero counties in New Mexico. MPO used a 2007 base year with demographic estimates and forecasts

provided for the years 2010, 2020, 2030, and 2040 (MPO, 2011). Roadway networks were prepared for these years showing the number of lanes and roadway types (functional class) that would be constructed according to proposed long-range and short-range project descriptions, as well as roadways that already exist. Included in the travel demand model are the roadways on which conformity is based and thus considered regionally significant. Roadways in the travel demand model are coded with functional class and capacity classifications. Roads are identified by the functional classification code provided by the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS), which designates codes to seven definitions of roads. The HPMS classification codes include interstate, "other freeways and expressways", "other principal arterial", minor arterial, major collector, minor collector, and local (FHWA, 2013). As discussed in the previous chapter, the MOVES model includes six road types: off-network, rural restricted, rural unrestricted, urban restricted, urban restricted. For the purpose of this emission estimation, freeways and interstates were identified as "urban restricted" inputs, which are described as urban highways that can only be accessed by an on-ramp. All other urban roads in the network were identified as "urban unrestricted". Table 4.1 displays the number of links and the road type assigned to the links in the impact zones at the three monitoring sites.

Table 4.1: Links in Impact Zones

	0.5		1		2	
	Urban Restricted	Urban Unrestricted	Urban Restricted	Urban Unrestricted	Urban Restricted	Urban Unrestricted
CAMS 12	0	48	18	156	-	-
CAMS 49	0	2	0	15	0	44
6ZM	0	1	0	4	-	-

Detailed link information is provided in Chapter 5, which includes link length, posted speed, total volume in all lane directions, VMT, and flow per hour in each time period.

4.4. Estimation of Traffic Emissions

The estimation of traffic emissions is conducted using MOVES modeling software. Utilizing the project-level analysis for the impact zones identified at the three station locations, emissions inventories will be provided for each zone. The traffic data from the links within the zones provided the inputs needed for the MOVES modeling. Estimation of pollutant concentrations in these zones was performed with a simplified box model using meteorological parameters also measured at each station.

Chapter 5: MOVES Model Application for El Paso Area

5.1. Project Details

This study focuses on three different locations in the El Paso del Norte area. Each location was selected with a chosen monitoring station at the center of each zone. The stations include two Continuous Air Monitoring Stations (CAMS) operated by the TCEQ and one station operated by the NMED. The first station chosen is located on the University of Texas at El Paso campus, also named CAMS 12 UTEP. The second station chosen is located on 320 Old Hueco Tanks Rd in the town of Socorro near the far east side of El Paso, labeled CAMS 49 Socorro. The third monitoring station is located 5935A Valle Vista in Sunland Park labeled 6ZM Desert View. Each monitoring station was included in impact zones analyzing traffic information using 0.5, 1.0 and 2.0 km radius, depending on the station.

5.2. MOVES Model Inputs

Most of the inputs for the RunSpec remained the same for each location, apart from link parameters. Due to lack of detailed data available on links, many inputs were simplified in order to complete analysis runs. For each zone, two different time periods were analyzed, summer weekday and winter weekday. The geographic bounds are set to be El Paso County, Texas.

The pollutants to be studied included carbon monoxide, oxides of nitrogen, primary exhaust PM_{10}, PM_{10} brakewear and tirewear particulates, primary exhaust $PM_{2.5}$, and $PM_{2.5}$ brakewear and tirewear particulates.

Meteorological data obtained from air monitoring stations was used for each different time period, including differences between times of day. Meteorological data for the summer runs is shown in Table 5.1. Site-specific data was acquired from air monitoring stations for the

month of July in El Paso County, Texas. Values for humidity were obtained from CAMS 12, as that station is the only of the three monitoring that meteorological parameter.

Table 5.1: Summer Meteorological Data

	Hour	Temperature (°F)	Relative Humidity
CAMS12	8	77.1	53.0
	12	86.3	35.3
	16	88.2	34.0
	24	78.9	51.7
CAMS49	8	76.7	53.0
	12	86.4	35.3
	16	87.5	34.0
	24	77.2	51.7
6ZM	8	76.9	53.0
	12	86.3	35.3
	16	87.8	34.0
	24	78.1	51.7

Default values were exported from MOVES for the Inspection/Maintenance program for each run. Fuel data was also exported from MOVES default database.

Link “source types” refers to the types of vehicles in the traffic network which were found using data from El Paso Registration Distribution for the entire city. Simplifying distributions of all vehicle types to include only the four vehicle types analyzed in this project, (motorcycle, passenger car, passenger truck, and light commercial truck), estimations were made using Fiscal Year Registration Class Code Count Report prepared by the IT Division of the TxDMV (TxDMV, 2014). This report provided the distribution of registered Texas passenger vehicles less than 6,000 lbs., motorcycles and trucks. Remaining fractions were attributed to light commercial trucks. Link source fractions are shown in Table 5.2 below. These describe the percentage of each type of vehicle per hour on each link. These ratios were used for all links in the traffic network.

Table 5.2: Link Source Type Fractions

Source Type ID	Source Type Name	Source Type Hour Fraction
11	Motorcycle	1.95%
21	Passenger Car	53.87%
31	Passenger Truck	26.00%
32	Light Commercial Truck	18.18%

Local link data was extracted from the Travel Demand Model (TDM) studied by the MPO in the Horizon 2040 Metropolitan Transportation Plan used for transportation conformity purposes. Three different monitoring stations in El Paso were chosen as the center of each zone. Impact zones with radiuses of 0.5km, 1km, and 2km were analyzed at each monitoring station. However, at CAMS12 and the 6ZM station the largest zone available was 1 km radius, as extending the radius would reach into Ciudad Juarez's traffic network, which was not attained for this study. Using ArcGIS in conjunction with the traffic network, data from roadway links was extracted from the impact zones chosen. Table 5.3 shows the link data obtained from the traffic network, which includes link length, posted speed, total volume in all lane directions, and VMT. Also included are the volume flows for one hour in each of the four time periods. This table shows data for the site CAMS 49 with an impact zone of 1 km radius.

Table 5.3: Detailed Link Data for CAMS 49 (1 km Impact Zone)

Length (mi)	Total Volume	Posted Speed (mph)	AM Flow/hr	MD Flow/hr	PM Flow/hr	NT Flow/hr	VMT
0.47	1955.67	30.00	290.42	58.08	216.20	13.46	914.33
0.44	294.01	20.00	66.00	2.80	33.49	0.94	128.42
0.24	3898.19	20.00	393.78	208.50	278.86	62.02	921.68
0.27	28385.72	40.00	3053.45	1509.45	2170.30	378.41	7554.99
0.43	4673.03	30.00	522.01	237.76	360.53	63.36	2002.35
0.26	1096.46	20.00	124.12	52.62	83.85	16.43	287.99
0.23	11800.11	30.00	1324.07	587.97	908.52	165.84	2728.75
0.32	281.25	20.00	30.57	11.48	27.68	3.37	89.48
0.90	11679.28	30.00	1311.50	579.86	903.24	163.68	10485.91
0.66	28385.72	40.00	3053.45	1509.45	2170.30	378.41	18604.32
0.12	10141.11	30.00	1070.39	551.99	709.11	154.33	1189.23
0.59	21943.83	40.00	2322.41	1183.46	1675.72	291.28	12852.63
0.02	4673.03	30.00	522.01	237.76	360.53	63.36	102.88
0.02	21943.83	40.00	2322.41	1183.46	1675.72	291.28	469.21
0.02	28385.72	40.00	3053.45	1509.45	2170.30	378.41	659.46

Using MOVES, project-level runs were created for different times of day. The TDM provided roadway link data for the average hour/peak-hour traffic scenario. The scenario divides 24 hours into four sections, morning peak (AM), midday (MD), evening peak (PM), nighttime (NT). The time of day periods were generated by using time of day factors developed from the 2009 House Hold Travel Survey (USDOT, 2009).

An approach of analysis was used which only required average speed of each link to be imported into the data manager. As per available data, posted speed was used for each link and assumed as average speed. Link volume and length were imported, as provided by the El Paso MPO, into the PDM. Table 5.4 displays the MOVES input file used for the project-level analysis of CAMS 49 for an AM time period using a 1 km radius for the impact zone. County ID indicates that the run is being conducted in El Paso County. The road type ID indicated that all roads in this impact zone are “urban unrestricted”. Link length is input in miles and link average

speed is in units of miles per hour. The link average speed is used as the posted speed extracted from the traffic network provided by MPO. The link volume indicated below is the volume of one hour in the AM time period.

Table 5.4: Detailed MOVES Input for CAMS 49 (1 km Impact Zone) AM

linkID	countyID	roadTypeID	linkLength	linkVolume	linkAvgSpeed
1	48141	5	0.47	290.4196	30
2	48141	5	0.32	30.5665	20
3	48141	5	0.27	3053.4452	40
4	48141	5	0.23	1324.0678	30
5	48141	5	0.26	124.1188	20
6	48141	5	0.12	1070.3856	30
7	48141	5	0.66	3053.4452	40
8	48141	5	0.90	1311.5015	30
9	48141	5	0.44	65.9961	20
10	48141	5	0.24	393.7769	20
11	48141	5	0.02	2322.4140	40
12	48141	5	0.59	2322.4140	40
13	48141	5	0.43	522.0090	30
14	48141	5	0.02	3053.4452	40
15	48141	5	0.02	522.0090	30

After extracting data from the GIS network, input files were separated by the volume flow per time period. Using the traffic data corresponding for the time of days, four runs were created for each zone at the three stations. Link data was input as the hourly average of traffic flow in each link for each of the four times of day.

Chapter 6: Results and Discussion

6.1. MOVES Outputs

The emission results are calculated by MOVES in terms of absolute grams for each link defined in the "Links" input file. Emissions by hour and link are the format in which estimates are produced and displayed in output files. Table 6.1 shows descriptions for the label IDs included in the output file of each run.

Table 6.1: Output Label ID Description

pollutantID	
2	Carbon Monoxide (CO)
3	Oxides of Nitrogen (NO_x)
100	Primary Exhaust PM_{10} - Total
106	Primary PM_{10}- Brakewear Particulate
107	Primary PM_{10} - Tirewear Particulate
110	Primary Exhaust $PM_{2.5}$ - Total
116	Primary $PM_{2.5}$ - Brakewear Particulate
117	Primary $PM_{2.5}$ - Tirewear Particulate
processID	
1	Running Exhaust
9	Brakewear
10	Tirewear
15	Crankcase Running Exhaust
sourceTypeID	
11	Motorcycle
21	Passenger Car
31	Passenger Truck
32	Light Commercial Truck

Because the project does not contain an off-network link, "Starting Exhaust", "Crankcase Starting Exhaust", "Extended Idling Exhaust", "Crankcase Extended Idling Exhaust", and "Auxiliary Power Exhaust" are not represented in the outputs. Table 6.2 displays the output file for only one link from the CAMS 12 location analyzing a 1 km impact zone for the pollutants PM_{10} and $PM_{2.5}$. This output file was conducted for the scenario of a weekday in July 2010 for

one hour in the AM time period. The output file displays total emissions quantities in grams for PM_{10} and $PM_{2.5}$ on one link, distinguishing between processes and source types. Brakewear and tirewear are identified as separate pollutants.

Table 6.2: MOVES Output per link CAMS 12 (1 km Impact Zone) AM, PM_{10} and $PM_{2.5}$

linkID	pollutantID	processID	sourceTypeID	emissionQuant
2	100	15	11	0.0000
2	100	1	11	0.0089
2	100	15	21	0.0009
2	100	1	21	0.0968
2	100	15	31	0.0016
2	100	1	31	0.0603
2	100	15	32	0.0051
2	100	1	32	0.0725
2	106	9	11	0.0018
2	106	9	21	0.5299
2	106	9	31	0.4057
2	106	9	32	0.2820
2	107	10	11	0.0021
2	107	10	21	0.1138
2	107	10	31	0.0536
2	107	10	32	0.0384
2	110	15	11	0.0000
2	110	1	11	0.0079
2	110	15	21	0.0008
2	110	1	21	0.0857
2	110	15	31	0.0015
2	110	1	31	0.0539
2	110	15	32	0.0047
2	110	1	32	0.0658
2	116	9	11	0.0002
2	116	9	21	0.0662
2	116	9	31	0.0507
2	116	9	32	0.0353
2	117	10	11	0.0003
2	117	10	21	0.0171
2	117	10	31	0.0080
2	117	10	32	0.0058

Table 6.3 displays the output file for only one link from the CAMS 12 location analyzing a 1 km impact zone for the pollutants CO and NO_x. This output file was conducted for the scenario of a weekday in July 2010 for one hour in the AM time period. The output file displays total emissions quantities in grams for CO and NO_x on one link, distinguishing between processes and source types.

Table 6.3: MOVES Output for one link CAMS 12 (1 km Impact Zone) AM, CO and NO_x

linkID	pollutantID	processID	sourceTypeID	emissionQuant
2	2	15	11	0.000000
2	2	1	11	6.554750
2	2	15	21	0.039300
2	2	1	21	59.457600
2	2	15	31	0.028553
2	2	1	31	44.768600
2	2	15	32	0.023452
2	2	1	32	27.887000
2	3	15	11	0.000000
2	3	1	11	0.202435
2	3	15	21	0.000382
2	3	1	21	8.531380
2	3	15	31	0.000361
2	3	1	31	6.465160
2	3	15	32	0.000493
2	3	1	32	4.426670

Using the emissions inventory for each run conducted with MOVES, total daily emissions were calculated from the four runs for the four different time periods of the day. Figures 6.1 through 6.6 display the emission estimates, for CO and NO_x and for PM_{10} and $PM_{2.5}$, acquired from using a 1 km radius as the impact zone analyzed for each of the three air monitoring stations. Emissions inventory graphs showing emissions estimates for winter weekdays are shown in Appendix A.

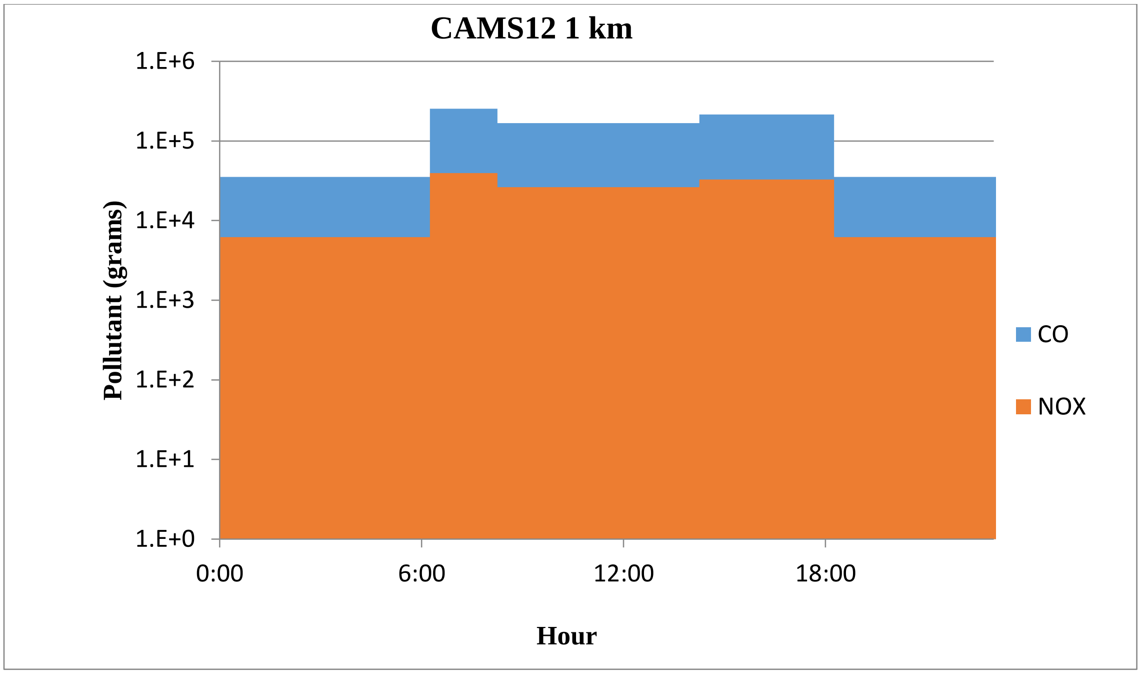

Figure 6.1: CAMS 12 CO and NOx Estimates

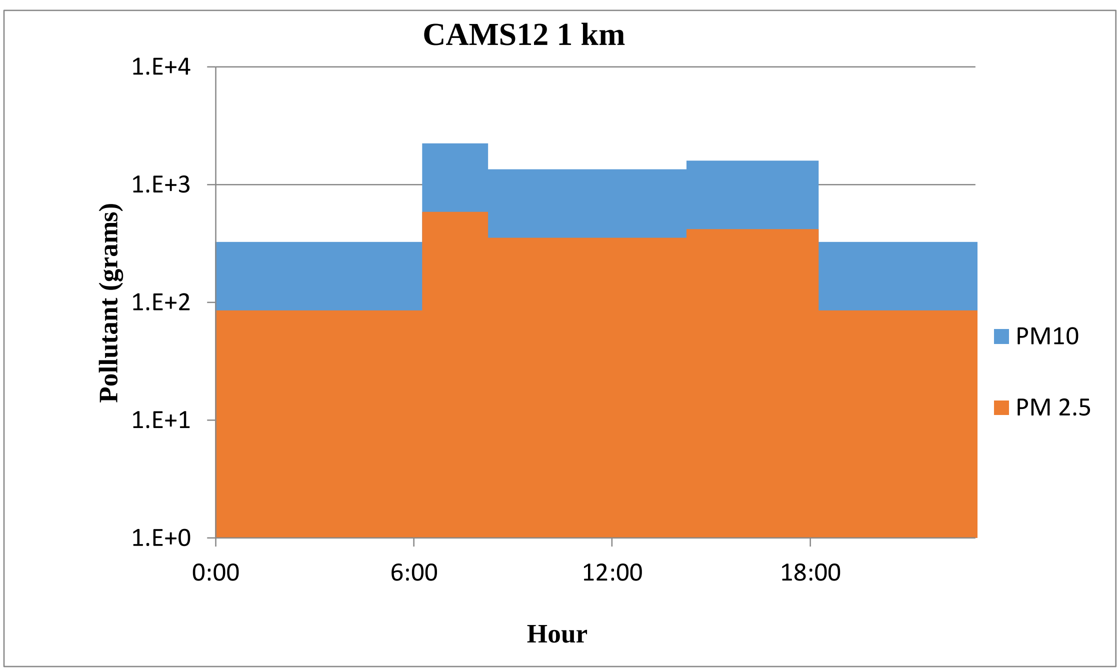

Figure 6.2: CAMS 12 Particulate Matter Estimates

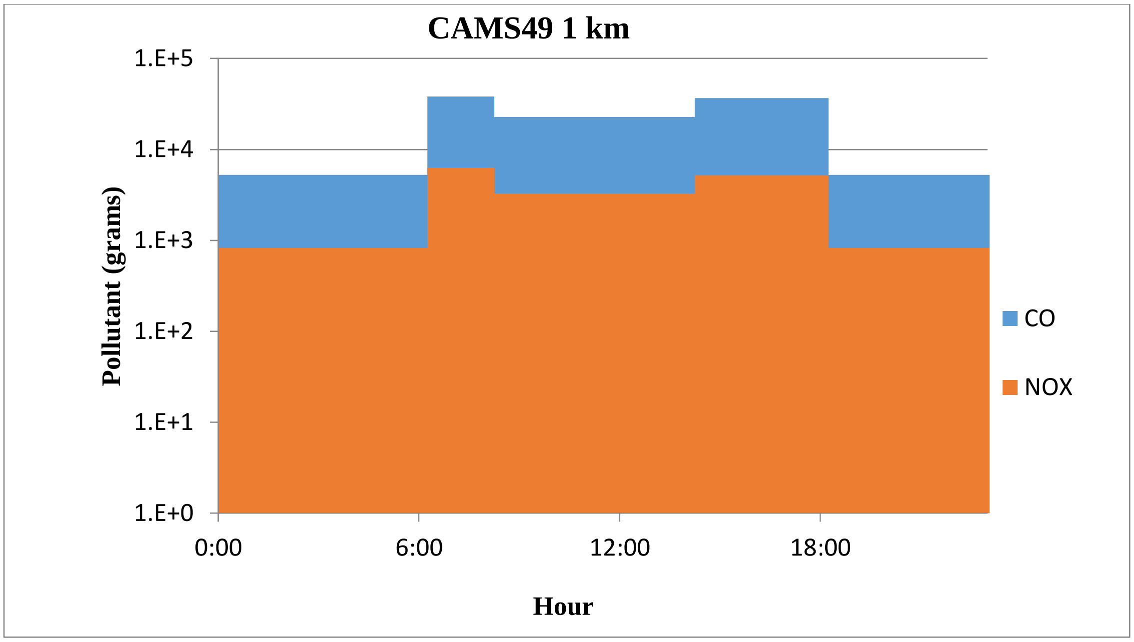

Figure 6.3: CAMS 49 CO and NOx Estimates

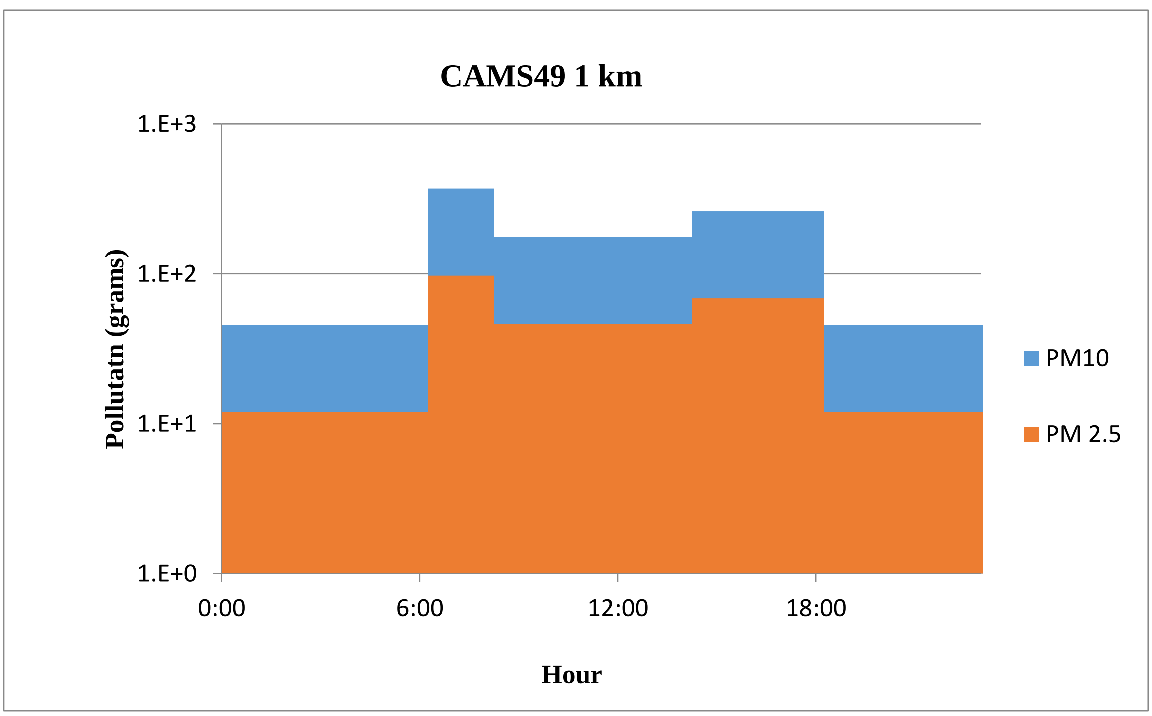

Figure 6.4: CAMS 49 Particulate Matter Estimates

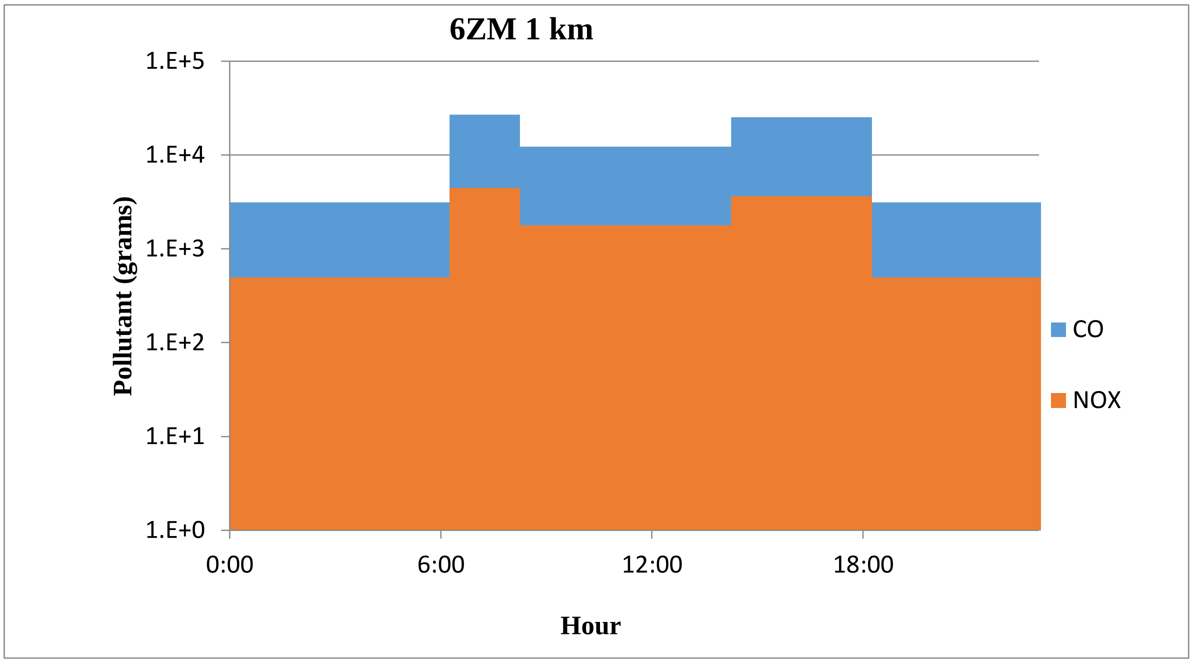

Figure 6.5: 6ZM CO and NOx Estimates

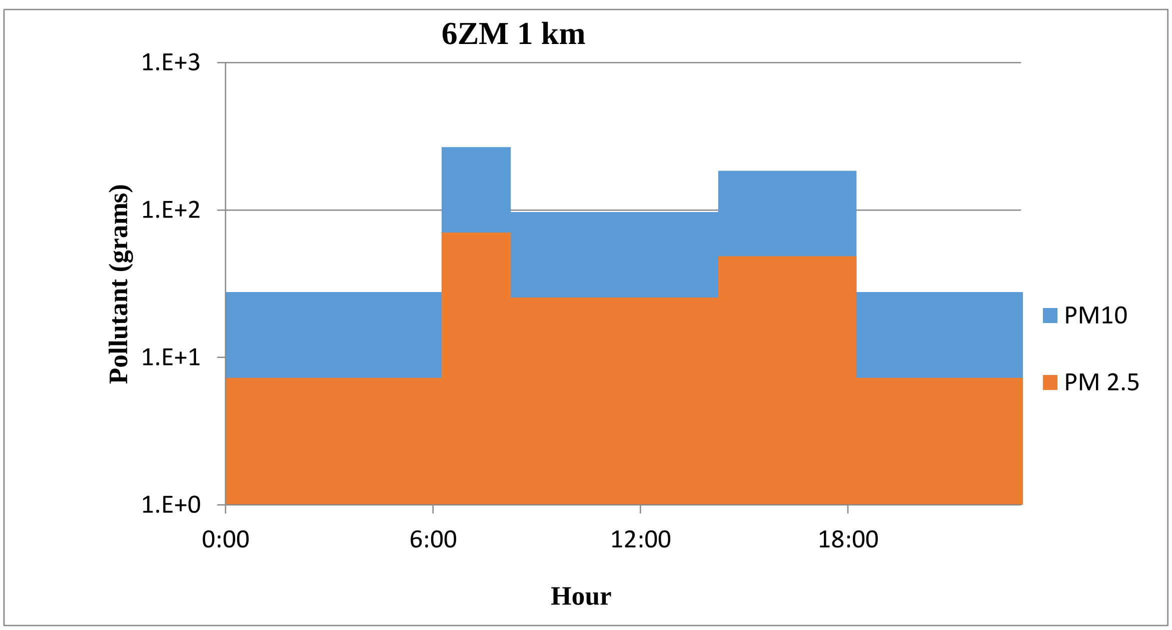

Figure 6.6: 6ZM Particulate Matter Estimates

Total daily emission estimate results in grams per day are displayed in Table 6.4 below. These daily estimates were calculated by multiplying the hourly average for each time span by the hours assigned to that time span, as shown in the equation below:

$$Daily\ Emissions = AM * 2 + MD * 6 + PM * 4 + NT * 12$$

where AM is the emissions produced in one hour in the morning time of day period, MD represents the value of emissions produced in one hour during the mid-day period, PM represents the value of emissions produced in one hour during the afternoon period, and NT represents the value of emissions produced in one hour during the overnight period. It is assumed that traffic volumes are the same during every hour of each particular period.

Table 6.4: Daily Emission Estimates Using MOVES

Station	Pollutant	0.5 km radius (g/day)	1 km radius (g/day)	2 km radius (g/day)
CAM12	CO	235,961	2,794,569	-
	NO_x	33,417	441,731	-
	PM_{10}	1,869	22,837	-
	$PM_{2.5}$	491	5,999	-
CAM49	CO	83,061	423,967	900,610
	NO_x	11,577	63,143	131,463
	PM_{10}	637	3,386	7,219
	$PM_{2.5}$	168	890	1,898
6ZM	CO	48,289	266,567	-
	NO_x	6,298	40,054	-
	PM_{10}	408	2,189	-
	$PM_{2.5}$	107	575	-

6.2. Discussion of MOVES Outputs

While the research presented here provides some estimates for comparisons, there are still various divergences. Because of lack of detailed traffic activity data, various inaccuracies are present in the input of data into the MOVES analysis. The greatest factor affecting

estimations from MOVES is the accuracy of each input. Project-level analysis in MOVES requires a large amount of different input data, therefore can result in inaccurate estimations.

Vehicle source type distributions from MPO for MOBILE purposes are adjusted into MOVES vehicle types using Texas Passenger vehicle registration distributions and adjusted into only three different vehicle types. Assumptions were made to estimate the percentage of each source type travelling through each link per hour. This assumption of percentage of vehicle types per hour per link was also applied to all links in the network, not distinguishing between highways or arterial roads. Inspection and maintenance programs were used as defaults set by MOVES. Fuel data was also input as defaults provided by MOVES. Fleet characteristics also include only defaults provided by the MOVES software.

The greatest simplification occurred in the traffic link analysis input into MOVES. Rather than using a detailed link drive schedule, or a detailed operating mode distribution for the link, the project analyzed average speed on the road type for all links. The “average speed” approach provides the least resolution when analyzing the impact of a project. Additionally, the posted speed on each link was used as the “average speed”. This method is insufficient to capture the environmental impacts of vehicle travel because the default drive cycles used by the model may not accurately reflect the specific project. It is observed that a single average speed would not spatially capture localized idling and acceleration emissions. Providing more detailed inputs would result in higher accuracy for a project-level analysis.

Additionally, using more impact zones would provide a more accurate description of what size area can be used to compare predicted air pollution concentrations with air pollution concentrations measured at monitoring stations. Varying sizes of radiuses as well as different

geographical locations can provide better estimates of which analysis can be better compared to measured pollutant concentrations at monitoring stations.

The research developed for this study only incorporated the regional transportation network of the City of El Paso. However, since the city is located on the border with Ciudad Juarez, Chihuahua, it is important to incorporate the transportation network of Ciudad Juarez to the analysis. Integrating the two transportation network requires developing OD matrixes between the two cities or addition of link data and requires the incorporation of new vehicle fleet characteristics in the model. In addition, further research can also include the use of a microscale transportation model to enable the framework to perform analyses with greater detail.

Chapter 7: Screening Validation by a Simple Box Model

7.1. Fixed-Box Model

The daily emissions estimates from MOVES were normalized by annual velocity and area using a simple Fixed-Box Model as described by De Nevers (De Nevers, 1999). Using the best estimate of sources and the best estimate of the meteorology, the concentration of various pollutants can be found. The first assumptions to be made are that the area of interest is assumed to be rectangular shaped, and that there occurs a complete mixing of pollutants up to the mixing height, H. the pollution concentration is assumed to be uniform in the whole volume of air over the area of interest. The wind speed used is constant and independent of time, location, elevation and blows in the x direction. Figure 7.1 shows the meaning of symbols used in the fixed-box model as well as visualization of the generic area of interest.

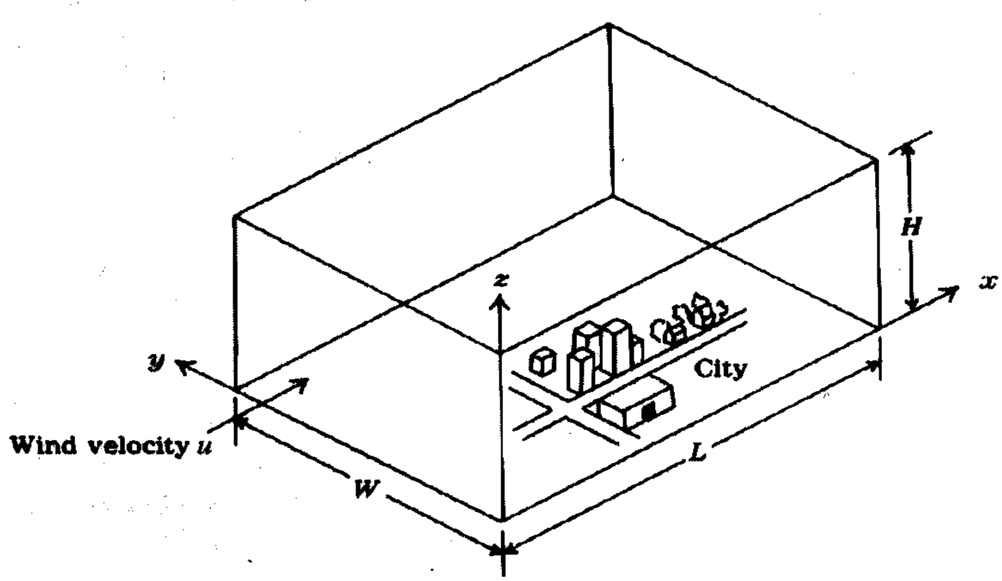

Figure 7.1: Area of interest, meaning of symbols in fixed-box model

Another assumption included in the model is that the air pollutant emission rate of the city is Q in g/s. The emission rate per unit area is q = Q/A with units of g/s*m^2. A is the area of the city (W x L). This emission rate is assumed constant. The final two assumptions are that no pollutant enters or leaves through the top or sides of the box model, and there is no destruction rate meaning the pollutant is sufficiently long-lived.

Using a general material balance equation:

$$Accumulation\ rate = (all\ flow\ rates\ in) - (all\ flow\ rates\ out)$$

$$+(creation\ rate) - (destruction\ rate)$$

The destruction rate is set at zero based on the assumptions. Accumulation rate is zero using a steady-state analysis.

The general material balance equation becomes:

$$0 = (all\ flow\ rates\ in) - (all\ flow\ rates\ out)$$

$$0 = u\ W\ H + q\ W\ L - u\ W\ H\ c$$

$$c = \frac{qL}{uH}$$

Where c is the concentration in the entire area of interest, u is the wind velocity, W is the width of the box model, L is the length of the box, H is the mixing height of the box, and q is the emission rate per unit area. Parameters for the box model are included in Table 7.1. Wind speed is used as the average of reported values for four years during the month of July.

Table 7.1: Box Model Parameters

	Wind Speed (m/s)	Frontal Area (m2)		
		0.5 km Radius	1 km Radius	2 km Radius
CAM12	3.27	10,000	20,000	-
CAM49	2.74	10,000	20,000	40,000
6ZM	2.70	10,000	20,000	-

The areas were calculated using the diameter of the zones as the width of the box and a mixing height of 10 meters. Using the simple fixed-box model, the results were calculated for air concentrations of particulate matter and are shown in Table 7.2.

Table 7.2: Air Concentrations of Particulate Matter

Station	Pollutant ($\mu g/m^3$)	0.5 km Radius	1 km Radius	2 km Radius
CAM12	PM_{10}	0.0661	0.4039	-
	$PM_{2.5}$	0.0174	0.1061	-
CAM49	PM_{10}	0.0269	0.0716	0.0763
	$PM_{2.5}$	0.0071	0.0188	0.0201
6ZM	PM_{10}	0.0175	0.0469	-
	$PM_{2.5}$	0.0046	0.0123	-

This dispersion model provides areas of low resolution for the analysis. The box model does not distinguish between area sources and point sources as all emissions are combined. The dispersion model may also dilute PM concentrations resulting in low emissions estimates.

Carbon monoxide and oxides of nitrogen are measured in parts per million (ppm) and parts per billion (ppb) by volume. One part per million (by volume) is equal to a volume of a given gas mixed in a million volumes of air: a micro liter volume of gas in one liter of air would therefore be equal to 1 ppm.

Expressing gas concentrations in metric units, although it has the advantage of metric expression, it has the disadvantage of being greatly influenced by changes in temperature and

pressure. Additionally, because of difference in molecular weight, comparisons of concentrations of different gases are difficult (Godish, 1991). To convert a metric expression to ppm, the density of the concerning gas is needed. The density of gas can be calculated by the Law of Avogadro's, which states that equal volumes of gases, at the same temperature and pressure, contain the same number of molecules. This law implies that 1 mole of gas at Standard Temperature and Pressure (STP) has a volume of 22.71108 liters, also mentioned as the molar volume of ideal gas.

STP is defined as a condition of 100.00 kPa (1 bar) and 273.15 K (0°C), which is a standard of IUPAC (IUPAC, 1987). The amount of moles of the concerning gas can be calculated with the molecular weight. For converting ppm by mole, this results in the dimensionless unit required of ppm.

Estimates for the conversion of Oxides of Nitrogen to ppb were made under the assumption of using the molecular weight of NO_2. NO_2 is assumed to be a good surrogate for NO_x because NO is rapidly converted to NO_2, and N_2O has such a long life because it is not highly reactive. Using these assumptions, estimates from the box model are converted into ppm and ppb. The values for estimates of air concentrations of carbon monoxide and oxides of Nitrogen are shown in Table 7.3.

Table 7.3: Air Concentrations of Carbon Monoxide and Oxides of Nitrogen

Station	Pollutant	units	0.5 km Radius	1 km Radius	2 km Radius
CAM12	**CO**	**ppm**	0.0677	0.4007	-
	NO_x	**ppb**	6.2869	41.5526	-
CAM49	**CO**	**ppm**	0.0285	0.0727	0.0772
	NO_x	**ppb**	2.6031	7.0986	7.3896
6ZM	**CO**	**ppm**	0.0168	0.0463	-
	NO_x	**ppb**	1.4359	4.5665	-

After finding air concentrations using emission estimates found through MOVES and combined with a simplified box model, these results are compared to data from ambient air monitoring stations at the impact zones.

7.2. Air Monitoring Stations

Three stations were identified to offer continuous ambient monitoring data, two in El Paso County and one in Sunland Park. Each monitoring station was chosen for the pollutants measured and monitored. Shown in Table 7.4 are the values extracted from TCEQ monthly summary reports and NMED Reports. Information was obtained as the monthly average values observed for July and data retrieved includes data from the year 2010 to 2014. Dashes in the table indicate missing or invalidated values from the station data as TCEQ only publishes data from the instrument that meets EPA quality assurance criteria for regulatory purposes. Dashes may also indicate pollutants not monitored at the station as discussed in Chapter 3.

Table 7.4: Air Concentrations Measured by Monitoring Stations

		units	**2010**	**2011**	**2012**	**2013**	**2014**
CAM12	**CO**	**ppm**	0.1	0	0	0	0
	NO_x	**ppb**	11.4	5.2	8.2	5.8	5.2
	PM_{10}	**(μg/m^3)**	21	25.5	20.7	24	21.7
	$PM_{2.5}$	**(μg/m^3)**	7.1	8.8	6.2	6.4	7.9
CAM49	**CO**	**ppm**	0	0	-	-	-
	NO_x	**ppb**	-	-	-	-	-
	PM_{10}	**(μg/m^3)**	22.4	25.6	-	25.3	27.7
	$PM_{2.5}$	**(μg/m^3)**	-	-	-	-	-
6ZM	**CO**	**ppm**	-	-	-	-	-
	NO_x	**ppb**	9	5	5	4	5
	PM_{10}	**(μg/m^3)**	25	30	24	34	34
	$PM_{2.5}$	**(μg/m^3)**	4.4	6	5.8	6.5	10.7

7.3. Comparison of Observed and Predicted

In order to identify the validity of the values obtained from MOVES a correlation was made between observed concentration values and the modeled and calculated air concentration values. Table 7.5 displays the ratio of the observed concentrations from air monitoring stations over the predicted concentrations provided by MOVES and box model estimations for July 2010. Because of missing data from monitoring stations, the ratios cannot be provided for these pollutants. In order to find the optimum zone that can be used to predict air concentrations more accurately, a ratio closest to one would prove for which pollutants and zones this comparison can be made.

Table 7.5: Ratio of Observed/Predicted

Station	Pollutant	0.5 km Radius	1 km Radius	2 km Radius
CAM12	CO	1.48	0.25	-
	NO_x	1.81	0.27	-
	PM_{10}	31.76	5.20	-
	$PM_{2.5}$	40.84	6.69	-
CAM49	CO	-	-	-
	NO_x	-	-	-
	PM_{10}	83.19	31.30	29.36
	$PM_{2.5}$	-	-	-
6ZM	CO	-	-	-
	NO_x	6.27	1.97	-
	PM_{10}	143.10	53.28	-
	$PM_{2.5}$	95.75	35.68	-

Shown in Figure 7.2 are the ratios for the two zones analyzed for each of the pollutants at CAMS 12. It is observed that the comparison is most relevant for the pollutants CO and NO_x, with ratios closest to one. For the pollutants PM_{10} and $PM_{2.5}$, the comparison seems less accurate especially for the zone using a 0.5 km radius.

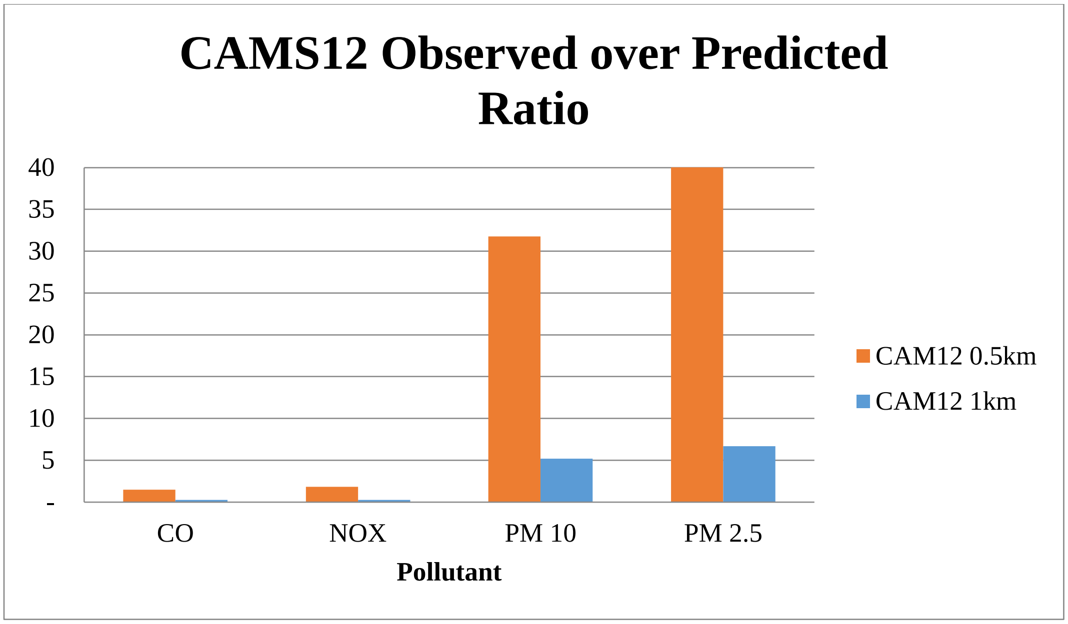

Figure 7.2: CAMS12 Observed over Predicted Ratio

Analyzing the ratios provided by the comparison, it is apparent that for the station 6ZM Desert View there is more variety with three different zones. The comparison again seems to be more accurate for the pollutants CO and NO_x as opposed to the vastly greater ratios seen for PM_{10} and $PM_{2.5}$. It is observed that the zone providing the optimum comparison is one using a radius of 1 km for analysis. Figure 7.3 on the following page shows the graphical representation of these ratios.

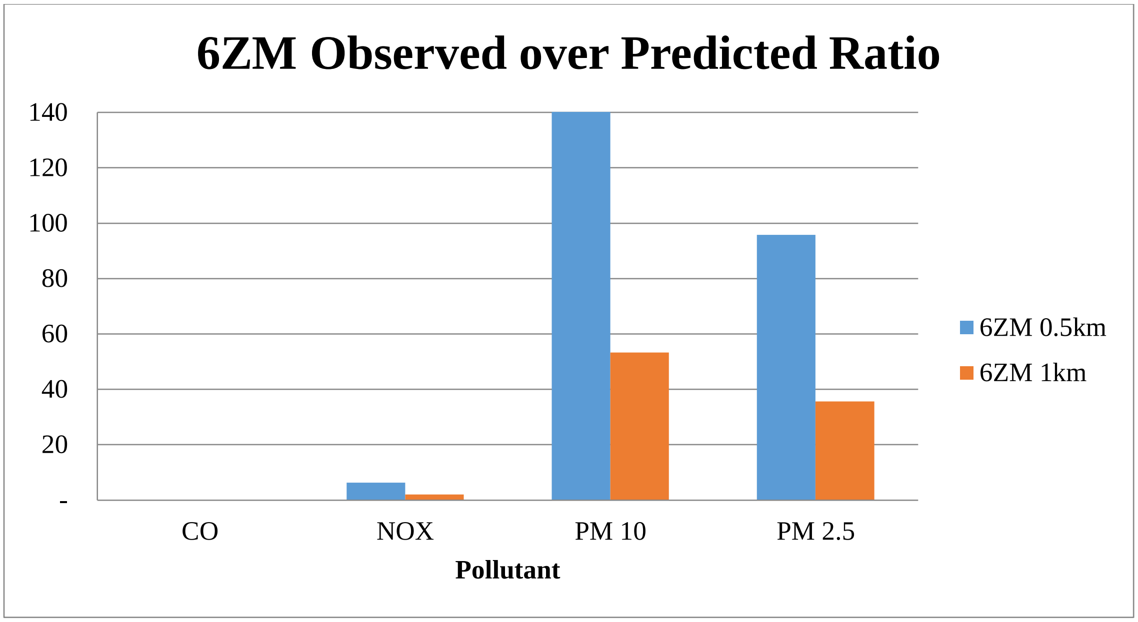

Figure 7.3: 6ZM Observed over Predicted Ratio

Because CAMS 49 did not have validated data for oxides of nitrogen or $PM_{2.5}$, there are no ratios available for those pollutants. Using only PM_{10} data to compare observed values with predicted values from MOVES, it can be seen that a 1 km radius and 2 km radius provide similar results, with higher accuracy than only using a 0.5 km radius. These ratios are shown on Figure 7.4 on the following page.

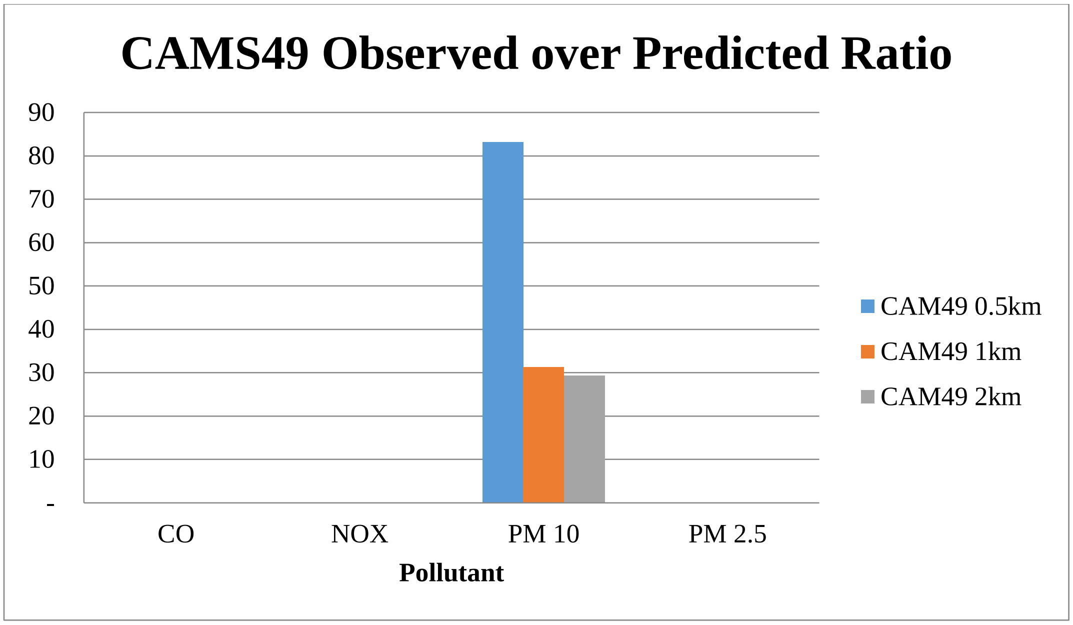

Figure 7.4: CAMS49 Observed over Predicted Ratio

7.4. Discussion of Comparison Results

Observing the ratios found comparing concentration estimations to observed air concentration values from monitoring stations, it can be seen that the least valid comparison occurs for particulate matter. Ratios for this pollutant are extremely high, suggesting a great difference in values. Reasons for this may include other sources other than vehicle emissions being a greater factor for high particulate matter air concentrations in the region. Meteorological factors also influence pollutant concentrations in the air. Alternatively, it can be seen that ratios for the pollutants CO and NO_x are much closer to one, suggesting a closer relationship. This may suggest that CO and NO_x are more directly correlated to vehicle emissions and ambient air concentrations of these pollutants. Accurate emission inventories for CO are important for air quality management; yet, past atmospheric observations have often yielded results that were significantly at odds with emission inventories (Parrish, 2006; Hudman et al., 2008; Miller et al., 2008; Kopacz et al., 2010)

The assumptions made for the Fixed-Box Model also provide areas of less resolution for the analysis. The box model does not distinguish between area sources and point sources as all

emissions are combined. The assumption that the pollutant concentration is uniform in the whole volume of air over the city results in concentrations at the upwind and downwind edges of the city being the same. In real conditions, concentration varies throughout the landscape geology and different meteorological conditions, which greatly affect the distribution of pollutants. A more refined dispersion model would provide better estimations of air pollution concentrations from emissions inventories provided by MOVES.

Chapter 8: Data Validation by Comparison of VMT with MPO estimates

8.1. El Paso MPO Transportation Conformity Report

The Air Quality Conformity Analysis performed for the Horizon 2040 Metropolitan transportation Plan (MTP) update and the Horizon 2013-2016 transportation Improvement Program (TIP) demonstrates that the projected emissions of CO and PM_{10} conform to the Motor Vehicle Emissions Budget (MVEB) enacted by the TCEQ and approved by the EPA (MPO 2013). This transportation conformity analysis was obtained by projecting vehicle miles and hours traveled from the TransCAD Travel Demand Model (TDM). The emissions of these vehicles in this report were calculated using the MOBILE6.2.03, released in September 24, 2003 and AP-42 section 13.2.1 models, and comparing the results to the MVEB for the County of El Paso, Texas. It is noted that the CO maintenance plan budget covers a portion of the City of El Paso and the PM_{10} budget covers El Paso County.

8.2. Mobile Source Emissions Estimate

Emissions for the MPO Conformity Report were found using MOBILE. In addition, various emission estimation utilities were used by TTI to develop link-based, time-of-day, on-road mobile source emissions estimates for air quality analyses. The emissions estimation utilities are TRANSVMT, POLFAC62_3, RATEADJ62DK, RATEADJV62DK, RATEADJV62hrDK, and EMSCALC which all perform various calculations regarding detailed link-based analysis used before processing with the MOBILE model (MPO, 2007).

8.3. MPO Emissions Results in Conformity Report

The final emission analysis results of the conformity report for the CO emissions are presented in Table 8.1. The table shows a summary of the VMT and associated CO emissions for the winter season emissions, as calculated by El Paso MPO. The VMT listed includes only the CO maintenance area in El Paso, which does not encompass all of El Paso County.

Table 8.1: Winter Season CO Emission Data MPO

Year	Total VMT	CO Emissions (ton/day)
2010	1,313,559	20.1
2020	1,454,831	16.99
2030	1,629,457	17.48
2040	1,864,928	19.8

The PM_{10} emissions data found in the Conformity Report are shown in Table 8.2. Total VMT detailed in this table represents data for all of El Paso County during the summer season, and particulate emissions are presented as tons per day.

Table 8.2: PM_{10} Emission Data MPO

Year	Total VMT	PM_{10} (ton/day)
2010	15,787,118	3.63
2020	19,559,220	4.29
2030	22,754,115	5.02
2040	26,304,644	5.81

8.4. Emission Estimates at Three Monitoring Stations

In order to make a comparison between MPO's values obtained with MOBILE, the VMT were estimated for the entire county from a ratio of the VMT in the impact zones analyzed, then compared to the value of the VMT used for the size of analyses done for the Conformity Report.

This ratio was then used to calculate the estimated emissions for the entire county. Shown in Table 8.3 are the VMT for each zone at the three different monitoring stations. Table 6.4 shows the winter CO emissions corresponding to each of the zones at the monitoring stations. Emissions are presented in units of ton/day. Table 8.5 presents the emission estimates for PM_{10} during the summer season for each of the zones.

Table 8.3: VMT of Zones at Three Stations

Station	0.5 km Radius	1 km Radius	2 km Radius
CAM12	30,180.68	408,182.58	-
CAM49	10,575.39	58,991.62	120,300.08
6ZM	4,805.04	37,021.72	-

Table 8.4: Winter CO Emissions Estimates in Ton/Day

	CO Emissions (ton/day)		
Station	**0.5 km Radius**	**1 km Radius**	**2 km Radius**
CAM12	0.18695	2.21417	-
CAM49	0.06581	0.33591	0.71356
6ZM	0.03826	0.21120	-

Table 8.5: PM_{10} Emissions Estimates in Ton/Day

	PM Emissions (ton/day)		
Station	**0.5 km Radius**	**1 km Radius**	**2 km Radius**
CAM12	0.00206	0.02517	
CAM49	0.00070	0.00373	0.00796
6ZM	0.00045	0.00241	-

8.5. Comparison of Emissions with MOVES

Using the ratio of VMT miles from the study area to the VMT in the CO maintenance area analyzed in the Conformity Report, as well as the VMT used to analyze PM_{10} emissions in all of El Paso County, emissions estimates were found to compare to emissions estimated by

MOBILE. Table 8.6 presents the winter CO emissions estimates obtained from MOVES for the maintenance area analyzed by MPO. Table 8.7 presents the summer season PM_{10} emissions estimates for all of El Paso County using the VMT ratio and MOVES software.

Table 8.6: Winter CO Emissions Estimates for Maintenance Area from MOVES

	CO Emissions (ton/day)		
Station	**0.5 km Radius**	**1 km Radius**	**2 km Radius**
CAM12	8.14	7.13	-
CAM49	8.17	7.48	7.79
6ZM	10.46	7.49	-

Table 8.7: PM_{10} Emissions Estimates for El Paso County from MOVES

	PM_{10} Emissions (ton/day)		
Station	**0.5 km Radius**	**1 km Radius**	**2 km Radius**
CAM12	1.08	0.97	-
CAM49	1.05	1.00	1.04
6ZM	1.48	1.03	-

The conclusion of this comparison first examines the process and steps involved in MPO's Conformity Report, which contained vast amount of details on links, link activity, etc., using TTI provided information and factors. The analysis conducted in this report was much narrower in details and scope. Using VMT ratios estimations were found from the impact zones in the study to compare to the citywide areas analyzed in the Conformity Report. A summary of emissions estimates comparing MOBILE values to MOVES values is shown in Table 8.8. Values shown from the Conformity Report are for the year 2010. MOVES values are averages of all values found at the three stations, at the different sized zones.

Table 8.8: Comparison of MOBILE MPO Values and MOVES

	CO (ton/day)	**PM_{10} (ton/day)**
MOBILE (MPO)	20.1	3.63
MOVES	8.03	1.09

As can be seen in this comparison, emission estimates calculated using VMT ratios could be provided for larger areas using a studied impact zone. While these comparisons are not exact, using analysis that is more refined and inputs with higher detail, this method can provide comparisons that are more accurate.

Chapter 9: Conclusions and Recommendations

9.1. Air Pollution Concentration Estimations

Using MOVES project-level analyses, emissions estimates were found using site-specific traffic data. With the emission inventory, air concentration estimations were found using a simple Fixed-Box Model. Modeled emissions were then compared to concentrations from air monitoring stations in El Paso. One station located in Sunland Park is operated by the NMED, the first TCEQ station is located on UTEP campus and the final station is located in the town of Socorro near far east El Paso. These stations were chosen for their proximity to major traffic intersections or for the pollutants monitored at those stations. Air concentrations were found to vary greatly between measured concentrations and the predicted concentrations using MOVES and the Fixed-Box Model.

While the correlation is stronger when comparing CO and NO_x measured concentrations to observed concentrations, there still appears to be a great discrepancy between values. Measured PM_{10} and $PM_{2.5}$ values at air monitoring stations were substantially greater than concentrations measured through MOVES and the box model. This suggests that PM_{10} and $PM_{2.5}$ concentrations at these sites can be caused by factors other than and in addition to traffic emissions.

Another conclusion made from these evaluations is that to achieve a closer comparison there must be an optimal radius and impact zone from which to obtain traffic activity information. Comparing ratios of observed and predicted air concentrations obtained from the different zones at the three monitoring stations it can be concluded that a 1 km radius zone can provide more equivalent comparisons of pollutant concentration to those measured by air

monitoring stations. However, this conclusion can be fortified with further research discussed in following sections.

9.2. VMT Comparisons with MPO Emissions

Data validation of this research included comparing previously modeled emissions from the El Paso Metropolitan Organization Transportation Conformity Report, which were obtained using MOBILE, EPA's previous air pollution modeling software, to the emissions obtained using MOVES. The emissions calculated in the Conformity Report included PM_{10} emissions for all of El Paso County during a summer weekday and the CO emissions during a winter weekday for the maintenance areas in El Paso. The emissions calculated by MPO were found using extensive traffic activity inputs for the MOBILE software and included a large amount of traffic link network to include all the areas necessary to make sure of conformity to the Motor Vehicle Emissions Budget set by TCEQ.

Using the ratio of VMT miles from the study area to the VMT in the CO maintenance area analyzed in the Conformity Report, as well as the VMT used to analyze PM_{10} emissions in all of El Paso County, emissions estimates were found to compare to emissions estimated by MOBILE to emissions estimated by MOVES. Conclusions from this analysis show that while the new emissions found using this ratio are lower, they still provide a close estimate to emissions found using extensive traffic activity input data compared to using only speed and flow data analyzed in this research. These results show that using emissions estimates from a small-scale impact zone with project –level analysis and a ratio of VMT analyzed to VMT in a citywide scale, an estimate can be provided without the need to conduct a larger scale analysis with more extensive traffic activity input in MOVES.

9.2. Further Research

For further research extrapolating results from estimations made at these air monitoring stations, a comprehensive map of the entire county can show emissions distribution spatially. Additionally, with more accurate data inputs, using VMT ratio estimations can also be improved to provide emissions estimates in larger areas using only data in a small impact zone chosen with enough traffic activity input data.

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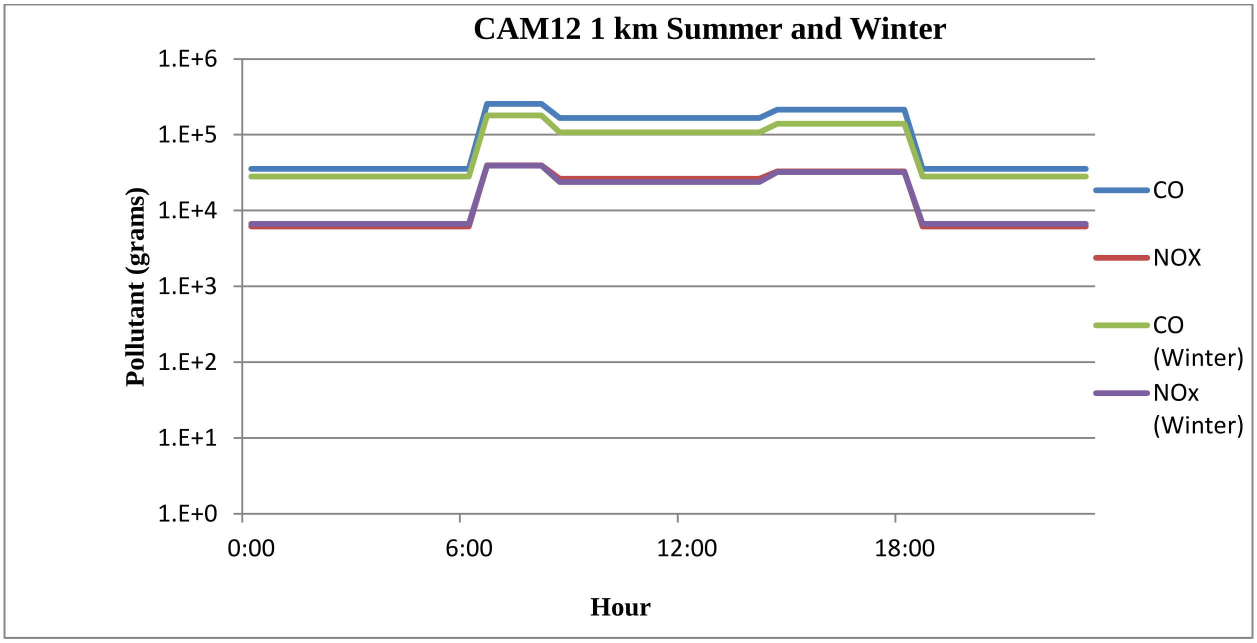
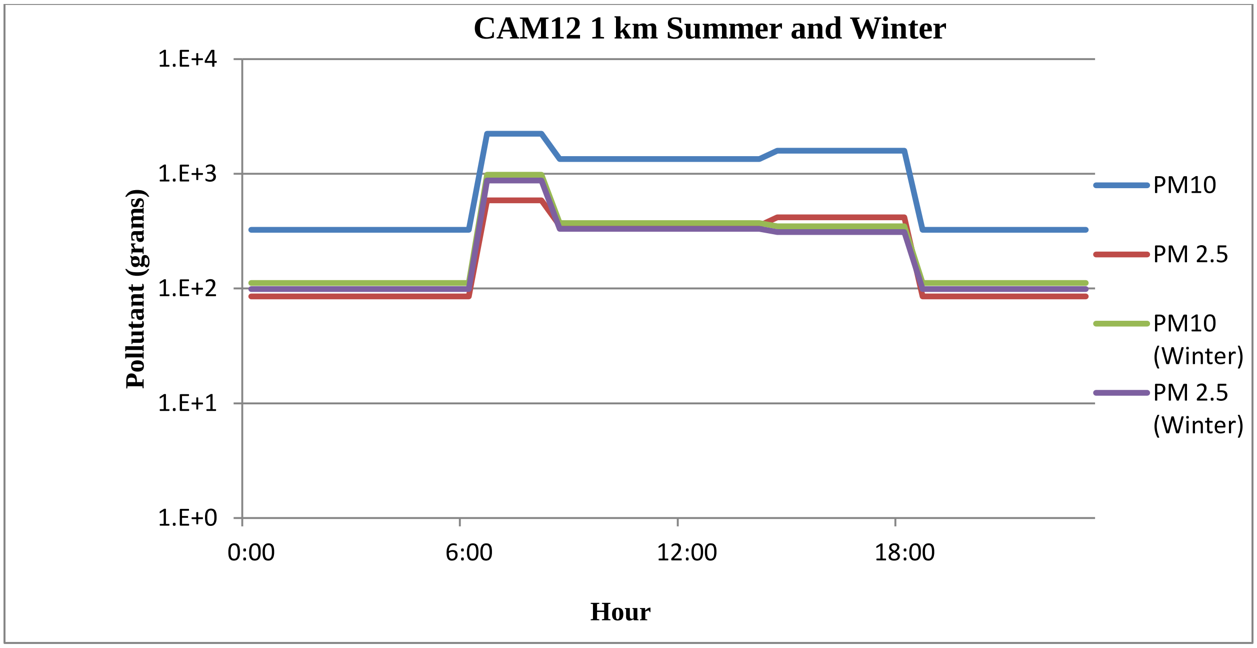
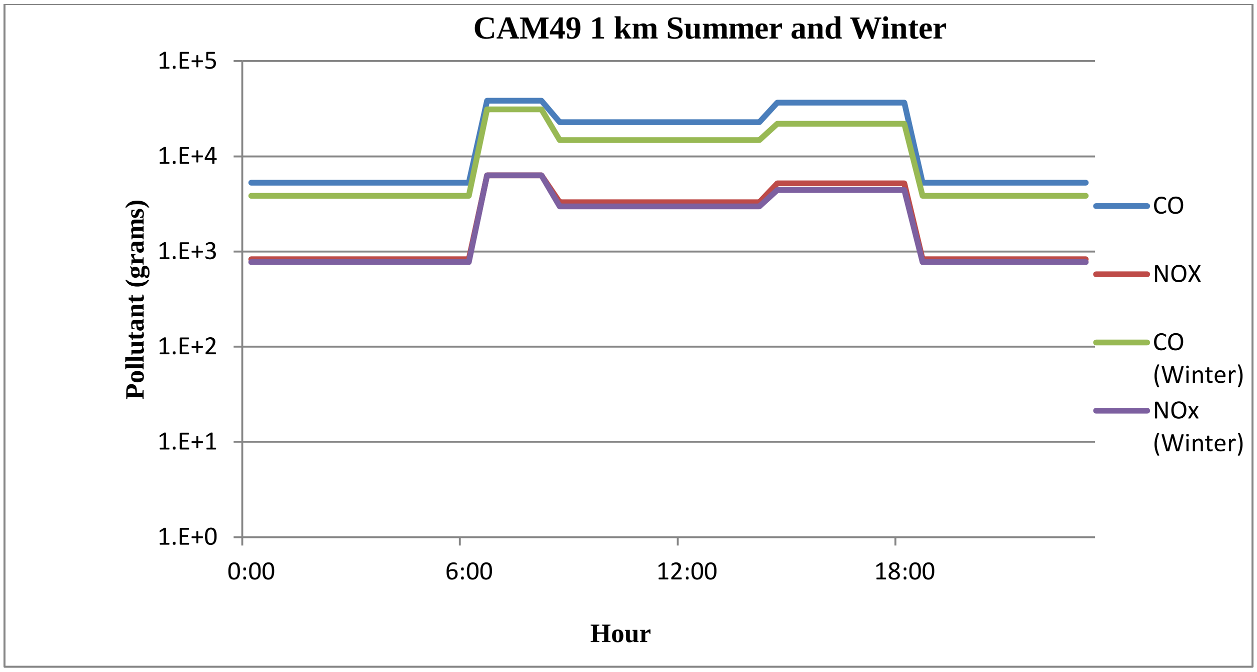
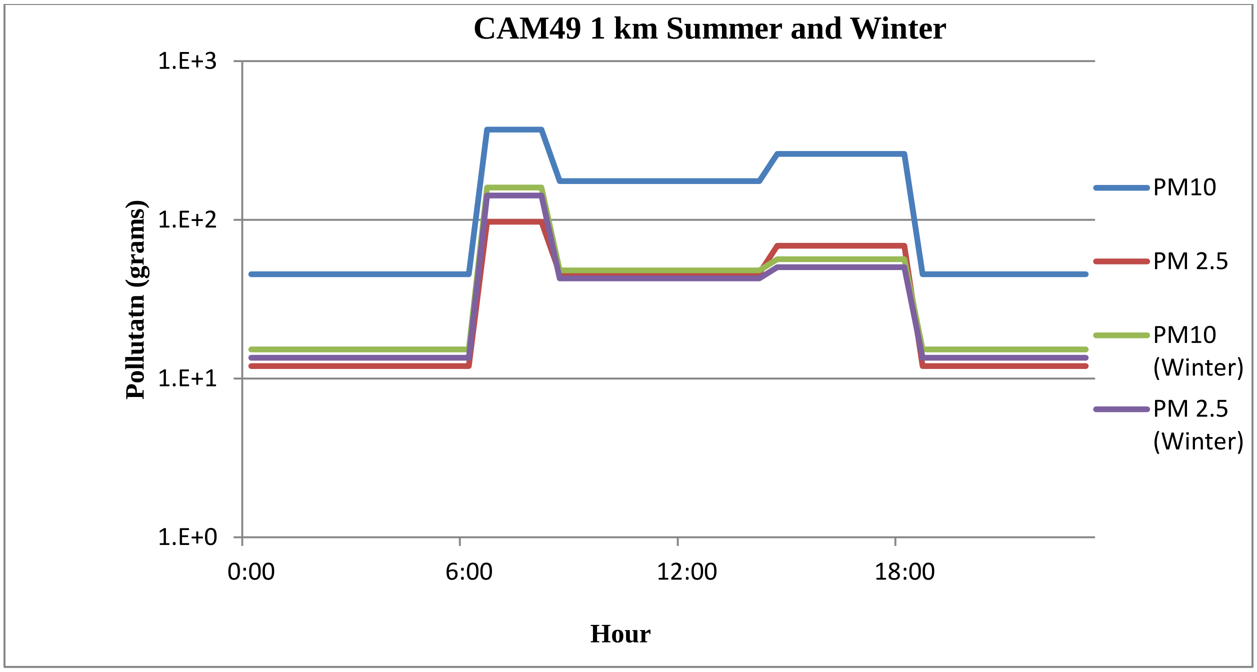
Appendix A

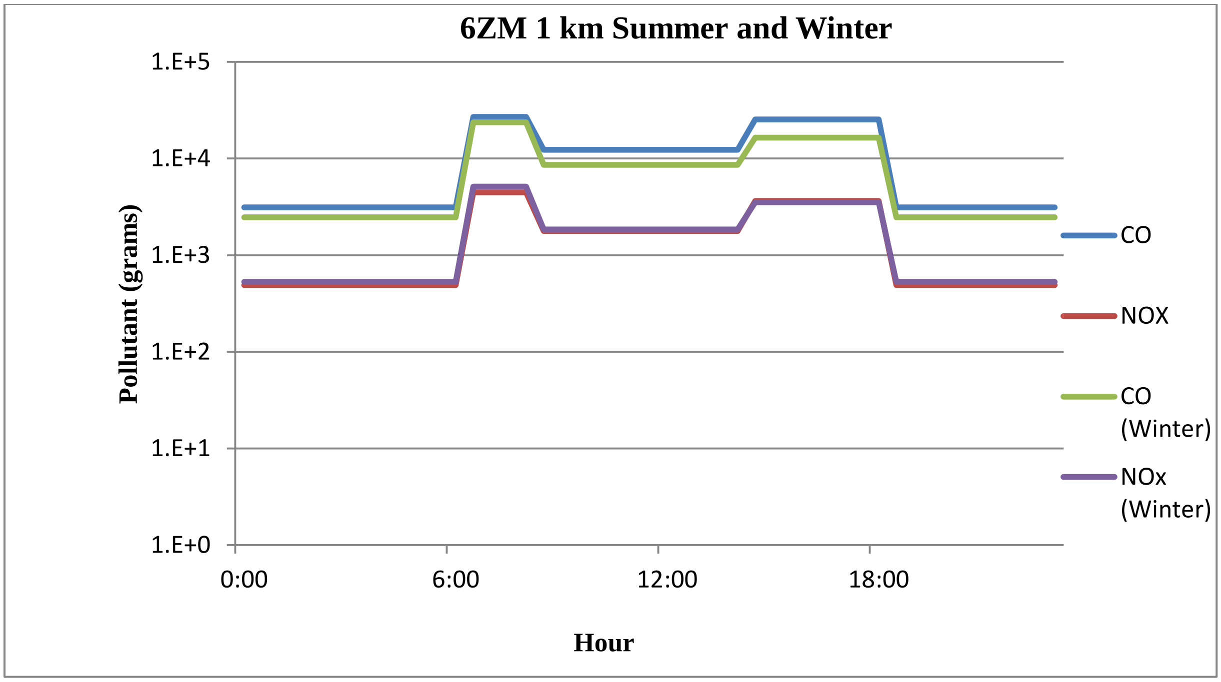
Summer and Winter Emissions Estimates

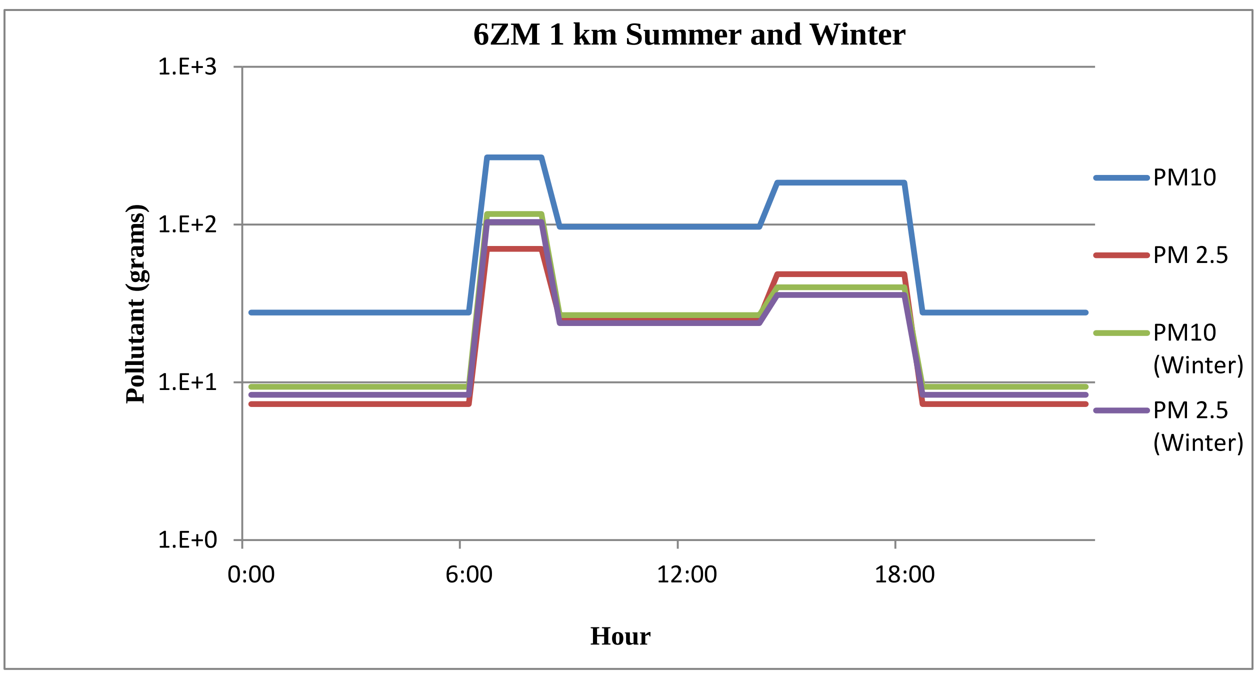





CAM49 1 km Summer and Winter
1.E+5
1.E+4
1.E+3
1.E+2
1.E+1
1.E+0
Pollutant (grams)
0:00
6:00
12:00
18:00
Hour
CO
NOX
CO (Winter)
NOx (Winter)


CAM49 1 km Summer and Winter
1.E+3
1.E+2
1.E+1
1.E+0
Pollutatn (grams)
0:00
6:00
12:00
18:00
Hour
PM10
PM 2.5
PM10 (Winter)
PM 2.5 (Winter)


6ZM 1 km Summer and Winter
1.E+5
1.E+4
1.E+3
1.E+2
1.E+1
1.E+0
Pollutant (grams)
0:00
6:00
12:00
18:00
Hour
CO
NOX
CO (Winter)
NOx (Winter)


6ZM 1 km Summer and Winter
1.E+3
1.E+2
1.E+1
1.E+0
Pollutant (grams)
0:00
6:00
12:00
18:00
Hour
PM10
PM 2.5
PM10 (Winter)
PM 2.5 (Winter)

Curriculum Vita

Mayra Chavez was born in El Paso, Texas. After graduating from Eastwood High School, she attended the University of Texas at El Paso from 2010-2016. She received her Bachelor's degree in Civil Engineering in 2010 and pursued a graduate degree in Master of Science in Environmental Engineering. She received an internship opportunity provided by the Border Air Quality internship program, sponsored by the U.S. Environmental Protection Agency, working for the Texas Commission on Environmental Quality (TCEQ) in the Summer of 2012. During the internship, she assisted with environmental compliance inspections, and worked on several projects identifying sites of concern for the TCEQ including hydraulic fracking sites, public water systems, and participated in research studying Rio Grande surface water. Following the internship, she worked as a research assistant as well as teaching assistant for Dr. Wen-Whai Li from 2012-2016. As a research assistant she worked on several projects involving monitoring criteria pollutants in the border region, providing valuable research to grants provided by the TCEQ and EPA.

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