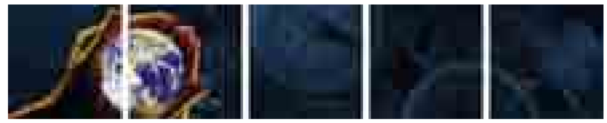
# Appendix B: Final Bay-Wide Regional Human Health Risk Assessment Tool for Diesel Exhaust Particulate Matter (DPM)



# BAY-WIDE REGIONAL HUMAN HEALTH RISK ASSESSMENT TOOL FOR DIESEL EXHAUST PARTICULATE MATTER (DPM)

Prepared for:
**Port of Los Angeles and**
**the Port of Long Beach**
**Los Angeles, California**
**and Long Beach, California**

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# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| AERMAP | AERMOD's Terrain Preprocessor |
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | American Meteorological Society/Environmental Protection Agency Regulatory Model |
| ARB | Air Resources Board |
| Basin | South Coast Air Basin |
| BWHRA | Bay-Wide Health Risk Assessment |
| CAAP | Clean Air Action Plan |
| Cal/EPA | California Environmental Protection Agency |
| CEQA | California Environmental Quality Act |
| CHE | Cargo Handling Equipment |
| COPC | Chemicals of Potential Concern |
| CSF | Cancer Slope Factor |
| DEM | Digital Elevation Maps |
| DPM | Diesel Exhaust Particulate Matter |
| HDV | Heavy-duty Vehicle |
| HRA | Health Risk Assessment |
| IARC | International Agency for Research on Cancer |
| ISCST3 | Industrial Source Complex Short Term (Version 3) Air Dispersion Model |
| kg | Kilogram |
| km | Kilometer |
| L | Liter |
| $m^3$ | Cubic Meter |
| mg | Milligram |
| µg | Microgram |
| NEPA | National Environmental Policy Act |
| NLCD | National Land Cover Dataset |
| NRC | National Research Council |
| NWS | National Weather Service |
| OEHHA | Office of Environmental Health Hazard Assessment |
| OGV | Ocean-going Vessels |
| POLA | Port of Los Angeles |
| POLB | Port of Long Beach |
| Ports | Port of Los Angeles and Port of Long Beach |
| PM | Particulate Matter |
| REL | Reference Exposure Level |
| SCAQMD | South Coast Air Quality Management District |
| SPPS | St. Peter and Paul School |
| Starcrest | Starcrest Consulting, LLC |
| TAC | Toxic Air Contaminants |

| | |
|---|---|
| TITP | Terminal Island Treatment Plant |
| TWG | Technical Working Group |
| USEPA | US Environmental Protection Agency |
| USGS | United States Geological Survey |
| WHO | World Health Organization |

# Executive Summary

In the San Pedro Bay Ports Clean Air Action Plan (CAAP 2006), the Port of Los Angeles and the Port of Long Beach (Ports) committed to develop goals and implement strategies that would substantially and constantly reduce emissions and public health risks from Ports-related mobile sources. These commitments were made in recognition of the Air Resources Board (ARB) statewide goal to reduce diesel-related health risks 85% by 2020 (ARB 2006a). As a means of characterizing reductions in public health impacts that could be achieved by implementation of CAAP commitments, and to understand the Ports progress towards meeting the CAAP Health Risk Reduction Standard, the Ports developed the Bay-Wide Health Risk Assessment (BWHRA) Tool. A key component in the development of the BWHRA Tool was preparation of a Bay-wide health risk assessment protocol (Protocol, Appendix A), developed in collaboration with the Technical Working Group (TWG) comprised of representatives from the Ports, United States Environmental Protection Agency (USEPA), ARB, and South Coast Air Quality Management District (SCAQMD). The Protocol identified cancer risk from diesel exhaust particulate matter (DPM) as the metric for characterizing cancer risk reductions achieved by implementation of Ports emission control strategies and current regulations, recognizing that cancer risk reductions are also a surrogate for reductions in other health effects. The ARB's exposure assessment of the Ports (ARB 2006b) served as the basis for the air dispersion modeling components of the Protocol. The Protocol also identified the methodologies to be followed in calculating exposure concentrations and cancer risk which are consistent with the guidance of the SCAQMD and California's Office of Environmental Health Hazard Assessment (OEHHA).

The selection of DPM-attributable cancer risk as the BWHRA Tool metric reflects the fact that DPM has been identified as the dominant contributor to state-wide cancer risks from airborne pollutants (ARB 2000). The ARB's exposure assessment of the Ports (ARB 2006b) also focused solely on DPM because of its potential to cause cancer and other health effects, and because cancer risks from DPM tend to be highest in areas with concentrated emissions, such as in areas impacted by the Ports. Notwithstanding the emphasis of the BWHRA Tool on DPM cancer risk, it is important to note that DPM emission control strategies that achieve cancer risk reductions will provide benefits towards reducing non-cancer health effects of DPM as well. Because diesel exhaust contributes particulate matter and other components to ambient air, DPM emission reduction strategies are also expected to reduce health impacts associated with small particulates (particulate matter with a diameter of 2.5 microns or less or $PM_{2.5}$) and to further attainment of the federal $PM_{2.5}$ standard in the South Coast Air Basin (Basin).

## Methods

The BWHRA Tool consists of three major components: (1) the DPM emission inventory of the mobile equipment operating at the Ports, (2) air dispersion modeling, and (3) an assessment of cancer risks from exposure to airborne DPM. The DPM emission inventory provides an estimate of how much DPM is generated from different emission sources, while air dispersion modeling incorporates the emission inventory and meteorological data inputs into a computer model to predict concentrations of DPM in ambient air. Potential health risks from DPM were estimated for residential populations based on these modeled concentrations of DPM.

The BWHRA Tool utilized the Ports' DPM emission inventories for the baseline year of 2005 (Starcrest Consulting, LLC [Starcrest] 2007a,b) and forecast DPM emissions for 2020 (Starcrest 2008). The 2020 forecast emissions account for pre-recession Ports growth estimates, implementation of CAAP emission reduction strategies, and adopted regulations. DPM emission rates were developed for each of five source categories; heavy duty vehicles (HDV); railroad locomotives; harbor craft; ocean going vessels (OGV); and cargo handling equipment (CHE). The BWHRA Tool addressed emissions from these mobile sources within the Ports boundaries as well as over-water emissions from activities that occurred approximately 40 nautical miles from the coast. DPM emissions from HDVs on Interstates 110 and 710 and Highways 47 and 103 north to Interstate 405, as well as locomotives on the Alameda Corridor north to Interstate 405 were also included.

Air dispersion modeling was performed to estimate exposure concentrations from the environmental transport and distribution of DPM emissions from mobile sources at the Ports into the atmosphere. This modeling was performed in a manner consistent with ARB (2006b) with a few key modifications. First, AERMOD, the current USEPA approved state-of-the-art regulatory model was used instead of the older model used in ARB's study, ISCST3. Second, Port-specific meteorological data were used. Third, off-Port sources such as trucks and locomotives were modeled on major transportation corridors to I-405, which is farther than considered in the ARB assessment. The air dispersion modeling provided estimated ambient air concentrations of DPM within the same 20 by 20 mile modeling domain used by ARB. These concentrations were used along with standard exposure parameters and California's DPM cancer slope factor (CSF) to develop estimates of individual lifetime cancer risks above background, and population-weighted average lifetime cancer risks attributable to inhalation of DPM for residential populations in 2005 and 2020.

## Results

Implementation of the CAAP and existing regulations are predicted to achieve widespread and significant reductions in individual cancer risk by 2020 throughout the BWHRA Tool modeling domain.

Between 2005 and 2020, residential cancer risks above 500 x $10^{-6}$ (500 in a million) are virtually eliminated from the zone around the Ports, with only small areas near Interstate 710 that still exceed this level. In 2005, estimated cancer risks between 251 and 500 x $10^{-6}$ (two hundred fifty one and five hundred in a million) impacted an extensive area around the Ports and major transportation corridors; by 2020, the zone that is affected by this level of risk is predicted to shrink dramatically, and is largely restricted to areas directly adjacent to transportation corridors and the Ports boundaries.

By 2020, these risk reductions exceed 75% in many areas, with risk reductions between 70 and 75% expected for the majority of the domain. For residents in communities within 2 kilometer (km) of the Ports boundaries, most individuals are expected to experience risk reductions of 70% or more by the year 2020. Approximately 10% of individuals are predicted to have risk reductions between 60 to 70%, and a small area is expected to have risk reductions between 50 and 60%. The areas with the lowest predicted cancer risk reductions, less than 50%, occur in commercially or industrially-zoned areas between the Ports that are not currently occupied by residents.

As a means of characterizing the population-based reduction in risk within both the BWHRA Tool modeling domain and highly impacted communities, population-weighted average cancer risks attributable to Ports DPM sources were also calculated. For the modeling domain overall, population-weighted average cancer risks for 2005 of $249 \times 10^{-6}$ (249 in a million) are predicted to be reduced significantly by 2020 to $66 \times 10^{-6}$ (66 in a million). This 74% decrease in risk is consistent with the domain-wide risk reductions calculated for individuals. For communities within 2 km of the Port boundaries, population-weighted average cancer risks for 2005 of $519 \times 10^{-6}$ (519 in a million) are predicted to be reduced by 2020 to $143 \times 10^{-6}$ (143 in a million), a 72% decrease in risk.

These predicted risk reductions for 2020 are directly attributable to the Ports' CAAP (2006) emission reduction strategies, implemented in combination with USEPA's and ARB's adopted regulations. Further, the Ports are committed to reviewing the CAAP on a regular basis, and to examine progress towards achieving the CAAP goals during these reviews. The CAAP reviews will focus on the need to adjust implementation strategies by incorporating newly-developed technologies or other available measures to ensure that the CAAP goals and Health Risk Standard[1] are achieved. By following this framework, the Ports expect to achieve significant reductions in risk, and to attain more than their 'fair share' of DPM emission reductions on a statewide basis (CAAP 2009).

[1] The Health Risk Reduction Standard for reducing overall port-related health risk impacts, relative to 2005 conditions is: By 2020, reduce the population-weighted cancer risk of ports-related DPM emissions by 85% in highly-impacted communities located proximate to port sources and throughout the residential areas in the port region (CAAP 2009).

# 1 Introduction

In the San Pedro Bay Ports Clean Air Action Plan (CAAP 2006), the Ports articulated diesel exhaust particulate matter (DPM) emissions and health risk reduction goals whose specific targets would be incorporated into the San Pedro Bay-wide Standards. The focus of the Health Risk Reduction Standard (Standard) was to identify a criterion to use for understanding and monitoring progress towards achieving the Ports commitment to expeditiously and constantly reduce public health risk associated with Ports-related mobile sources. To inform development of that Standard, the Ports developed the Bay-wide health risk assessment (BWHRA) Tool, whose methodologies and results are described in this report and supporting appendices. A key component in the development of the BWHRA Tool was preparation of a BWHRA protocol (Protocol, Appendix A). The Protocol was developed in collaboration with the Technical Working Group (TWG), comprised of representatives from the Ports, the California Air Resources Board (ARB), the United States Environmental Protection Agency (USEPA) and the South Coast Air Quality Management District (SCAQMD). The Protocol identified cancer risk from DPM as the metric for characterizing cancer risk reductions achieved by implementation of Ports emission control strategies and current regulations, recognizing that cancer risk reductions are a surrogate for reductions in DPM non-cancer health effects as well. The ARB's exposure assessment of the Ports (ARB 2006b) provided the basis for the air dispersion modeling components of the Protocol. The Protocol also identified methodologies to be followed in calculating exposure concentrations and cancer risk which are consistent with the guidance of the SCAQMD and California's Office of Environmental Health Hazard Assessment (OEHHA).

The focus of the BWHRA Tool on DPM reflects the fact that long-term exposure to air pollution in the South Coast Air Basin (Basin) has been linked to a number of serious health effects including impaired lung function and an increased incidence of asthma (ARB 2004a) and impaired lung development in children (Gauderman et al. 2007). Diesel exhaust contributes particulate matter (PM) and other components to air pollution, and ARB determined that DPM accounts for approximately 70% of California's estimated potential cancer risk from toxic air contaminants (TACs) based on its monitoring data (ARB 2000). The ARB's Exposure Assessment for the Ports focused solely on DPM because of its potential to cause cancer and other health effects, and because cancer risks from diesel exhaust tend to be highest in areas with concentrated emissions (ARB 2006a). Consistent with those facts, ARB's analysis identified elevated regional cancer risks associated with ports-related DPM emissions (ARB 2006a). These results, supplemented by recently-completed project analyses at the Ports (*e.g.,* Port of Los Angeles [POLA] 2007, 2008; and Port of Long Beach [POLB], 2009) indicate that DPM sources at the ports may be the most significant single contributor of any TAC to regional health effects. The ambient DPM concentrations in the vicinity of the Ports are below the State of California's current non-cancer reference exposure level (REL) (OEHHA & ARB 2009), and thus are lower than the level at which significant adverse non-cancer health effects would be anticipated. Therefore, the BWHRA Tool focuses solely on cancer risk estimation.

## 1.1 Objective

The objective of the BWHRA Tool was to prepare an exposure and risk assessment for Ports-related DPM sources in the baseline year 2005 relative to those estimated for forecasted DPM emissions from the Ports in 2020. These analyses were conducted to characterize the effectiveness of implementing current CAAP measures and adopted regulations, while providing an understanding of the overall progress of the Ports towards achieving the Standard. The year 2020 assessment includes assumptions of a 7.1% annual increase in growth of the Ports (*i.e.,* pre-recession rates of growth) in the years between 2005 and 2020 (Starcrest 2008), implementation of adopted regulations, and implementation of additional select control measures (CAAP 2006; Starcrest 2007a,b, 2008). These scenarios, the underlying assumptions, and emissions estimation methodologies were developed by Starcrest (2008) with the participation of staff of the Ports, the ARB, and the SCAQMD.

For diesel exhaust from goods movement in particular, the ARB has prepared a series of risk assessments, including human health risk assessments (HRAs) for a number of railyards (*e.g.,* ARB 2004b, 2007a,b), a human HRA for diesel emissions associated with the statewide goods movement system (ARB 2006b), and an evaluation of regional health risks posed by diesel emissions from the Ports (ARB 2006a). While the risk assessments prepared for the individual rail yards focused on local impacts, the risk assessments prepared as part of the Emission Reduction Plan for Ports and Goods Movement (ARB 2006b) and for the Ports (ARB 2006a) focused on sub-regional impacts. This BWHRA Tool also focuses on sub-regional, rather than local, impacts. Local impacts are addressed in the facility-specific risk assessments prepared with project-specific protocols by the Ports under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) as part of the Ports' environmental programs. Since the BWHRA Tool is a sub-regional assessment that was specifically developed to support the CAAP health risk standard development, the methodologies of the BWHRA Tool have certain differences from specific guidance of state and local programs whose focus is on regulating single emission sources. In addition, due to the nature of the assessment, the BWHRA Tool utilized several technical approaches *e.g.,* analysis only of ports-related emission sources, use of fleet-average parameters to represent emission sources, and the generalization (grouping) of emission sources, that prevent the use of this tool to quantitatively assess project-specific cumulative risk under CEQA and NEPA.

Consistent with the Ports emissions inventories, and for comparability to ARB (2006a), the BWHRA Tool addresses mobile sources within the Ports' boundaries as well as over-water emissions. In addition, DPM emissions from trucks on major roadways (*i.e.,* Interstates 110 and 710 and Highways 47 and 103) and locomotives on the major rail line (*i.e.,* the Alameda Corridor) associated with Port operations - but outside the Ports' boundaries – were included. Based on an evaluation of meteorological data collected from stations in the vicinity of the Ports, the BWHRA Tool included out-of-port truck and locomotive DPM emissions over an area extending approximately to Interstate 405 (see Appendix A).[2]

## 1.2 Project Scope

The Port of Los Angeles and the Port of Long Beach are owned by the cities of Los Angeles and Long Beach, respectively, and are operated and managed under a State Tidelands Trust that grants local municipalities jurisdiction over ports. Collectively, the two Ports encompass approximately 10,700 acres and more than 50 miles of waterfront. The Ports build and lease the terminals, but do not operate the ships, CHE, trucks, harbor craft, and locomotives that support activities of the Ports tenants. The BWHRA Tool evaluates on-port mobile source emissions from the Port of Los Angeles and the Port of Long Beach, and their respective cargo terminals, passenger terminals, inter-modal rail facilities, and maritime support services. Port-related truck emissions on major freeways (*i.e.,* Interstates 110 and 710 and Highways 47 and 103) and locomotive emissions on the major rail line (*i.e.,* the Alameda Corridor) in the vicinity of the Ports and north to Interstate 405 were also considered in the BWHRA Tool. Over-water emissions from OGVs are also included for activities within 40 nautical miles off the coast of Los Angeles and Orange counties. The mobile source categories evaluated in this assessment include OGVs, harbor craft (*e.g.,* tugboats, ferries, commercial fishing vessels, etc.), off-road CHE, railroad locomotives, and on-road HDVs (see Section 3).

To facilitate comparisons with ARB's Exposure Assessment of the Ports (ARB 2006a), the BWHRA Tool assesses sub-regional impacts of DPM, and uses the same geographic area (domain) of air dispersion modeling for estimation of DPM exposure point concentrations as that used by ARB.

## 1.3 Methodology

This report provides the background to the analysis, and also describes the methodologies followed for the air dispersion modeling and human health risk assessment elements of the BWHRA Tool. These approaches were established in a health risk assessment Protocol reviewed by the TWG (Appendix A). Emissions estimation methodologies are described in separate documents prepared by Starcrest (2007 a,b, 2008) and reviewed by the TWG.

Like any risk assessment for chemicals emitted to air, the BWHRA includes estimation of air emissions, dispersion modeling to estimate exposure concentrations, and calculation of potential health risks associated with modeled exposure concentrations. The risk assessment methods used in the BWHRA Tool are based on the fundamental principles of human health risk assessment described by the National Research Council ([NRC] 1983, 1994). The risk assessment methods of the BWHRA Tool are also consistent with guidance of the California

[2] The section of Interstate 110 between 223rd Street and Interstate 405 in northern Long Beach is not included in the analysis, as discussed in Appendix A.

Environmental Protection Agency (Cal/EPA), OEHHA (2003), the USEPA (2005a) and the SCAQMD (2003, 2005). These regulatory guidelines were developed to conform to the fundamental human HRA principles of the NRC (1983, 1994).

To foster comparability of the cancer risk estimates developed in this assessment with risk estimates from other analyses prepared for goods movement in California, the methods used in this BWHRA Tool are generally consistent with the risk assessment guidelines cited above - in particular with the ARB Hot Spots Guidance (OEHHA 2003). However, because those guidance documents were developed as part of specific regulatory programs that are not addressed by the BWHRA Tool, the detailed guidance in those documents is not necessarily consistent with the methodology and objectives of the BWHRA Tool sub-regional assessment.

For air dispersion modeling, the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was used to estimate DPM exposure concentrations at off-site receptor locations. Air dispersion modeling with AERMOD follows a similar approach to that used by the ARB (2006b). Additional details of how the air modeling was performed are provided in Section 3 and in Appendices A and B.

The BWHRA Tool utilizes default exposure assumptions that are consistent with those recommended by OEHHA for screening-level (*i.e.,* Tier 1) assessments under the AB2588 Hot Spots program (OEHHA 2003). Cancer risk was calculated using a CSF for DPM that was derived by OEHHA to represent the toxicity of the diesel exhaust mixture (OEHHA 1998, 2000). The BWHRA Tool evaluates risks to residential receptor populations, with exposure quantified for the inhalation exposure pathway. Details of the exposure and risk calculations are given in Section 4 and Appendix C, and the results are presented in Section 5.

## 1.4 Report Organization

This report is divided into six sections as follows:

**Section 1.0 – Introduction:** describes the purpose and scope of this report and outlines the report organization.

**Section 2.0 – Emission Inventory Summary:** summarizes the DPM emission inventory results prepared by Starcrest.

**Section 3.0 – Air Dispersion Modeling:** describes the air dispersion modeling methods used to estimate DPM concentrations.

**Section 4.0 – Risk Characterization:** describes the methods used to estimate cancer risk from DPM exposure.

**Section 5.0 – Results:** provides the results of applying the BWHRA Tool, and discusses uncertainties in risk assessment.

**Section 6.0 – References:** provides citations for all references given in this report.

The appendices include supporting information as follows:

**Appendix A:** provides the Protocol developed for the BWHRA Tool.

**Appendix B:** provides additional details of the air dispersion modeling.

**Appendix C:** provides additional details of the risk characterization.

# 2 Air Emission Inventory Methodology

Starcrest was commissioned by each of the Ports to conduct a comprehensive, activity-based baseline emissions inventory of off-road CHE, railroad locomotives, on-road HDVs, OGVs, and harbor craft associated with the Ports activities in 2005 (Starcrest 2007a,b).

The Starcrest inventory addresses emissions that occur within the Ports boundaries from the five mobile sources categories noted above (OGVs, harbor craft [*e.g.,* tugboats, ferries, commercial fishing vessels, etc.], CHE, railroad locomotives, and HDVs). In addition, out-of-port Port-related truck emissions on major freeways (*i.e.,* Interstates 110 and 710 and Highways 47 and 103) and locomotive emissions on the major rail line (*i.e.,* the Alameda Corridor) in the vicinity of the Ports are also included in the BWHRA Tool. For consistency with ARB (2006a), Port-related over-water emissions from OGVs have also been included. The Starcrest inventories do not include mobile emissions from activities or facilities within the Ports' boundaries that are either on private land or that are unrelated to Ports operations. As noted in the Introduction, only those emission sources under Ports control are evaluated in the BWHRA Tool.

The baseline inventory encompasses emissions from a single calendar year (2005), and relies on methodologies described in Starcrest (2007a,b). Although Starcrest developed emissions data for a number of compounds, the BWHRA Tool only utilizes data for DPM emissions (see discussion in Introduction). Starcrest also developed an emission forecast for 2020 (Starcrest, 2008). That emission forecast incorporated growth projections for mobile sources at the Ports and reflects adopted regulations as well as implementation of the CAAP (2006). Table 2-1 summarizes the 2005 and 2020 DPM emissions by source category, and also provides the total mass and percentage reductions in DPM emissions for each Port.

# 3 Air Dispersion Modeling Methodology

Air dispersion modeling is performed to estimate exposure concentrations from the environmental transport and distribution of DPM emissions into the atmosphere from mobile sources at the Ports and from over-water Port-related vessel and harbor craft emissions and out-of-port Port-related truck emissions on major freeways as well as locomotive emissions on the major rail line in the vicinity of the Ports. Air dispersion modeling requires the selection of an appropriate dispersion model and input data based on regulatory guidance, common industry standards/practice, and/or professional judgment. In general, ENVIRON performed the air dispersion modeling in a manner consistent with the BWHRA Tool Protocol reviewed by the TWG (Appendix A). Air dispersion methodologies from other studies are used, where appropriate. These included ARB's Exposure Assessment study of the Ports (ARB 2006a) and/or guidance documents related to intermodal and railyard facilities prepared by ARB (2004b, 2005a, 2005b, 2006c) and SCAQMD (2003).

Air dispersion modeling is performed to estimate DPM exposure concentrations at off-Port locations within the modeling domain ("receptor locations") for two emissions scenarios:

- Baseline (year 2005) emissions inventory and
- Year 2020 emissions forecast inventory including projected growth of the Ports, emissions reductions due to adopted regulations, and implementation of the CAAP measures.

These scenarios, the underlying assumptions, and emissions estimation methodologies were developed by Starcrest (2007a,b, 2008) with the participation of staff of the Ports, the ARB, and the SCAQMD. The type of air dispersion model and modeling inputs that were used (i.e., pollutants modeled, pollutant averaging times, source characterization and parameters, meteorological data, terrain, land use, and receptor locations) are summarized below with further details in Appendix B.

## 3.1 Model Selection and Option

The air dispersion modeling conducted for the BWHRA tool uses the USEPA's state-of-the-art regulatory model AERMOD (version 07026) to estimate DPM exposure concentrations at off-Port receptor locations (USEPA 2005b). AERMOD is a near-field, steady-state Gaussian plume model, and uses site-representative hourly surface and twice-daily upper air meteorological data to simulate the effects of dispersion of emissions from industrial-type releases (e.g., point, area, and volume sources) for distances of up to 50 kilometers. The use of AERMOD represents an update to the approach taken in ARB's Exposure Assessment of the Ports (ARB 2006a) in which an older USEPA model, Industrial Source Complex Short Term version 3 (ISCST3), was used to estimate exposure concentrations of DPM.

Because the BWHRA tool focuses solely on DPM-associated cancer risk, ENVIRON calculated the annual average DPM concentration for both the 2005 and 2020 emission scenarios consistent with regulatory guidance for the averaging time used for cancer risk assessments.

### 3.2 Source Characterizations and Parameters

Source characterization, location, and model-specific parameter information is necessary to model the dispersion of air emissions. As the BWHRA tool is developed to evaluate sub-regional impacts, ENVIRON performed the air dispersion modeling analyses using a simplified source treatment similar to the methods applied by ARB in their assessment of the Ports (ARB 2006a), which includes the identification of major source categories (e.g., OGVs, harbor craft, locomotives, CHEs, on-terminal and on-road HDVs), the approximation of locations for major source categories, and the use of fleet-average source parameter.

Details of emission source model parameters and locations are described further in Appendix B. Sources are assumed to have identical spatial allocation for both the 2005 and 2020 scenarios except for a few specific changes associated with approved or anticipated projects at the Ports. See Appendix B for a list of projects and spatial allocation changes that are either approved or anticipated to occur by 2020. ENVIRON used temporal data to represent the daily time variation of emissions for the major source types consistent with ARB's study (ARB 2006a).

### 3.3 Meteorological Data

AERMOD requires meteorological data from both near the surface and higher up in the atmosphere ('upper air data") to characterize the transport and dispersion of pollutants in the atmosphere. Details of the meteorological selection and processing are provided in Appendices A (which includes the BWHRA Tool Protocol prepared for this project) and B.

Given the large extent of the modeling domain for this assessment and the influence of geographic features on prevailing wind patterns, several surface meteorological stations were needed to fully characterize the varying conditions found in different areas of the Ports' operations. In order to determine the area(s) over which individual surface meteorological stations would be applicable, ENVIRON divided the Ports' operational areas into four zones: Inner Harbor, Middle Harbor, Outer Harbor and Beyond the Breakwater. The geographical areas comprising the operational zones are shown in Figure 3-1 and are defined in Appendix B. In the BWHRA tool Protocol and Sphere of Influence Report (Appendix A), the following stations, located on or near Port operational areas and operated by the Port of Los Angeles, were identified as the most representative of meteorological conditions within or near the Ports:

- St. Peter and Paul School (SPPS): Inner Harbor and Land-side Out of Port Emissions
- Terminal Island Treatment Plant (TITP): Middle Harbor
- Berth 47: Outer Harbor and Beyond Breakwater

As recommended by the National Climatic Data Center, Upper air data from the San Diego Miramar Naval Air Station is used in AERMET (USEPA's meteorological data processor for AERMOD) processing for the Ports. The cloud cover data from Long Beach Daugherty Field, as recommended by ARB, is also used in AERMET processing for the Ports.

Prior to running AERMET, surface characteristics for the meteorological monitoring site and/or the selected Port facilities must be specified. The surface parameters include surface roughness, albedo, and Bowen ratio, which are used to compute fluxes and stability of the atmosphere (USEPA 2004). The evaluation and selection of surface parameters, including the selection of surface parameter values and land use sectors is described in the BWHRA Tool Protocol found in Appendix A and utilizes USEPA methods applicable at the time that the BWHRA tool was developed.[3]

## 3.4 Land Use and Terrain

AERMOD can evaluate the effects of urban heat island effects on atmospheric transport and dispersion using an urban boundary layer option. ENVIRON selected the urban boundary layer option for this study based on the highly urbanized areas present in the modeling domain Appendix B provides additional details on the model inputs used for this option.

To ensure the modeling reflected the geographic features found in the modeling domain, ENVIRON used United States Geological Survey (USGS) 7.5 minute digital elevation maps (DEMs) for the entire modeling domain, similar to ARB's Ports study (ARB 2006a). Appendix B lists the specific terrain files used and any exceptions to the incorporation of elevation data into AERMOD.

## 3.5 Receptor Locations and Estimation of Exposure Concentrations

As described in the Protocol (Appendix A), two Cartesian grids representing off-site receptor locations around the Ports were included in the dispersion modeling to estimate DPM exposure concentrations for use in the estimation of DPM cancer risks. ENVIRON uses a receptor grid with 200-meter spacing, similar to ARB's Ports study (ARB 2006a), out to a distance of two kilometers (km) from the Ports' boundaries. A second Cartesian receptor grid with 500-meter spacing covering a total area of approximately 20 miles by 20 miles is also included. The extent of this grid is similar to the Cartesian receptor grid in ARB's Ports study (ARB 2006a) and extends south of the Ports over the San Pedro Bay, north to approximately Lynwood, west to approximately Torrance, and east to approximately Buena Park, as shown in Figure 3-1.

[3] In January 2008, USEPA released updated guidance for surface parameters analysis with the release of AERSURFACE, a model preprocessor to assist in determining surface parameters consistent with the new guidance (USEPA 2008a,b). The guidance recommends different methods than those used in the BWHRA tool for calculating the surface parameters. However, the impact of using these different methods relative to the methods used in the BWHRA Tool is insignificant, as discussed in more detail in Appendix B.

DPM exposure concentrations from all modeled sources were summed to estimate the total DPM exposure concentration at each receptor location for both the 2005 baseline and 2020 future forecast scenarios.

# 4 Health Risk Assessment Methodology

This section describes the methodology used in evaluating potential human health risk from exposure to DPM emitted during operations of the Ports, and Section 5 presents the principal results of that assessment. Supplemental material is provided in Appendix C, including a discussion of the derivation of the DPM CSF.  Quantification of potential health effects from DPM exposure incorporates the four elements of risk assessment identified by the NRC (1983): (1) hazard identification (including identification of chemicals of potential concern); (2) exposure assessment; (3) dose-response assessment; and (4) risk characterization. Each of these components is addressed in the following sections.

The risk assessment regulations and guidance documents that were considered in developing the methodology used in this assessment include:

- Air Toxics Hot Spots Program Risk Assessment Guidelines (OEHHA 2003),
- Air Resources Board Recommended Interim Risk Management Policy for Inhalation-Based Residential Cancer Risk (ARB 2003b)
- Supplemental Guidelines for Preparing Risk Assessments for the Air Toxics “Hot Spots” Information and Assessment Act (SCAQMD 2005)

The BWHRA Tool utilized screening-level (Tier 1) assumptions and parameters in accordance with the guidance cited above.  The focus of the BWHRA Tool on sub-regional effects distinguishes it from project-specific CEQA or NEPA evaluations at the Ports, which are designed to address questions of local impacts and health effects associated with a project or facility.  Using air dispersion modeling of contaminants to near-source receptors, project-specific analyses examine impacts at maximum impact points, sensitive receptors locations, and other receptor populations that are not consistent with the source characterization methods and air dispersion modeling of the BWHRA Tool.  In contrast, the BWHRA Tool estimates overall sub-regional cancer risks attributable to DPM emissions from the Ports consistent with the ARB (2006a) Exposure Assessment of the Ports.  The BWHRA Tool methodology is further distinguished from that used in project analyses by the manner in which emission rates are averaged.  The BWHRA Tool uses discrete DPM emission rates estimated for 2005 and 2020 and held constant over the subsequent respective 70-year averaging periods, whereas project analyses utilize emission rates calculated for each year of the project life.  Because of these significant technical differences, the BWHRA Tool results are appropriate for informing development of the Standard as well as emission reduction strategies in general, but are not applicable for evaluating the impacts of an individual project or facility on the bay-wide scale.

## 4.1 Hazard Identification (Identification of Chemicals of Potential Concern)

Hazard identification is defined by the NRC (1983) as the determination of whether a particular chemical is or is not causally linked to particular health effects.  In practice, this component of a risk assessment identifies chemicals associated with a site or activity that are also linked to adverse health effects, and determines whether they should be carried through the risk assessment as chemicals of potential concern (COPCs).

As discussed in the Introduction, this BWHRA Tool focuses on DPM as the sole COPC. Under California regulatory guidelines (OEHHA 1998, 2007), DPM is used as a surrogate for the chemical mixture that is diesel exhaust, and the unit risk factor (URF) that OEHHA developed for DPM reflects that approach (OEHHA 1998). Diesel exhaust is a complex mixture of hydrocarbons, particulates, gases, water, and other compounds. The precise composition of the mixture depends on several factors including the fuel source, engine type, engine age, and operating condition. Diesel exhaust is classified by OEHHA and the USEPA as a carcinogen, and both agencies also recognize that diesel exhaust causes non-cancer effects as well (OEHHA 1998, 2007; USEPA 2007). DPM is a component of PM, and recent scientific data have linked prolonged exposure to PM to premature mortality, respiratory effects, and cardiovascular disease (see discussion in the Introduction and in Section 5.3).

## 4.2 Exposure Assessment

This component of a human health risk assessment is used to determine the extent of human exposure before or after application of regulatory controls (NRC 1983). As implemented here, the exposure assessment identifies the scenarios and receptor populations, and selects exposure pathways and exposure parameters appropriate to quantification of intake and potential cancer health effects associated with DPM emissions from the Ports. Theoretical chemical intakes for each potentially exposed human population and exposure pathway are estimated using equations consistent with or recommended by OEHHA (2003) and ARB (2003b).

### 4.2.1 Potentially Exposed Populations

The BWHRA Tool quantifies health effects to residential populations. In accordance with the sub-regional focus of the BWHRA Tool, impacts on sensitive receptors are not addressed in this assessment, but are considered in project HRAs that address local impacts.

Exposure of residential receptors was estimated based on DPM concentrations in all areas outside of the Ports boundaries, excluding over water areas, within the modeling domain. Actual land use zoning was not considered in the evaluation of residential receptor exposure.

### 4.2.2 Exposure Pathways

At the Ports, DPM is released to ambient air as exhaust from internal combustion engines. Because air is the principal environmental medium affected by DPM emissions, inhalation is the dominant route of exposure, and is the only exposure pathway evaluated by the BWHRA Tool.

### 4.2.3 Exposure Parameters

The parameters used to calculate exposure are based on a series of reported and assumed factors regarding human activity in the vicinity of the Ports *e.g.,* exposure time, exposure frequency, and exposure duration. The exposure parameters listed below for residential populations are consistent with a screening level, Tier 1 risk assessment when applied pursuant to OEHHA guidelines (OEHHA 2003).

Exposure estimates for residential receptors were based on the assumption that exposure to DPM occurs outdoors 24 hours per day, 350 days per year for 70 years (*i.e.,* that residents are present in their home seven days a week for 50 weeks a year [or about 96 percent of the time] with approximately two weeks [15 days] spent away from home) (OEHHA 2003). Uptake of DPM by inhalation was calculated using the 80th percentile breathing rate of 302 liters per kilogram of body weight per day (L/kg BW-day) (ARB 2003a). A default value for averaging time of 70 years, or 25,550 days was used.

The equation used to calculate exposure to a modeled concentration of DPM is provided in Appendix C.

## 4.3 Dose-Response Assessment

Because of the decision to focus on DPM-attributable cancer risk as the sole assessment metric (see Introduction), cancer risk was the only health effect end point evaluated in this BWHRA Tool. Both OEHHA (2008) and the USEPA have classified diesel exhaust as a carcinogen (USEPA 2008c). Consistent with OEHHA and the USEPA, other health agencies, including the International Agency for Research on Cancer ([IARC] 1998), and the World Health Organization ([WHO] 1996) have also concluded that diesel exhaust is a probable human carcinogen.

For DPM, the value used to estimate cancer risk from exposure is the CSF. The CSF is defined by OEHHA (2003) as the “theoretical upper bound probability of excess cancer cases occurring in an exposed population assuming a lifetime exposure to the chemical when the chemical dose is expressed in exposure units of milligrams/kilogram-day (mg/kg-d).” OEHHA’s CSF for DPM is 1.1 $(mg/kg\text{-}d)^{-1}$; derivation of the CSF for diesel exhaust is discussed in Appendix C.

# 5 Results

This section presents the results of the risk calculations for Ports-related DPM emissions in 2005 and 2020. Details of how cancer risks were calculated are provided in Appendix C.

## 5.1 Individual Cancer Risks

Implementation of CAAP emission reduction measures and adopted regulations are predicted to achieve widespread and significant reductions in individual cancer risk.

Between 2005 and 2020, residential cancer risks above 500 x $10^{-6}$ (500 in a million) are virtually eliminated from the zone around the Ports, with only small areas near Interstate 710 that still exceed this level (Figures 5-1 and 5-2). In 2005, estimated residential cancer risks between 251 and 500 x $10^{-6}$ (two hundred fifty one and five hundred in a million) impacted an extensive area around the Ports and major transportation corridors; by 2020, the zone that is affected by this level of risk is predicted to shrink dramatically, and is largely limited to areas directly adjacent to transportation corridors and the Ports boundaries.

Figure 5-3 shows the percentage reduction in individual cancer risk between 2005 and 2020 across the BWHRA Tool modeling domain. This method of presenting cancer risk provides important perspective on the scale of the risk reductions; by the year 2020, risk reductions exceed 75% in many areas of the domain, with risk reductions between 70 and 75% expected for the majority of the domain.

The Ports recognize that individuals who reside in communities within 2 km of the Ports boundaries and nearby transportation corridors may be more highly impacted by Ports-related emissions than for individuals in the domain as a whole. Evaluation of this near-Port area (Figure 5-4), showed that while significant risk reductions of 70% or more are predicted for the majority of this 2 km zone by 2020, approximately 10 % of individuals are predicted to have risk reductions between 60 to 70% and a small area is expected to have risk reductions between 50 and 60%.The areas with the lowest predicted cancer risk reductions, less than 50%, occur in commercially or industrially-zoned areas between the Ports that are not currently occupied by residents.

DPM emissions and risks from all sources decrease by the year 2020, with the relative importance to cancer risk of different source categories such as HDVs, locomotives, or OGVs varying throughout the domain (Figure 5-5). For the communities closest to the Ports and transportation corridors, ports-related truck and locomotive emissions are important contributors to risk in both 2005 and 2020. Although risks attributable to HDV remain for these communities in 2020, overall HDV emissions are expected to have decreased 84%, resulting in substantial decreases in risk from this source by 2020 relative to 2005 levels. CHE-associated risks are also important contributors to 2005 risks near intermodal operations, but by 2020 the importance of this source decreases markedly due to significant reductions in emissions from this source. For the year 2020, the planned increased reliance on on-port rail as a means of decreasing HDV emissions results in only modest reductions in rail-related emissions and risk for locations near the Ports. OGV emissions, while reduced significantly by 2020, continue to be a major contributor to risk levels throughout the domain. OGV emissions are the focus of ARB and international regulatory efforts targeting reductions in fuel sulfur content. When implemented, along with ARB's regulation for the use of shorepower, these regulations should yield public health benefits throughout the Basin.

## 5.2 Population-Weighted Average Cancer Risks

Population-weighted average cancer risks attributable to Ports DPM sources were calculated to characterize the population-based reduction in risk within the BWHRA Tool domain between 2005 and 2020. For the modeling domain overall, population-weighted average cancer risks for 2005 of $249 \times 10^{-6}$ (249 in a million) are predicted to be reduced significantly by 2020 to $66 \times 10^{-6}$ (66 in a million), a decrease of 74% (Table 5-1). For highly impacted communities, population-weighted average cancer risks for 2005 of $519 \times 10^{-6}$ (519 in a million) are predicted to be reduced by 2020 to $143 \times 10^{-6}$ (143 in a million), a 72% decrease in risk (Table 5-2). These decreases in risk are consistent with the risk reductions calculated for individual residential receptors (see preceding discussion), and confirm the magnitude of the risk reductions expected from the Ports current DPM emission reduction strategies.

## 5.3 Discussion and Conclusions

The BWHRA Tool was used to predict reductions in both individual and population-weighted average cancer risk in 2020 from implementing CAAP (2006) DPM emission reduction strategies in combination with regulations adopted by the USEPA and ARB. The cancer risks calculated for 2005 and 2020 represent the predicted risks, above background levels, attributable to Ports-related DPM sources. These analyses indicate that widespread public health benefits will result from the reduction in DPM emissions from Ports-related mobile sources, yielding risk reductions of 70% or more for the majority of the modeling domain in 2020.

For the entire Basin in the year 2000, individual cancer risk from all TACs combined has been estimated at $1000 \times 10^{-6}$ (1000 in a million); risks of approximately $720 \times 10^{-6}$ (720 in a million) have been attributed to DPM alone (ARB 2006d). These values represent risk to individuals from all sources, and they indicate that Ports DPM sources represent only a portion of the air quality and public health risk concerns facing the Basin.

As discussed in the CAAP (2009) update, the Ports cannot singlehandedly resolve the Basin's air quality issues, the results from application of the BWHRA Tool demonstrate that the Ports' CAAP commitments, actions, and policies to reduce DPM levels can have significant beneficial effects on public health. The reduction in DPM emissions will also reduce $PM_{2.5}$, producing additional health benefits while supporting Basin-wide efforts to attain the federal $PM_{2.5}$ standard. The Ports have committed to reviewing the CAAP on a regular basis, and during these reviews, to examine progress towards achieving the CAAP goals. The CAAP reviews will focus on the need to adjust implementation strategies by incorporating newly-developed technologies or other available measures to ensure that the CAAP goals and Health Risk Standard are achieved. By following this framework, the Ports expect to attain the significant reductions in cancer risk noted above, and to identify and apply technologies not yet available to ultimately reach the Health Risk Reduction Standard (CAAP 2009).

## 5.4 Uncertainties Associated with Health Risk Analysis

There is inherent uncertainty in all risk assessments, with the source(s) of that uncertainty dependent on the specific assumptions and models used to estimate risk (Council on Environmental Quality 1989). Understanding the degree of uncertainty associated with each component of a risk assessment is critical to interpreting the results of that assessment. As recommended by the NRC (1994), [a risk assessment should include] “a full and open discussion of uncertainties in the body of each … risk assessment, including prominent display of critical uncertainties in the risk characterization.” In accordance with these recommendations, the key uncertainties and critical assumptions associated with the air dispersion modeling and health risk estimation are provided in Appendices B and C. The uncertainties associated with the emission estimations used in this BWHRA Tool are provided in Starcrest (2007a,b and 2008).

The risks calculated by application of the BWHRA Tool were estimated using a series of conservative assumptions regarding exposure concentrations, the magnitude and duration of exposure, and carcinogenic potency of DPM. These assumptions, applied in a manner consistent with current guidance (OEHHA 2003; ARB 2003b), tend to produce upper-bound estimates of risk, ensuring that these values do not underestimate the actual risks posed by DPM emissions from the ports. It is important to note that the risks calculated in the BWHRA Tool do not necessarily represent the actual risks experienced by populations in the modeling domain. By using standardized conservative assumptions in a risk assessment, the USEPA (1989) has noted that:

> *“These values [risk estimates] are upper-bound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero.”*

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# Tables

**Table 2-1: Forecasted 2020 Compared to 2005 Emissions Bay-Wide Health Risk Assessment Tool**

| Emissions Source | | 2005 Emissions (tpy) | 2020 Emissions (tpy) | Percent Reduction (2020/2005) |
|---|---|---|---|---|
| OGV | **Total** | **1189** | **255** | **79%** |
| | POLA Hoteling (At Berth) | 196 | 27 | 86% |
| | POLA Transit | 301 | 69 | 77% |
| | POLA Maneuvering | 44 | 16 | 63% |
| | POLA Maneuvering | 44 | 16 | 63% |
| | POLA Anchorage | 11 | 7 | 38% |
| | POLB Hoteling (At Berth) | 236 | 28 | 88% |
| | POLB Transit | 318 | 82 | 74% |
| | POLB Maneuvering | 41 | 15 | 63% |
| | POLB Anchorage | 41 | 11 | 74% |
| HC | **Total** | **68** | **36** | **47%** |
| | POLA | 38 | 20 | 46% |
| | POLB | 30 | 15 | 48% |
| CHE | **Total** | **117** | **16** | **86%** |
| | POLA | 62 | 7 | 88% |
| | POLB | 56 | 9 | 84% |
| HDV | **Total** | **198** | **32** | **84%** |
| | *Total On-Port* | *141* | *18* | *87%* |
| | POLA On-Port On-Road | 36 | 6 | 83% |
| | POLA On-Port On-Terminal | 36 | 2 | 94% |
| | POLB On-Port On-Road | 48 | 8 | 83% |
| | POLB On-Port On-Terminal | 21 | 1 | 93% |
| | *Total Off-Port* | *57* | *14* | *75%* |
| Rail | **Total** | **41** | **40** | **2%** |
| | *Total On-Port* | *37* | *38* | *-4%* |

**Table 2-1: Forecasted 2020 Compared to 2005 Emissions Bay-Wide Health Risk Assessment Tool**

| | | | | |
|---|---|---|---|---|
| | POLA On-Port | 23 | 20 | 11% |
| | POLB On-Port | 14 | 18 | -27% |
| | *Total Off-Port* | *4* | *1* | *63%* |
| **TOTAL (with Off-Port HDV and Rail)** | | **1612** | **379** | **77%** |
| **TOTAL (without Off-Port HDV and Rail)** | | **1551** | **363** | **77%** |

Key:

OGV = Ocean-Going Vessels
HC = Harbor Craft

CHE = Cargo Handling Equipment
HDV = Heavy Duty Vehicles

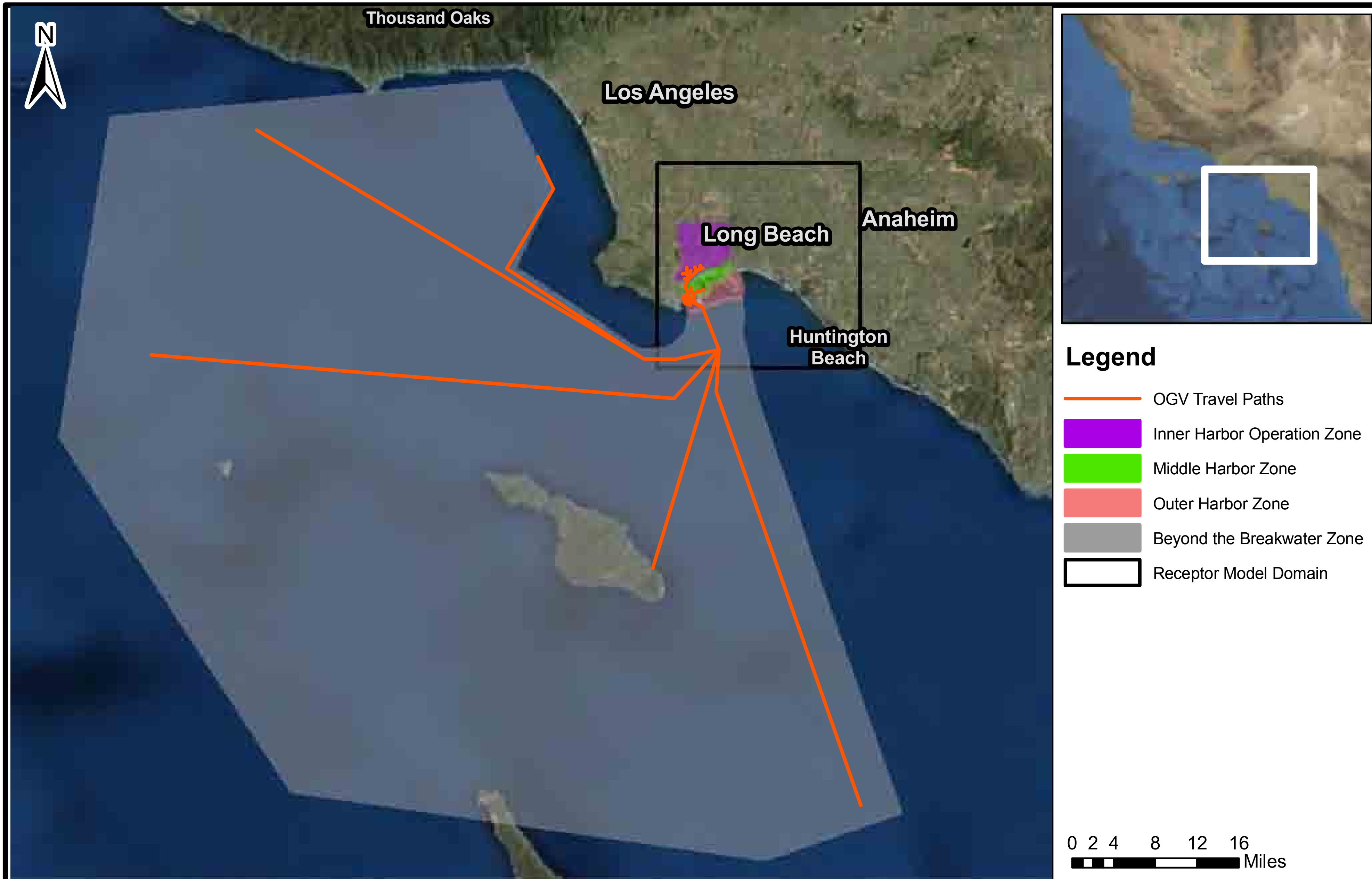
**Table 5-1: Population-weighted Average Risk to Residential Populations from DPM Emissions, 2005 and 2020**

| Year | Population-weighted Averaged Risk (per million) | Percent Reduction in Risk from 2005 |
|---|---|---|
| 2005 | 249 | ----- |
| 2020 | 66 | 74 |

**Table 5-2: Population-weighted Average Risk from DPM Emissions to Residential Populations in Nearby Communities, 2005 and 2020**

| Year | Population-weighted Averaged Risk (per million) | Percent Reduction in Risk from 2005 |
|---|---|---|
| 2005 | 519 | ----- |
| 2020 | 143 | 72 |

# Figures

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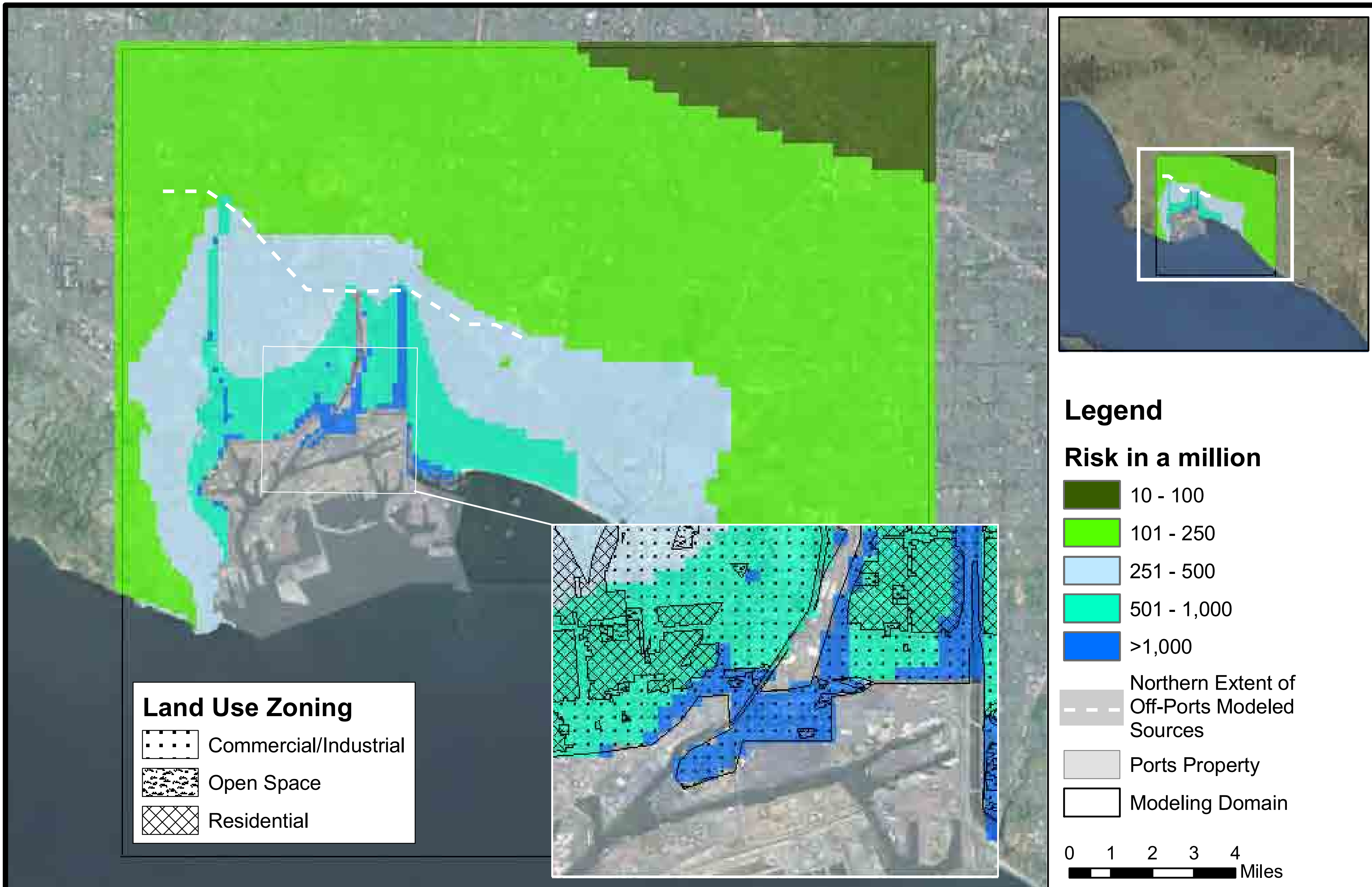
**Source and Receptor Modeling Domains**
**San Pedro Bay Ports, California**

Figure

3-1

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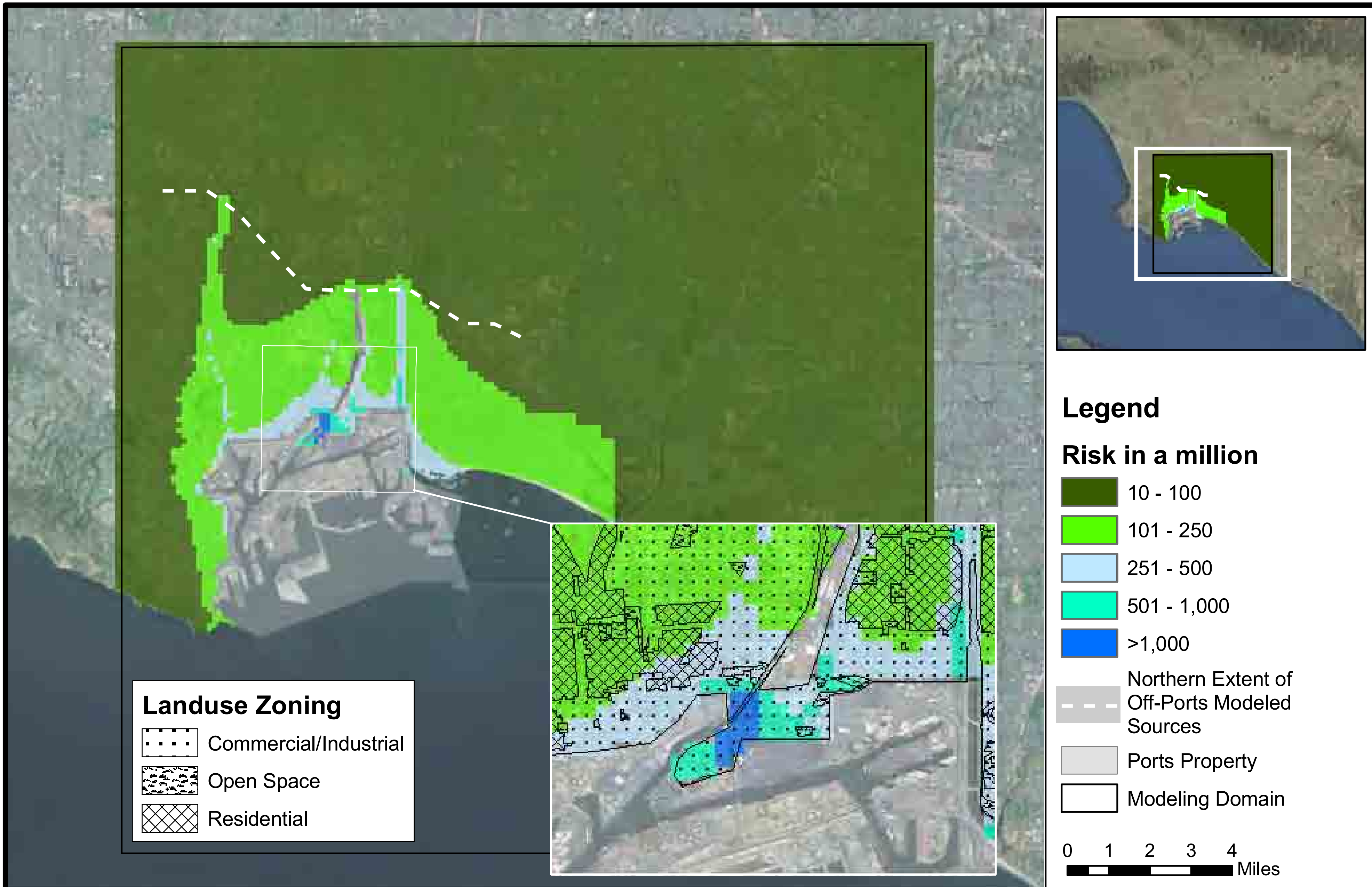
**Health Risk Results - DPM from All Sources, 2005**
**Residential Exposure Assumptions**
**San Pedro Bay Ports, California**

Figure

5-1

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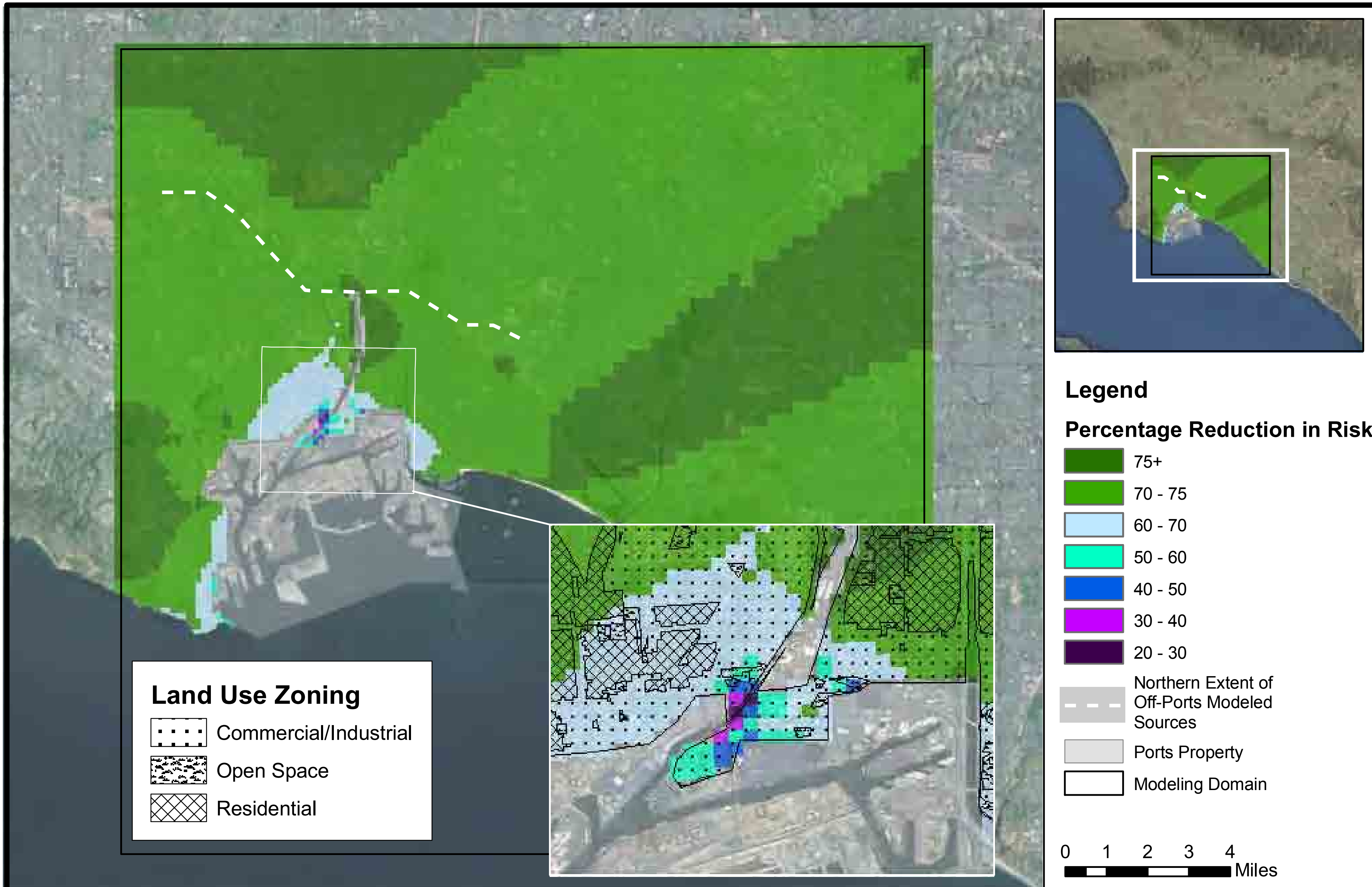
**Health Risk Results - DPM from All Sources, 2020**
**Residential Exposure Assumptions**
**San Pedro Bay Ports, California**

Figure 5-2

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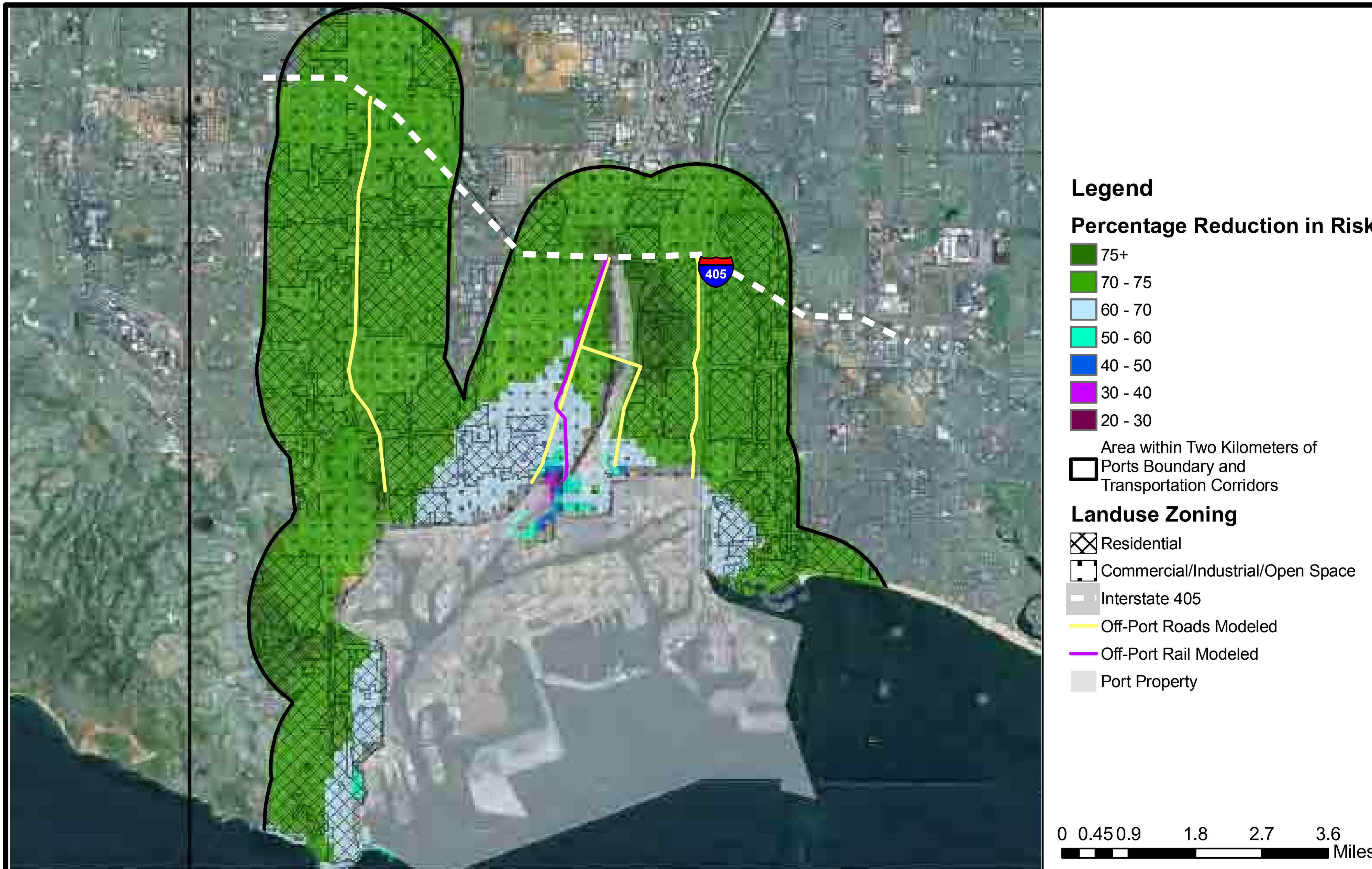
**Health Risk Results - DPM from All Sources**
**Percent Difference between 2005 and 2020 Emissions,**
**Residential Exposure Assumptions**
**San Pedro Bay Ports, California**

Figure
5-3





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**Health Risk Results – DPM from All Sources. Localized Impacts Analysis.**
**Percent Reduction in Risks Between 2005 and 2020 Emissions.**
**Residential Exposure Assumptions**
**San Pedro Bay Ports, California**

Figure

5-4


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**Health Risk Results - DPM from All Sources: Source Breakdown**
**2005 and 2020 Emissions,**
**Residential Exposure Assumptions**

Figure

5-5

# Figures

**Figure 1: ARB Modeling Domain and Approximate Extent of Port Emissions Activities**

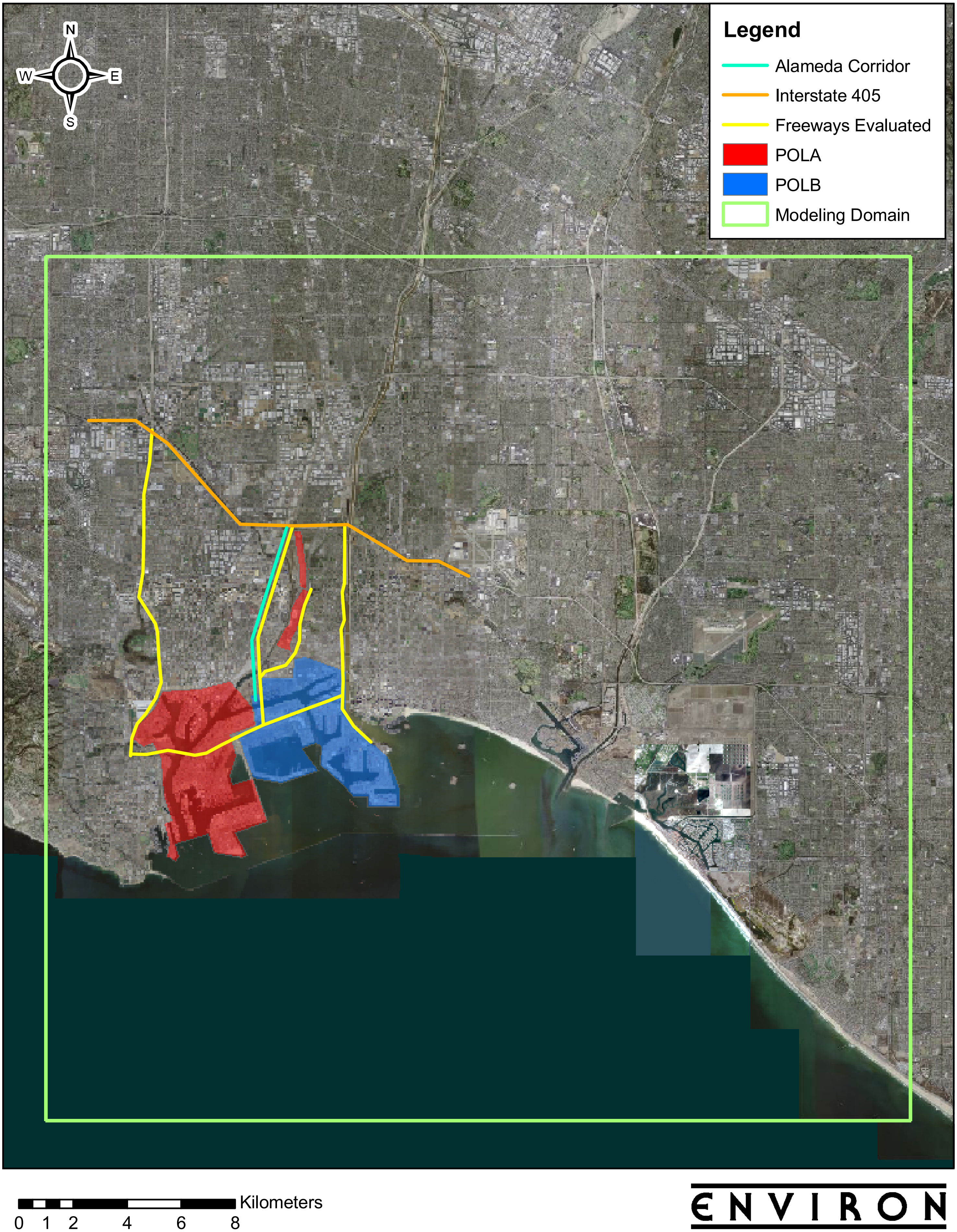


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**Figure 2. Extent of Emission Source Operating Areas - Ocean Going Vessels and Commercial Harbor Craft**

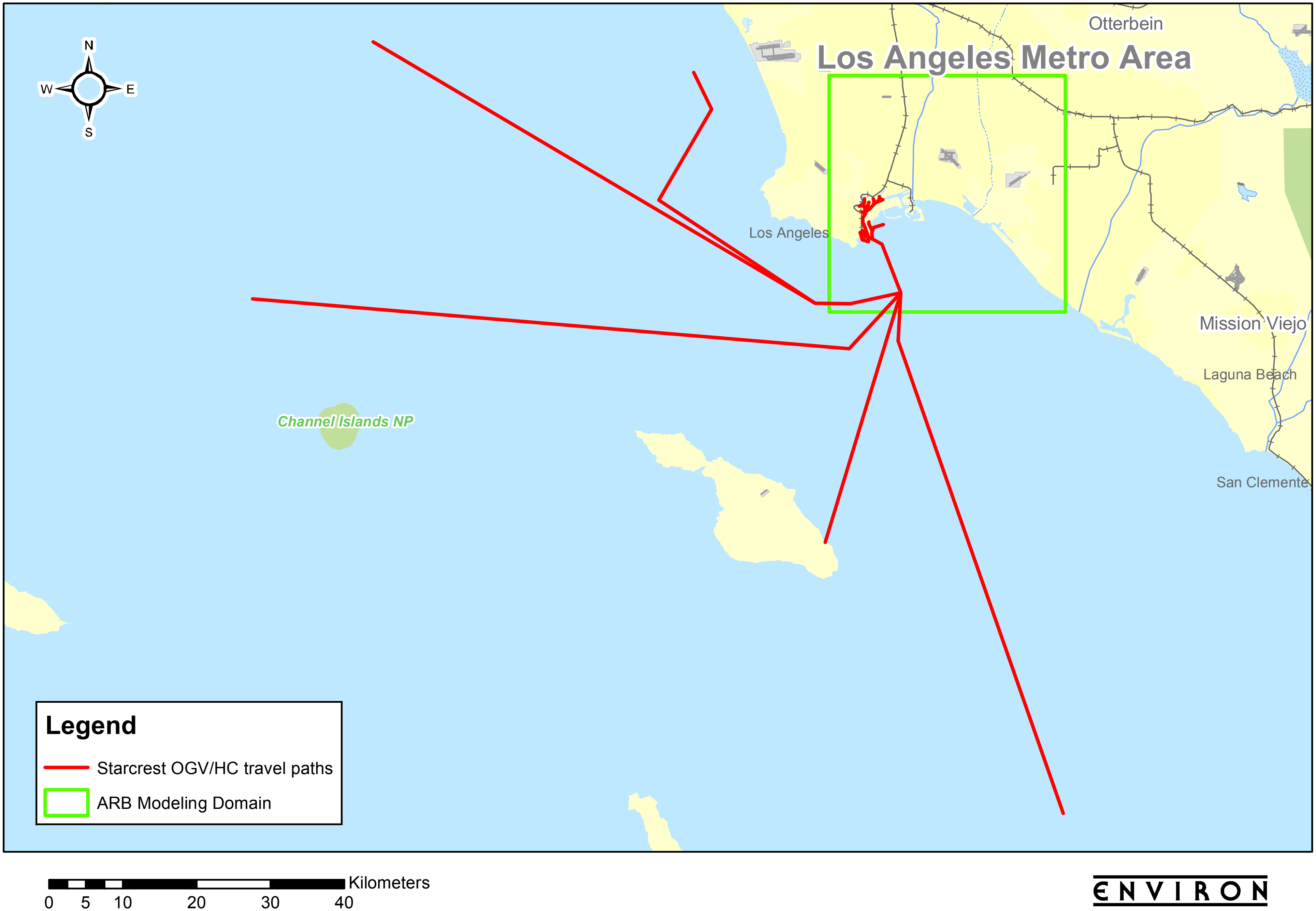


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**Figure 3: Inner, Middle, and Outer Harbor Zones for Meteorological Applicability POLA/POLB**

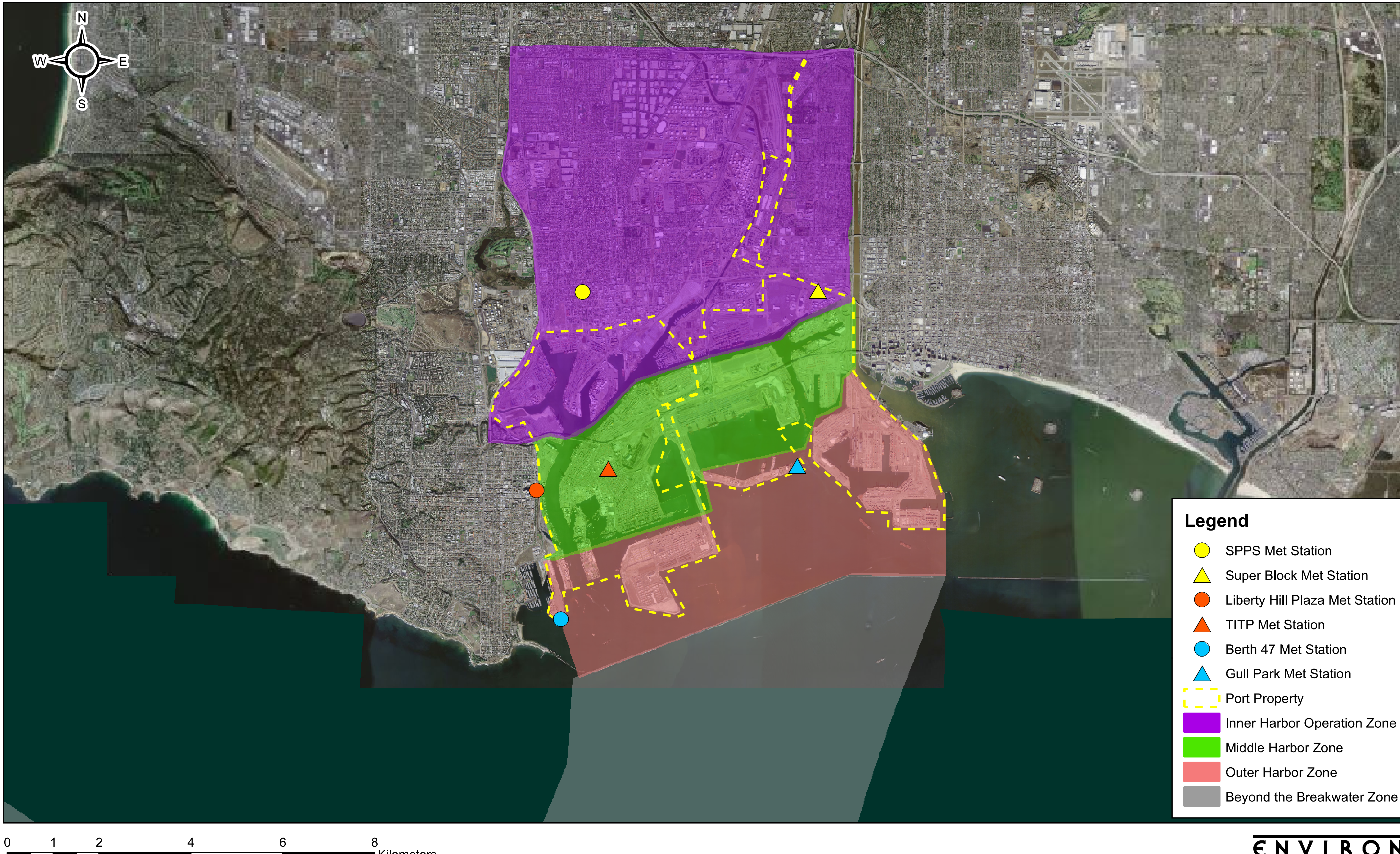
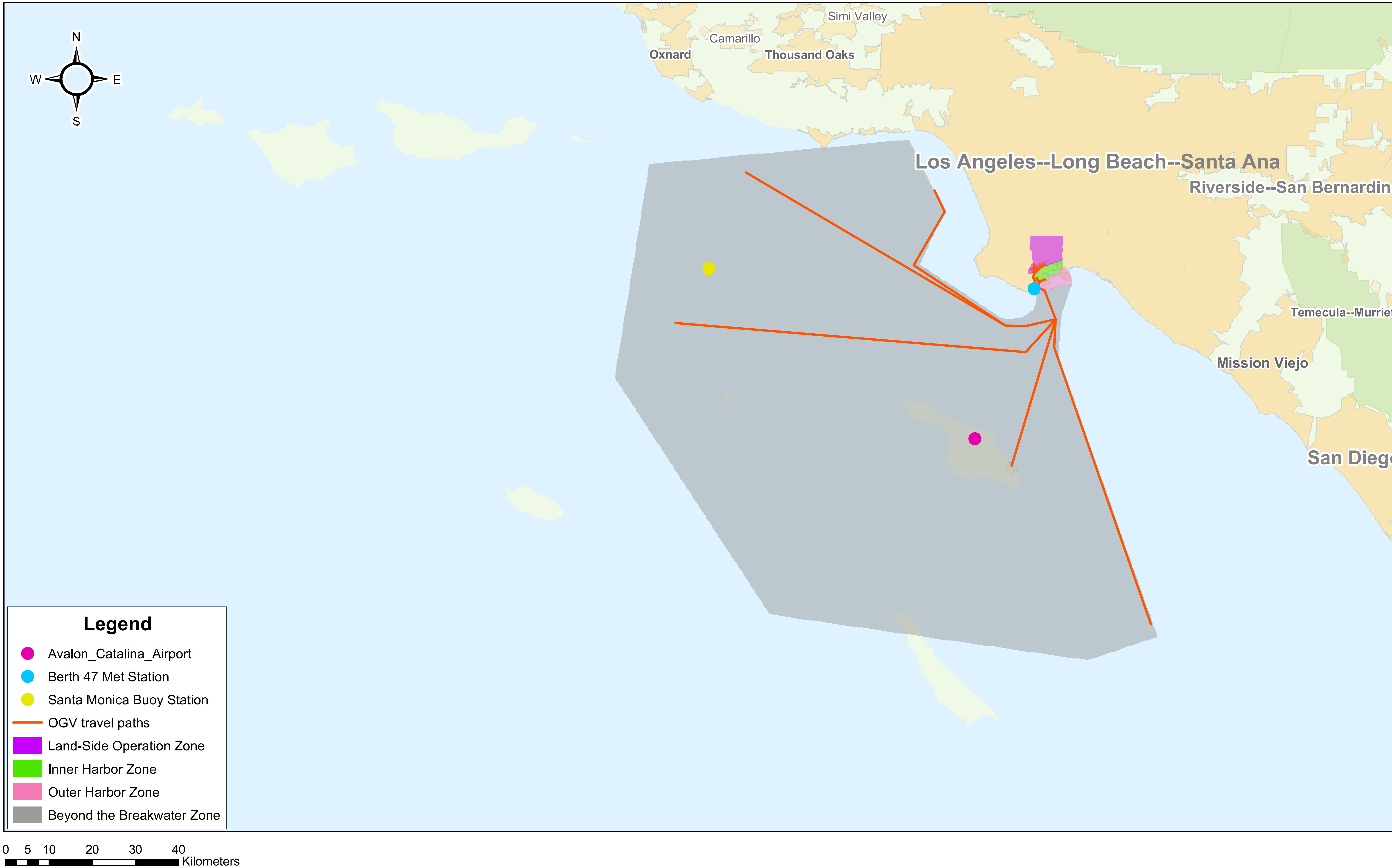


**Figure 4: Beyond the Breakwater Zone for Meteorological Applicability**
**POLA and POLB**



# Attachment I:

## Bay-Wide Sphere of Influence Analysis for Surface Meteorological Stations Near the Ports

# Attachment I:

**Bay-Wide Sphere of Influence Analysis of Surface Meteorological Station Near the Ports Baseline Bay-Wide Regional Human Health Risk Assessment for Diesel Exhaust Particulate Matter (DPM)**

# Contents

# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | American Meteorological Society/Environmental Protection Agency Regulatory Model |
| BWHRA | Bay-Wide Health Risk Assessment |
| CEQA | California Environmental Quality Act |
| EIR | Environment Impacts Report |
| HRA | Health Risk Assessment |
| km | Kilometer |
| NWS | National Weather Service |
| Ports | Port of Los Angeles and Port of Long Beach |
| SPPS | St. Peter and Paul School |
| TITP | Terminal Island Treatment Plant |
| USEPA | US Environmental Protection Agency |

# 1 Introduction

The Port of Los Angeles and the Port of Long Beach, referred to collectively as the San Pedro Bay Ports (the Ports), has requested that ENVIRON prepare a report on a “Sphere of Influence Analysis” for surface meteorological stations near the Ports. Its purpose is to provide additional guidance on the approach, methodology, and assumptions on selection of meteorological data for air dispersion modeling of individual health risk assessments (HRAs) or for environmental impact reports (EIRs) at the Ports, prepared to meet the requirements of the California Environmental Quality Act (CEQA). In addition, this memorandum is to provide consistency for the Ports in selecting meteorological data for CEQA projects and for the Bay-Wide Health Risk Assessment (BWHRA).

This document summarizes the selection of available, representative meteorological data near the Ports. It also describes the approach used to divide the Ports’ operational areas into four zones over which individual meteorological stations would be applicable. A general description of the methodology used to select appropriate station(s) within each zone for the project under consideration is also provided.

Please note that although this document aims to provide consistency for the Ports in selecting meteorological data for CEQA projects and for the BWHRA, it allows flexibility and encourages professional judgment to be used when selecting meteorological station(s) for individual CEQA projects. This document is subject to the review of other consultants and parties who are currently conducting EIR or HRA projects for the Ports.

# 2 Selection of Surface Meteorological Data

When characterizing near-field air pollutant dispersion using models such as AERMOD, representative hourly surface meteorological data inputs are required to characterize the atmospheric transport and dispersion in the area to be studied. AERMET, the meteorological preprocessor to AERMOD, requires certain surface meteorological parameters in order to prepare an AERMOD meteorological data input file. The minimum surface meteorological parameters required include wind speed, wind direction, temperature, and cloud cover (United States Environmental Protection Agency [USEPA] 2004b). Station pressure is also recommended, but not required for AERMET (USEPA 2004a).

A comprehensive search was conducted to identify surface meteorological stations in the vicinity of the Ports. Fourteen meteorological stations located within a 20-Kilometer (km) radius of the Ports with at least one year of meteorological data[1] were evaluated to select surface meteorological data that are representative of conditions at the Ports. Two additional off-shore meteorological stations were evaluated to select surface meteorological data that are representative of conditions of ocean-going vessels and harbor craft traveling near the Ports. The relative location of each station to the Ports, the data quality, and the wind patterns at each station as compared to the general wind patterns in the vicinity of the Ports were investigated. The detailed evaluation of each station can be found in Appendix A. As the result of the evaluation, seven meteorological stations were selected as candidates to represent meteorological conditions for individual CEQA projects of the Ports and for the BWHRA:

- St. Peter and Paul School (SPPS)
- Liberty Hill Plaza
- Terminal Island Treatment Plant (TITP)
- Berth 47
- Gull Park
- Super Block
- Santa Monica Buoy Station (Santa Monica)

Note that the stations above only collect wind speed, wind direction, temperature, and pressure data in some cases. Because cloud cover data (a required data input for AERMET) is only available from National Weather Service (NWS) stations, the evaluation and treatment of cloud cover data is discussed separately in Section A.5 in Appendix A.

[1] The two meteorological stations operated by the Port of Long Beach – Gull Park and Super Block-east began collecting data since September 1, 2006. Current evaluation of these two stations was based on data collected between September 1, 2006 and June 30, 2007. An updated evaluation will be performed once the a complete year of data has been collected for these two stations.

# 3 Definition of Zones

In order to determine over which area individual meteorological stations would be applicable, ENVIRON divided the Ports' operational area into four zones:

- Inner harbor – north of the East Basin Channel, Cerritos Channel, and Vincent Thomas Bridge, and bounded by Interstate 110 on west, Interstate 710 on the east, and an approximate east-west line created by Interstate 405 and 223rd Street in the northern part of Long Beach on the north
- Middle harbor – the majority of Terminal Island and San Pedro
- Outer harbor – the terminals on the southern end of Terminal Island and inside the breakwater
- Beyond the breakwater – San Pedro Bay and Pacific Ocean outside of the breakwater

Figure I-1 and Figure I-2 show the boundaries of the four zones. Terrain features in the vicinity of the Ports, shipping channels and water bodies in and near the Ports were evaluated to determine the boundaries of the zones.

Under current definition of the zones, two meteorological stations fall within each zone except for the "beyond the breakwater" zone for which Berth 47 appears representative of conditions in this zone as discussed in Section A.4 of Appendix A:

- Inner harbor – SPPS; Super Block
- Middle harbor – Liberty Hill Plaza; TITP
- Outer harbor – Berth 47; Gull Park
- Beyond the breakwater – Berth 47 (Primary); Santa Monica (project-specific considerations)

Figure I-3 and Figure I-4 present the relative location of each meteorological station within each zone. Wind flow patterns at each station are also shown in these figures. Please note that the wind roses of the Gull Park station and the Super Block-east station were currently based on data collected between September 1, 2006 and June 30, 2007. There may be differences once a full year of data has been collected due to potential seasonal and annual variations.

# 4 Sphere of Influence Analysis

The applicable zone(s) for each project under consideration will be selected based on the location of the project. Once the zone of the project has been determined, a more in-depth analysis will be necessary in order to select appropriate meteorological station(s) within the zone(s) for the air dispersion modeling of the project. This document discusses general methodology used to select appropriate station(s) within each zone for the project under consideration in the following paragraphs. It should be noted that this methodology is somewhat flexible and allows professional judgment to be used when selecting meteorological station(s) for individual CEQA projects.

- If the project location is very close to a particular meteorological station within the zone, select this station
- If there are obvious terrain features between the project location and a particular meteorological station within the zone, consider not selecting this station
- If there are significant water bodies and shipping channels between the project location and a particular meteorological station within the zone, consider not selecting this station
- In many cases, the project location will fall between two meteorological stations within one or more zones or cover more than one zone. Under such conditions, a comparison of wind roses may be performed to investigate the similarities and differences of wind flow patterns at these stations. A meteorological station can be selected which, when used, will yield more conservative results from the air dispersion modeling
- Multiple meteorological stations can be used for air dispersion modeling when appropriate. Sensitivity analyses are recommended to balance the use of multiple stations with the level of precision and to evaluate the uncertainties

Figure I-3 and Figure I-4[2] identify the available surface meteorological data sets for the various zones for conducting the analysis described above. The area over which each meteorological station is representative can be determined using the general methodology discussed above, which allows for flexibility and the application of professional judgment to select surface meteorological data for individual CEQA projects.

[2] Note that Figure 4 also shows a windrose for the Avalon Catalina Airport station to support the selection of Berth 47 for the operational area outside the breakwater. Although five years of meteorological data were available from the Avalon station, the data do not meet the minimum completeness criteria for air dispersion modeling.

# 5 Summary

ENVIRON prepared this report to provide consistency for the Ports in selecting meteorological data for CEQA projects and for the BWHRA. Hourly surface data from seven meteorological stations near the Ports are available for air dispersion modeling. The Ports' operational area is divided into four zones over which a "sphere of influence" of each meteorological station is analyzed. At least two meteorological data sets per zone are identified for use in air dispersion modeling conducted for Port-related sources. Selection methodology is proposed that is flexible and encourages professional judgment to be applied when selecting meteorological station(s) for individual CEQA projects.

# 6 References

United States Environmental Protection Agency (USEPA). 2004a. User's Guide for the AERMOD Meteorological Preprocessor (AERMET). Office of Air Quality Planning and Standards. Emissions Monitoring and Analysis Division. Research Triangle Park, North Carolina. EPA-454/B-03-002. 5-9, 4-49. November

USEPA. 2004b. User's Guide for the AMS/EPA Regulatory Model - AERMOD. Office of Air Quality Planning and Standards. Emissions Monitoring and Analysis Division. Research Triangle Park, North Carolina. EPA-454/B-03-001. September

# Figures

## Figure I-1: Inner, Middle, and Outer Harbor Zones for Meteorological Applicability POLA/POLB

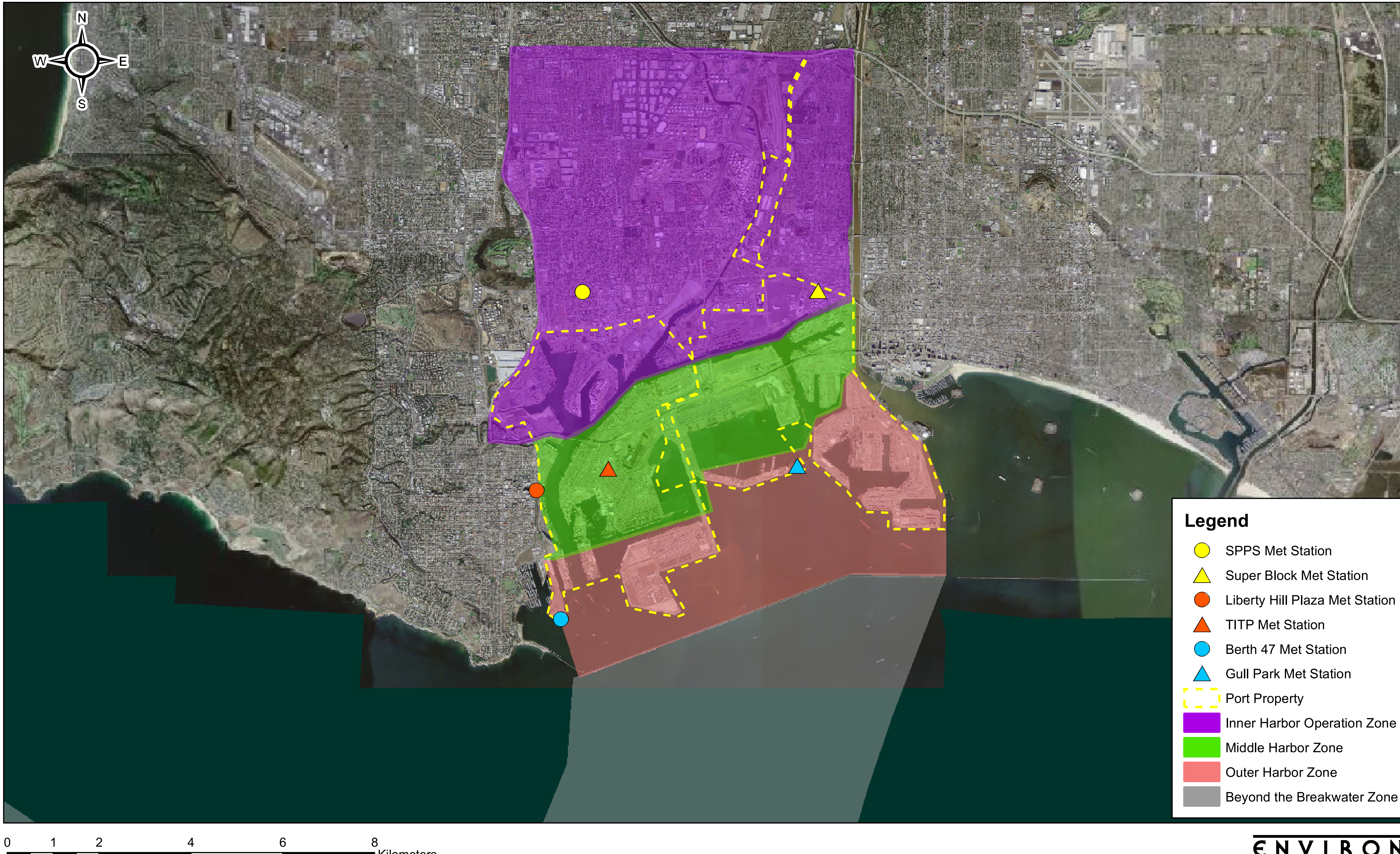



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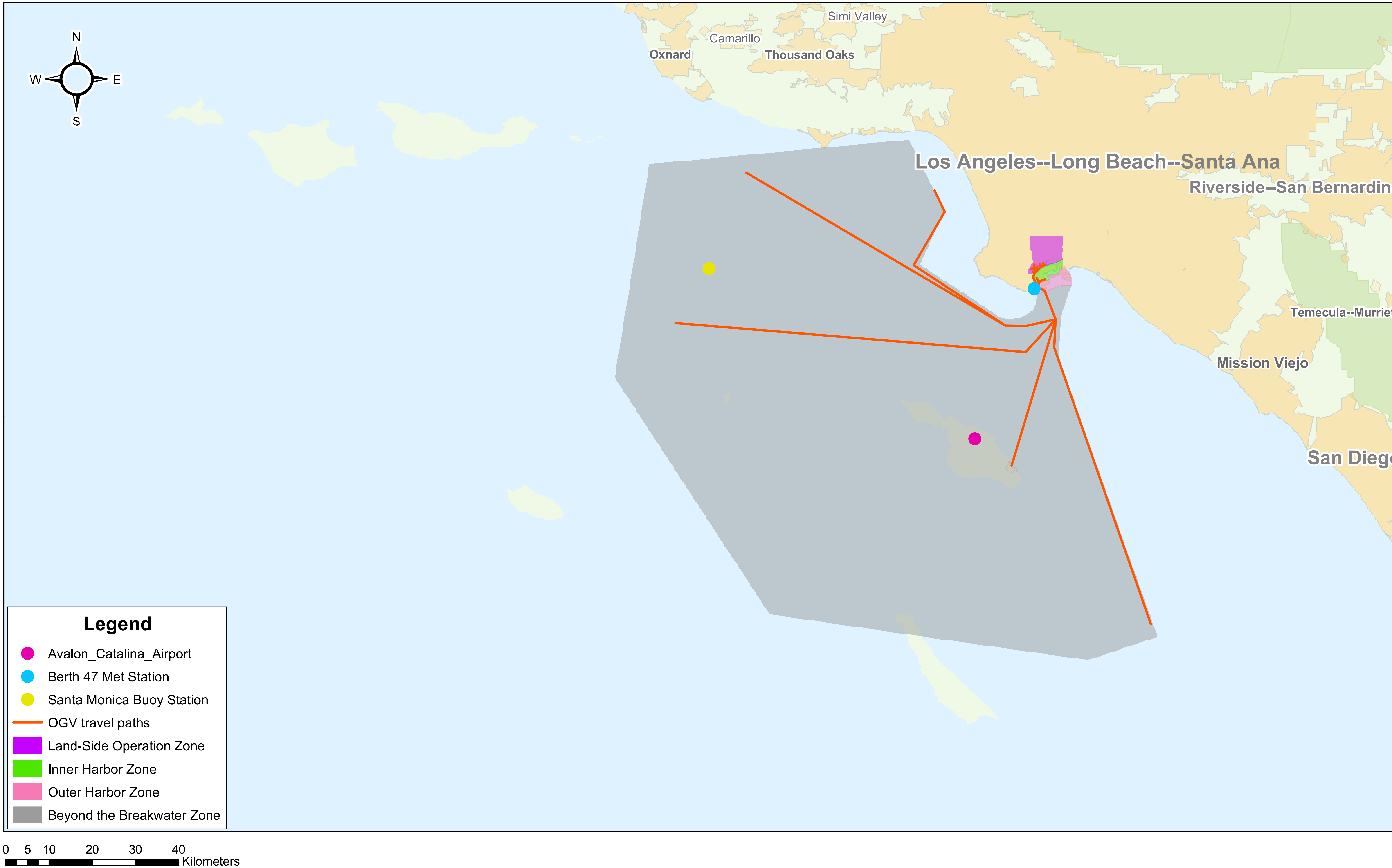
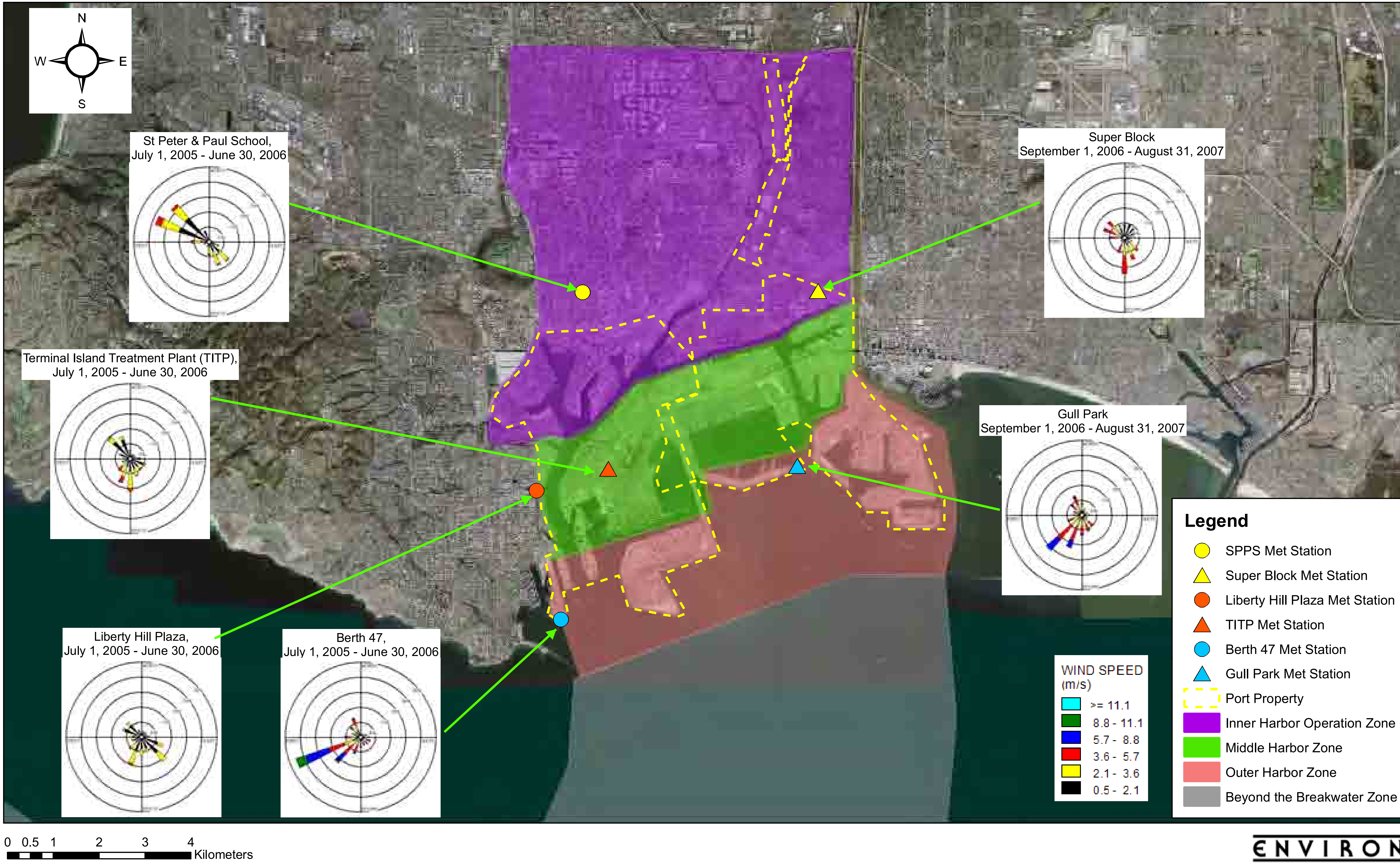
**Figure I-2: Beyond the Breakwater Zone for Meteorological Applicability**
**POLA and POLB**



# Figure I-3: Wind Patterns for Surface Meteorological Stations POLA and POLB

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# Figure I-4: Wind Patterns for Beyond the Meteorological Stations POLA and POLB

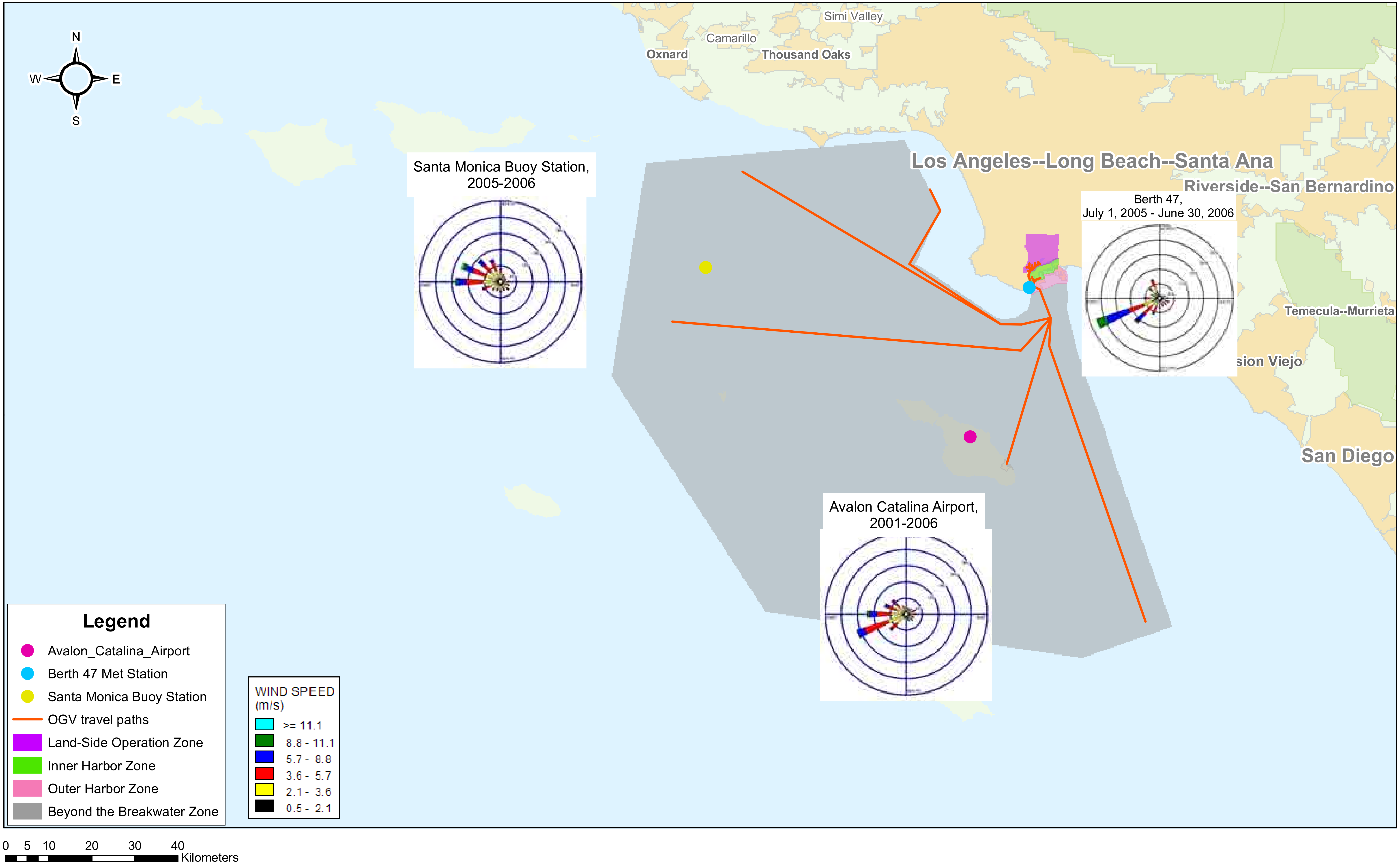
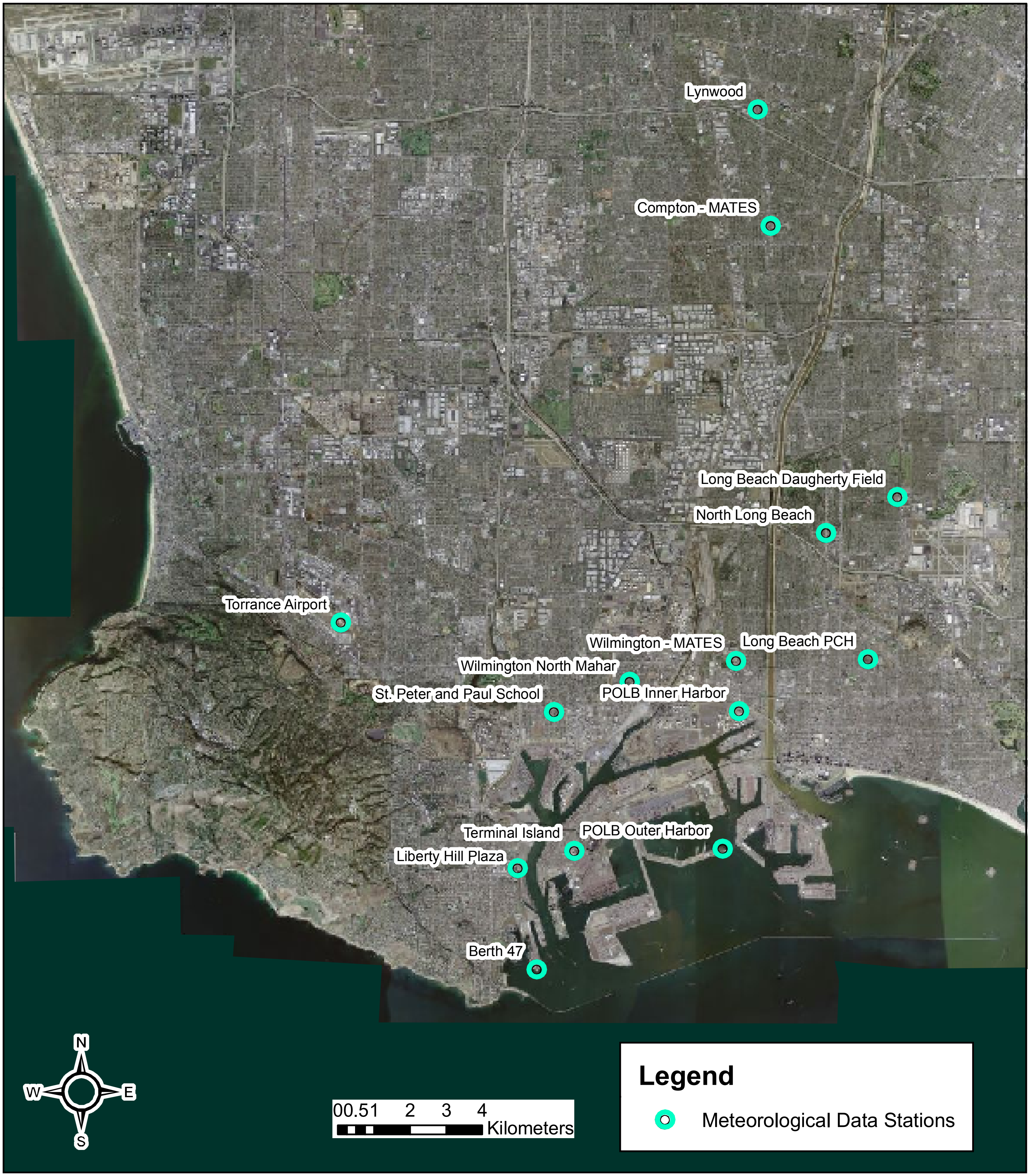


**Figure I-A-1: Surface Meteorological Stations near POLA and POLB**

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# Figure I-A-2: Wind Patterns for Surface Meteorological Stations near the POLA and POLB

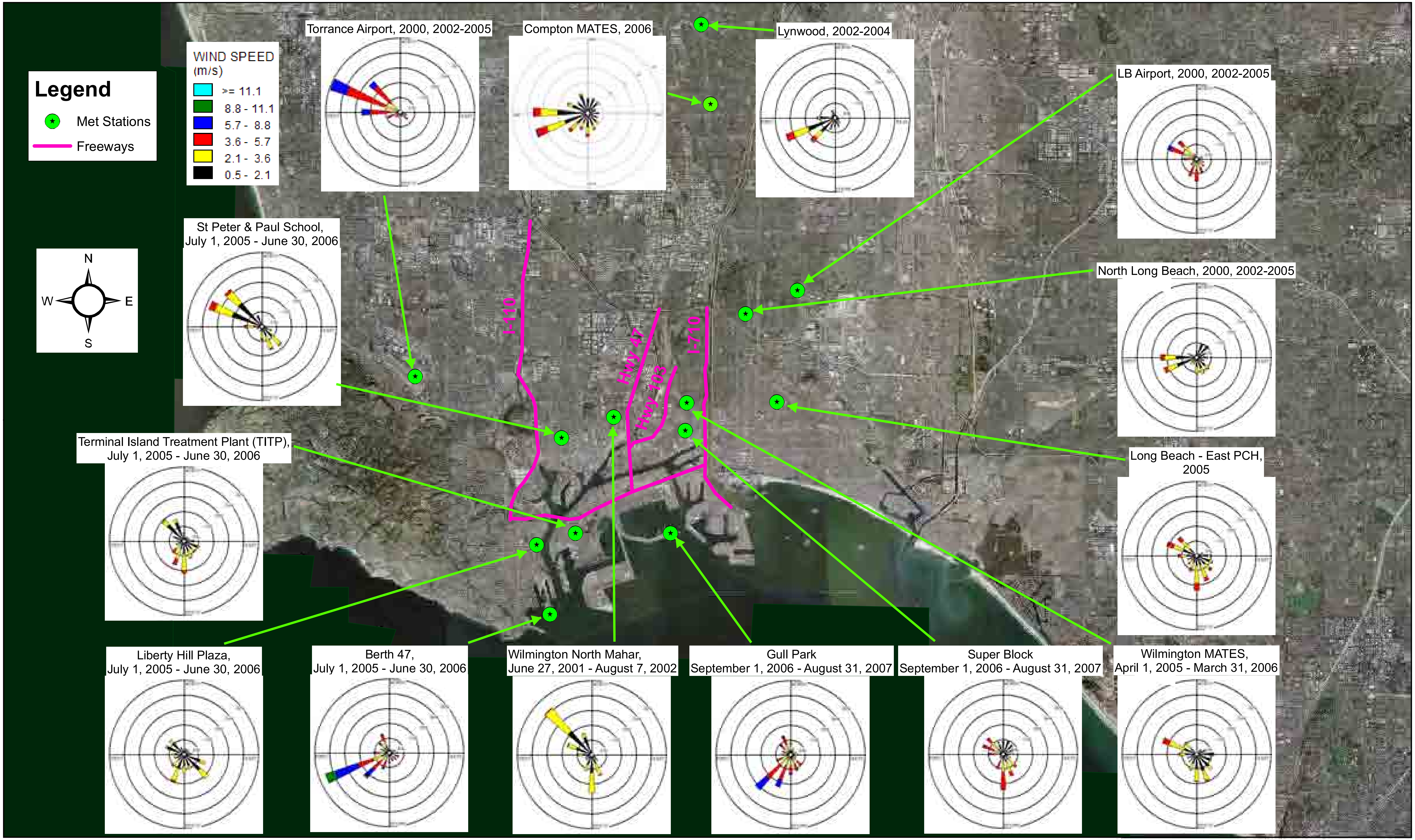

**Figure I-A-3: North Long Beach Surface Meteorological Station and Nearby Buildings**

# Figure I-A-4: POLA and POLB Surface Meteorological Stations

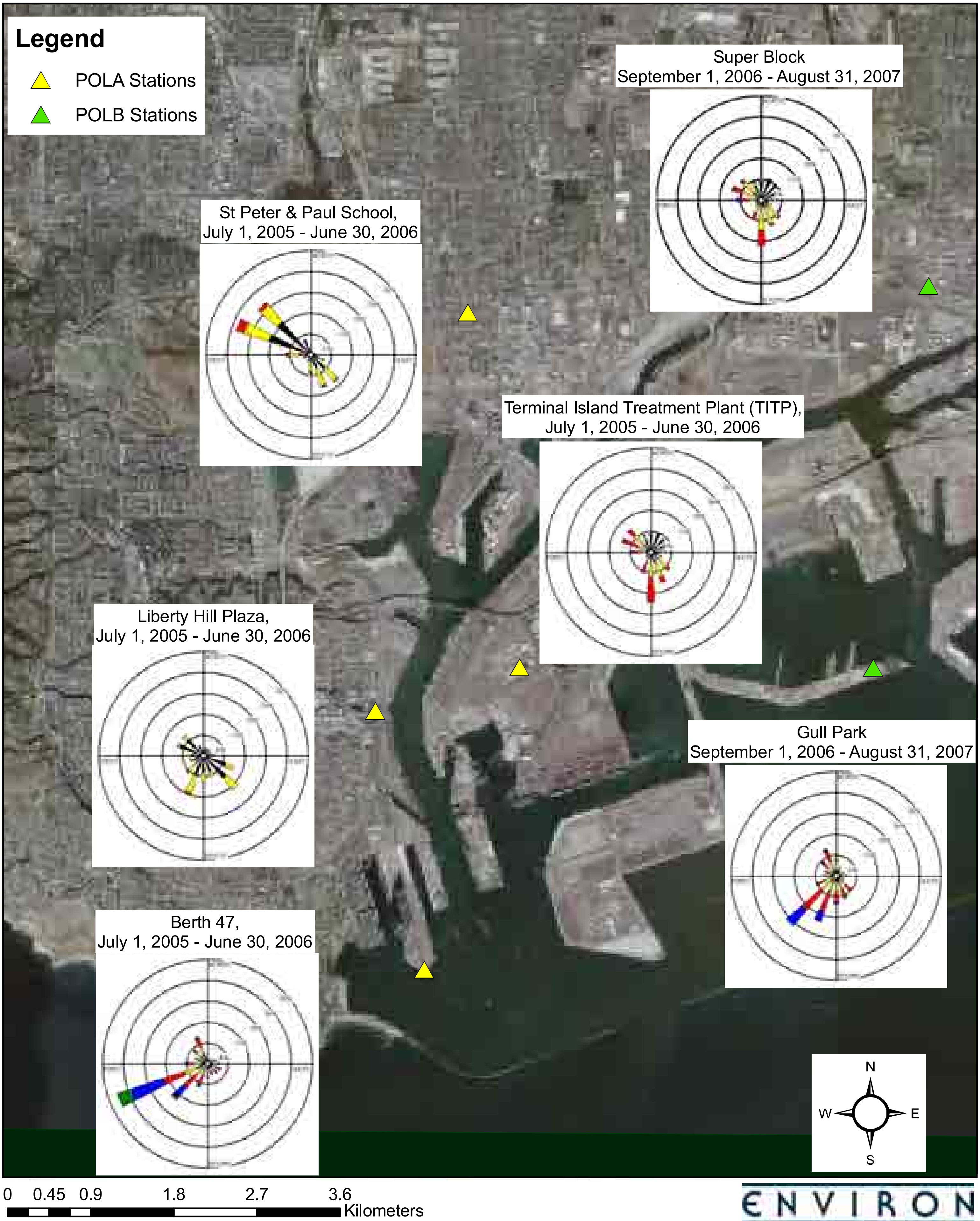


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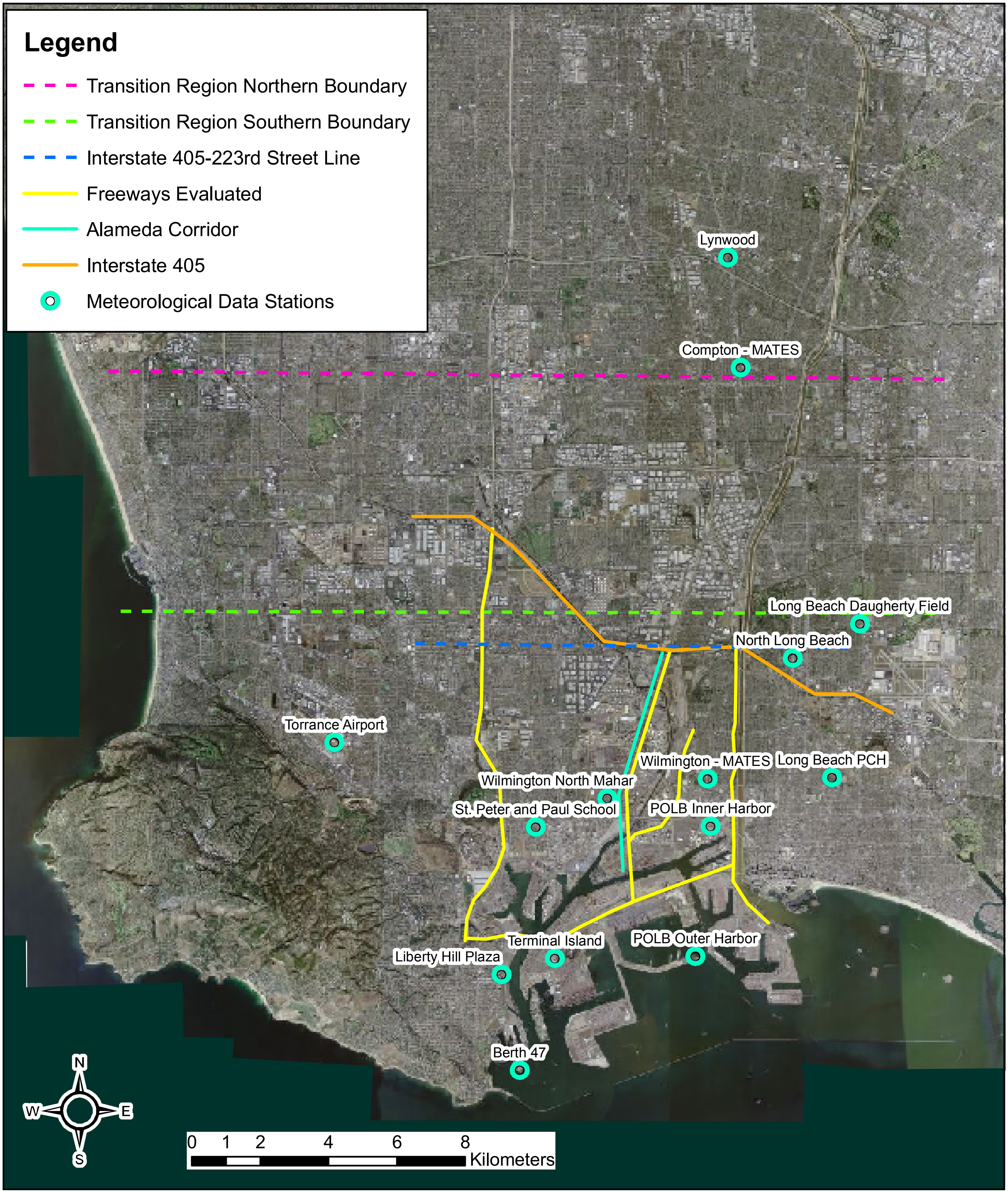
Figure I-A-5: Surface Meteorological Data Transition Region

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# Appendix A:
## Meteorological Data

# APPENDIX A

## A.1 Hourly Surface Meteorological Data Stations

When characterizing near-field air dispersion using models such as AERMOD, representative hourly surface meteorological data inputs are required in order to characterize the atmospheric transport and dispersion in the area to be studied. AERMET, the meteorological preprocessor to AERMOD, requires certain surface meteorological parameters in order to prepare an AERMOD meteorological data input file. The minimum surface meteorological parameters required include wind speed, wind direction, temperature, and cloud cover (United Staes Environmental Protection Agency [USEPA] 2004b). Station pressure is also recommended, but not required, for AERMET (USEPA 2004a). This appendix discusses the availability of such surface meteorological data, the selection criteria used to choose representative surface meteorological data for the Ports and the major freeways and rail line near the Ports, and the results of this selection methodology. The methodologies employed in this selection process were previously approved by the California Air Resources Board (ARB) for air dispersion modeling purposes at the BNSF Watson/Wilmington Rail Yard (ENVIRON 2006), located within one mile of the Ports.[1] Because cloud cover data is only available from national weather service (NWS) stations, the evaluation and treatment of cloud cover data is discussed separately in Section A.5 below.

The dominant terrain features/water bodies that may influence wind patterns in this part of the Los Angeles Basin include the Pacific Ocean to the west, the hills of the Palos Verdes Peninsula to the west/southwest and the San Pedro Bay and shipping channels to the south of the study area. Although the area in the immediate vicinity of the Ports is generally flat, these terrain features/water bodies may result in significant variations in wind patterns over relatively short distances. In order to identify meteorological data stations that may be representative of operations at the Ports and out-of-port emissions on major freeways and the major rail line extending north from the Ports, a comprehensive search was conducted to identify surface meteorological data stations in the vicinity of the Ports. Databases of meteorological stations referenced by the USEPA's Support Center for Atmospheric Modeling (SCRAM) website and available from the National Climatic Data Center (NCDC 2006a,b,c) were searched. The database of stations operated by ARB or managed by local agencies and reporting to ARB was also used (ARB 2006a). Meteorological stations that contain wind speed, wind direction, temperature, and pressure data that may be appropriate for air dispersion modeling located within a 20-km radius of the studied area include four ARB stations, two NCDC/NWS stations, two South Coast Air Quality Management District (SCAQMD) stations, four stations at the Port of Los Angeles, and two stations at the Port of Long beach. Figure I-A-1 shows the locations of the fourteen meteorological stations in the vicinity of the Ports and the freeways near the Ports. Meteorological data from the most recent five years were obtained, where available, from each

[1] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

of the stations identified above. For stations that had less than five years of data available, the longest possible time period for which complete data were available was used in the evaluation. Wind flow patterns at each of the stations are shown in Figure I-A-2.

## A.2 Hourly Surface Meteorological Data Selection for On-Port Emission Sources

ENVIRON evaluated the fourteen meteorological stations located within a 20-km radius of the Ports with at least one year of quality-checked meteorological data to select surface meteorological data that are representative of conditions at the Ports.[2,3] ENVIRON evaluated the relative location of each station to the Ports, the data quality, and the wind patterns at each station as compared to the general wind patterns in the vicinity of the Ports when evaluating each station. ENVIRON also evaluated the data quality (e.g., completeness and quality assurance reports) and monitor siting against USEPA guidelines (USEPA 2000) based on available information. ENVIRON previously evaluated each of these stations based on criteria significant to dispersion modeling (e.g. representativeness, proximity to emissions sources, and proximity to terrain features) during the meteorological data selection process for the BNSF Watson/Wilmington Rail Yard (ENVIRON 2006), which was previously approved by ARB.[4] The remainder of this section describes the results of ENVIRON's evaluation.

From May 2001 through July 2002, ARB operated a Wilmington station (Wilmington North Mahar) as part of a Special Community Air Quality Monitoring Study (ARB 2003a). ARB used the meteorological data from this station in their diesel exhaust particulate matter (DPM) Exposure Assessment for the port area (ARB 2006a). [Note that data from the Port of Los Angeles sites were not available at the time for use in the ARB (2006a) study.] This report states that the Wilmington North Mahar station was chosen rather than the North Long Beach station because it is closer to the combined ports area and the data is more recent. It should be noted that the ENVIRON analyses described above (ENVIRON 2006) chose not to recommend the Wilmington North Mahar station because requested wind speed data for this station was provided in vector-averaged format and this format is discouraged by USEPA and ARB Memorandum of Understanding (MOU) modeling guidelines (USEPA 2000; ARB 2006b).

The Torrance Municipal Airport station, located approximately eight kilometers west of the Ports is situated at the eastern edge of the Palos Verdes Hills. The wind flow patterns at the Torrance Municipal Airport station appear to reflect channeling of the winds parallel to these hills. Therefore, the Torrance Municipal Airport station was eliminated from further consideration.

[2] The SCAQMD Lynwood and Compton-MATES stations were not evaluated as part of the meteorological data evaluation for the on-port emission sources as these stations are located more than 10 km from the Ports.
[3] The two meteorological stations operated by the Port of Long Beach – Gull Park and Super Block-east began collecting data since September 1, 2006. Current evaluation of these two stations was based on data collected between September 1, 2006 and June 30, 2007. An updated evaluation will be performed once a complete year of data has arrived for these two stations.
[4] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

Of the four remaining NCDC/NWS stations and ARB stations, all of the stations except the North Long Beach station exhibited a significant component of the winds (20% to 35%) blowing from the northwest. The North Long Beach Station wind rose shows only a small component of winds blowing from the northwest (approximately 3%), with predominant winds from the west and southwest. According to USEPA meteorological monitoring guidance (USEPA 2000), sensors for wind speed and wind direction should be located at a distance at least ten times the height of nearby obstructions. An inspection of photographs[5,6] of this meteorological station indicated that buildings located approximately 100 meters to the northwest of the station and 90 meters to the south/southwest of the building may be obstructing winds from the northwest and south/southwest, respectively. Figure I-A-3 shows the location of the North Long Beach station and the outline of these two buildings in the vicinity of the station. Based on this evaluation, the North Long Beach station was eliminated from further consideration.

NCDC recommended the Long Beach Daugherty Field station as the most complete NCDC station in the vicinity of the Wilmington Yard[7], located within one mile of the Ports. However, the Long Beach Daugherty Field wind rose exhibited almost twice as many hours with calm winds (approximately 28% of all hours for the five year period 2000 plus 2002 to 2005) when compared to the other stations under consideration (approximately 2% for Wilmington-North Mahar, 3% for Wilmington-Multiple Air Toxics Exposure Assessment (MATES), 4% for Long Beach-East Pacific Coast Highway, and 3% for SPPS stations). In addition, the wind speed distribution for the Long Beach Daugherty Field station appeared to show a higher frequency of high-speed winds than the other stations under consideration. Most importantly, the Long Beach Daugherty Field station is much farther from the Ports than the other stations considered in this evaluation. Therefore, wind patterns and speeds at the Long Beach Daugherty Field station are likely to be the least representative of the conditions at the Ports. Based on the station's relative distance from the Ports, the relatively high percentage of calms and higher frequency of high-speed winds at the Long Beach Daugherty Field, this station was eliminated from further consideration for all surface measurements except cloud cover.

According to SCAQMD, meteorological data collected at the Wilmington-MATES and Long Beach-East Pacific Coast Highway stations have not been quality-assured/quality-checked by ARB or SCAQMD. In addition, wind speed data for the Wilmington-MATES station were provided in vector-averaged format, which is discouraged by USEPA modeling guidelines (USEPA 2000). Because the meteorological data at these two stations have not been quality-assured, and vector-averaged format is not recommended by USEPA or ARB, the Wilmington-MATES and Long Beach-East Pacific Coast Highway stations were eliminated from further consideration.

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[5] http://www.arb.ca.gov/qaweb/photo_view.php?file=0570072-tationw.jpg&site_no=70072&date=05&caption=Looking%20West%20from%20the%20probe.

[6] http://www.arb.ca.gov/qaweb/photo_view.php?file=0470072-stations.jpg&site_no=70072&date=04&caption=Looking%20South%20from%20the%20probe.

[7] Personal Communication. William Brown of NCDC by telephone to C. Mukai of ENVIRON on May 5, 2006.

Four air quality monitoring stations operated by the Port of Los Angeles collect meteorological data in the vicinity of the Port of Los Angeles (POLA) as part of the POLA Terminal Improvement Project monitoring program.[8] The Port of Long Beach also operates two meteorological stations.[9] The wind flow patterns at each of these six meteorological monitoring stations are displayed as period-average wind roses in Figure I-A-4. The period-average wind roses for the four POLA stations are based on the most complete one year of data since the stations began operating in 2005. The period-average wind roses for the two Port of Long Beach (POLB) stations are based on data collected between September 1, 2006 and June 30, 2007. There may be differences once a full year of data have been collected due to potential seasonal differences. As shown in Figure I-A-4, the "SPPS", "TITP", "Liberty Hill Plaza", "Super Block" stations are all located in the central or northern area of the harbor. The SPPS, TITP, and Super Block stations are located on flat terrain, and wind patterns at these stations may be representative of winds at Port leaseholders inland or in the mid-harbor. The "Liberty Hill Plaza" station, located on the eastern edge of the Palos Verdes Hills, may be representative of winds at Port leaseholders very close to this station.

Two other potentially important stations are the Port of Los Angeles "Berth 47" station, and the Port of Long Beach "Gull Park" station, which are both situated in the outer harbor and may be representative of meteorology affecting plumes of ships entering and leaving the port. Outer harbor wind patterns are very different than wind patterns closer to the port-area and port-area receptors. As seen in Figure I-A-4, the wind rose for Berth 47 indicates different wind patterns than those at the other four Port of Los Angeles and Port of Long Beach stations but similar to the Port of Long Beach Gull Park Station. Specifically, the wind rose indicates that patterns characterized by higher wind speeds and less variation in direction than patterns further inland. Further discussion of these two stations is provided in Section A.4

Based on the ENVIRON's review of available meteorological data near the Ports, discussed above and in ENVIRON's meteorological analysis for the BNSF Wilmington Yard (ENVIRON 2006), six meteorological stations were selected as candidates to represent meteorological conditions for on-Port sources:

- Port of Los Angeles- SPPS
- Port of Los Angeles-Liberty Hill Plaza
- Port of Los Angeles- TITP
- Port of Los Angeles-Berth 47
- Port of Long Beach-Gull Park
- Port of Long Beach-Super Block

[8] Los Angeles Harbor Department. http://www.portoflosangeles.org/AQ_Monitoring/Workplan.pdf
[9] Port of Long Beach. http://www.polb.com/environment/air_quality/air_monitoring.asp

## A.3 Hourly Surface Meteorological Data Selection for Land-Side Out-of-Port Emission Sources

Due to the increase in air dispersion modeling uncertainty associated with the use of multiple meteorological stations with different predominant wind directions, ENVIRON evaluated the geographical area over which Port-representative meteorological data (e.g., data from SPPS and TITP) were also representative of out-of-port emissions from trucks on major freeways (i.e., Interstates 110 and 710 and Highways 47 and 103) and the major rail line (i.e., the Alameda Corridor) extending north from the Ports. As part of this evaluation, two additional stations north of the Ports, Compton-MATES and Lynwood, operated by SCAQMD, were identified and evaluated in addition to the twelve meteorological stations described above. The period-average wind roses for Lynwood and Compton-MATES stations are displayed in Figure I-A-2.

As discussed above, the dominant terrain features/water bodies that may influence wind patterns in this part of the Los Angeles Basin include the Pacific Ocean to the west, the hills of the Palos Verdes Peninsula to the west/southwest, and the San Pedro Bay and shipping channels to the south. As indicated in Figure I-A-2, the meteorological data stations to the west of the Palos Verdes Hills and within approximately 5 kilometers of the San Pedro Bay (i.e., SPPS, TITP, Wilmington-North Mahar, Wilmington-MATES, Long Beach-East Pacific Coast Highway, and Long Beach Airport) generally exhibit predominant winds from the northwest and from the south or southeast. The consistency of the predominant winds among these stations indicate that the Palos Verdes Hills are channeling the winds from the northwest and that the San Pedro Bay and shipping channels influence the winds from the south and southeast. As discussed above, other nearby stations that do not show these patterns may be influenced by additional factors. For instance, the Torrance Airport station is located within one kilometer (km) of the Palos Verdes Hills and on the north side of the hills (i.e., the influence of the San Pedro Bay is blocked by the hills), thus the predominant winds are only from the northwest. The Berth 47 station is located at the southern tip of the POLA, where the winds appear to be heavily influenced by the San Pedro Bay and predominant winds are from the southwest. At the North Long Beach station, two buildings located to the northwest and south/southwest of the buildings may be obstructing winds from these directions, as described in Section A.2.

As indicated in Figure I-A-2, the Lynwood and Compton-MATES stations, located further to the north and out of the region of influence of the both the Palos Verdes Hills and the San Pedro Bay, exhibit different wind patterns than those stations that are within approximately 10 kilometers of these terrain features/water bodies. The predominant wind directions at these two stations are from the west and southwest, indicating that on-shore flow is the dominant influence on the wind patterns in the area around these stations.

As indicated in Figure I-A-2, there is a large geographical area between the Long Beach area meteorological stations, which exhibit predominant winds from the northwest and south/southeast, and the Lynwood and Compton-MATES meteorological stations which exhibit predominant winds from the west and southwest, where there are no meteorological data stations. Thus, the transition region where wind patterns shift from the northwest and south/southeast (i.e., in the Long Beach area) to the west/southwest (i.e., the Compton/Lynwood area) is currently not well defined. However, the locations of the meteorological data stations, aerial photographs, and topographical maps may be used to approximate the northern and southern extents of this transition region. As shown in Figure I-A-5, the southern boundary of this transition region may be approximated by the Long Beach Airport meteorological data station (i.e., just to the north of the north edge of the Palos Verdes Hills), and the northern boundary of the transition region may be approximated by the location of the Compton-MATES meteorological station. The boundaries of this transition region are likely conservative (i.e., the transition region is likely not as wide as indicated in Figure I-A-5).

As discussed above, due to the absence of surface meteorological data stations between the northern edge of the Palos Verdes Hills and the City of Compton, a more precise determination of the area over which the predominant wind directions change cannot be made. Therefore, ENVIRON has assumed that a shift in wind patterns likely occurs in a transition area north of the approximate east-west line created by Interstate 405 and 223rd Street in the northern part of Long Beach (see Figure I-A-5). Because all of the Long Beach area stations indicate the same general wind patterns (i.e., predominant winds from the northwest and south/southeast), and due to the data quality issues identified for most of the other stations identified in Section A.2, ENVIRON has assumed that the Port of Los Angeles-SPPS meteorological station or Port of Long Beach-Super Block may be used as a representative meteorological data set for the out-of-Port truck emissions on major freeways and locomotive emissions on the Alameda Corridor to the south of the east-west line approximated by Interstate 405 and 223rd Street in the northern part of Long Beach.

## A.4 Hourly Surface Meteorological Data Selection for Ocean-Side Emission Sources

ENVIRON also evaluated off-shore meteorological stations which might be representative of ocean-side emission sources. The stations considered in this evaluation were the Berth 47 Station, located at the southern tip of the Port of Los Angeles in the outer harbor, the Santa Monica Station, located in open ocean approximately 70 kilometers west of the Ports, and the Avalon Catalina Airport, located on Catalina Island as shown in Figure I-2. Figure I-4 shows wind flow patterns for these three stations. As discussed in section A.3, the Berth 47 station appears to be strongly influenced by the San Pedro Bay. The wind patterns observed there differ in both characteristic direction and wind speed from the nearby stations further inland and are characterized by higher wind speeds and directional consistency. The wind rose for the Avalon Catalina station also indicates high wind speeds generally blowing from west-south-west. Although five years of meteorological data were available from the Avalon Catalina Airport Station, the data do not meet the minimum completeness criteria for air dispersion modeling purposes. However, the wind-rose for the Avalon Catalina Station confirms that the Berth 47 wind patterns are representative of those seen by ocean-side sources between Catalina Island and the Ports. An examination of the wind-rose for the Santa Monica Station indicates that the wind is more variable in direction than the pattern at the Berth 47 Station with a higher frequency of winds blowing parallel to or away the shoreline. Since the Santa Monica Station has a higher frequency of winds that are parallel or away from the shoreline, air dispersion modeling using meteorological data from the Santa Monica Station may result in lower concentrations at over-land receptors. In addition, the Santa Monica station is far from the Ports. However, the higher wind speeds at this buoy confirms the expectation of higher wind speeds in the area outside of the Ports breakwater. In cases in which the modeling domain extends into the area near to this buoy, further project-specific consideration could be given to this station. Based on the above evaluation, ENVIRON selected the Port of Los Angeles Berth 47 station as representative of the wind patterns at off-shore locations outside of the Ports breakwater.

## A.5 Cloud Cover Data Selection

In general, most non-NWS stations do not collect cloud cover, but AERMET, the meteorological preprocessor to AERMOD, requires cloud cover data. Therefore, since cloud cover data was not available for the station identified as the most representative for the Ports area in the other required surface parameters, the nearest available cloud cover data from an NWS station was selected for use. The substitution of data from a nearby NWS station into an incomplete set of otherwise more representative data is an option in the AERMET preprocessor algorithm (USEPA 2004a). In addition, substitution of nearby cloud cover data was approved by ARB.[10]

The nearest NCDC/NWS stations with available cloud cover data are located at Torrance Airport and Long Beach Daugherty Field. Figure I-A-1 shows the locations of these two stations with respect to the Ports area. The Long Beach Daugherty Field station is located approximately twelve kilometers to the northeast of the Ports, and the Torrance Municipal Airport station is located approximately ten kilometers to the northwest of the Ports at the eastern edge of the Palos Verdes Hills. Due to the potential for coastal fog conditions and the effects of the Palos Verdes Hills at the Torrance Airport, measurements of cloud cover at Long Beach Daugherty Field are likely more representative of cloud cover conditions in the vicinity of the Ports. NCDC also recommended the use of surface meteorological data from Long Beach Daugherty Field over Torrance Municipal airport due to the completeness and quality of the Long Beach Daugherty Field data.[11] Based on NCDC's recommendation and the potential for coastal fog conditions at the Torrance Municipal Airport, cloud cover data from the Long Beach Daugherty Field station should be merged with the surface data from the surface meteorological data stations identified above.

[10] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.
[11] Personal communication. William Brown of NCDC by telephone to Catherine Mukai of ENVIRON. 2006.

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# Attachment II:

## Surface Parameter Analysis for Berth 47 Surface Meteorological Station

# Attachment II:

## Surface Parameter Analysis for Berth 47 Baseline Bay-Wide Regional Human Health Risk Assessment for Diesel Exhaust Particulate Matter (DPM)

# Contents

# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | American Meteorological Society/Environmental Protection Agency Regulatory Model |
| ARB | Air Resources Board |
| BWHRA | Bay-Wide Health Risk Assessment |
| Ports | Port of Los Angeles and Port of Long Beach |
| USEPA | US Environmental Protection Agency |
| USGS | United States Geological Survey |

# 1 Introduction

AERMOD requires a meteorological input file to characterize the transport and dispersion of pollutants in the atmosphere. Surface and upper air meteorological data inputs as well as surface parameter data describing the land use and surface characteristics near the site are first processed using AERMET, the meteorological preprocessor to AERMOD. The output file generated by AERMET is the meteorological input file required by AERMOD. Details of AERMET and AERMOD meteorological data needs are described in USEPA guidance documents (United States Environmental Protection Agency [USEPA] 2004a,b). This attachment describes one key aspect of the AERMET analysis for Berth 47: the surface parameter evaluation. ENVIRON proposes to modify standard USEPA guidance (USEPA 2004a) to account for a several orders-of-magnitude change in surface roughness for shoreline meteorological stations as described in "Wind Flow and Vapor Cloud Dispersion at Industrial and Urban Sites" (Hanna and Britter 2002). This proposed modification would be applied only to Berth 47 (and Gull Park when sufficient data are available) as other Port of Los Angeles and Port of Long Beach (collectively referred to as the Ports) stations are sufficiently inland from a clear water/land interface.

Due to the large difference in surface parameters between water and land, the use of meteorological data from stations located near the shoreline may require a more detailed land use analysis than for a station in a more homogenous area, as described in Hanna and Britter (2002). The division of the surface parameter analysis area into radial sectors does not account for transitions in surface parameters that occur normal to the sector boundaries. In such cases, applying a distance weighted average based on zones defined in the radial direction from the meteorological station can result in surface roughness estimates which, when used for dispersion modeling applications, produce more representative results. In practice, changes of several orders of magnitude in surface roughness most frequently occur in transitions between water and land. In the AERMOD model, land-use analysis is also performed such that concentrations estimated in a sector downwind of a source are based on surface characteristics upwind from the source. However, for shoreline sources, the assignment of surface parameters to such a mixed-use sector containing significant amounts of both land and water based on upwind surface characteristics can significantly over or under predict concentrations depending on the configuration of the land-use, sources, and receptors. The approach adopted in by Hanna and Britter (2002) only includes the effects of roughness downwind of the source, because the distance to achieve a new equilibrium boundary layer is typically much less than distances of interest.

## 2 Surface Parameter Evaluation Methodology

Prior to running AERMET, it is necessary to specify the surface characteristics for the meteorological monitoring site and/or the project area. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004a) and require the evaluation of nearby land use and temporal impacts on these surface parameters. USEPA (2005) and Air Resources Board (ARB) recommend use surface parameters specified for the area surrounding the meteorological monitoring site, rather than the project area, for AERMET. However, an analysis may be necessary to determine whether the area surrounding the meteorological monitoring site is representative of the area surrounding the project area. Because the Berth 47 meteorological station is within the boundary of the Outer Harbor Zone of the Ports, where its surface meteorological data are determined to be representative, the area surrounding the meteorological station overlaps with the area surrounding project area. In addition, the land use pattern surrounding the Berth 47 station is very similar to the land use pattern in the Outer Harbor Zone. Therefore, surface parameters calculated for the Berth 47 meteorological station should be representative of many areas in the Outer Harbor Zone.

In general, ENVIRON determined radial land-use sectors around the meteorological monitoring site using United States Geological Survey (USGS) land cover maps in conjunction with recent aerial photographs. ENVIRON then specified surface parameters for each sector using default seasonal values adjusted for the local climate as allowed under USEPA guidance (USEPA 2004a). When a radial land-use sector consisted of multiple land-use types, ENVIRON, in general, used an area-weighted average of each surface parameter as recommended by USEPA (2004a) with a few exceptions as noted below. Because of the meteorological monitoring station's proximity to the shoreline, ENVIRON made additional considerations of the appropriateness of using default methods in assigning surface roughness to radial sectors surrounding the facility. The locale-specific surface parameters used in this evaluation were described in an ENVIRON report to ARB (ENVIRON 2006).

Table 1 gives land use type breakdown surrounding the Berth 47 Met Station. Urban and water land uses contribute to over 99% of the land use in the surrounding area (3-kilometer [km] buffer):

**Table 1: Land Use Surrounding Berth 47 Met Station**

| US EPA Class (Grid Code) | Land Use | AREA (m2) | % of Total |
|---|---|---|---|
| 4 | Desert Shrubland | 63,095 | 0.22% |
| 5 | Grassland | 69,490 | 0.25% |

| Table 1: Land Use Surrounding Berth 47 Met Station | | | |
|---|---|---|---|
| **US EPA Class (Grid Code)** | **Land Use** | **AREA (m2)** | **% of Total** |
| 7 | Swamp | 125,365 | 0.44% |
| 8 | Urban | 11,337,630 | 40.08% |
| 9 | Water | 16,690,399 | 59.01% |
| Sources: USGS 2007, USEPA 2004a | | | |

Table 2 displays the surface roughness characteristics by land use type. Urban and water are most predominant around the Outer Harbor Zone of the Ports, and do not vary by season:

| Table 2: Surface Roughness Characteristics by Land Use Type | | | | |
|---|---|---|---|---|
| **Land Use** | **Surface Roughness** | | | |
| | **Spring** | **Summer** | **Summer/Autumn** | **Autumn** |
| Coniferous Forest | 1.3 | 1.3 | 1.3 | 1.3 |
| Cultivated Land | 0.03 | 0.2 | 0.13 | 0.05 |
| Deciduous Forest | 1 | 1.3 | 1.05 | 0.8 |
| Desert Shrubland | 0.30 | 0.30 | 0.30 | 0.30 |
| Grassland | 0.05 | 0.1 | 0.06 | 0.01 |
| Mixed Forest | 1.150 | 1.300 | 1.175 | 1.050 |
| Swamp | 0.2 | 0.2 | 0.2 | 0.2 |
| Urban | 1 | 1 | 1 | 1 |
| Water | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Sources: USEPA 2004a | | | | |

In general, USEPA-default land-use analysis is performed such that concentrations estimated in a sector downwind of a source are based on surface characteristics upwind from the source. However, for shoreline sources, sectors can be comprised of both land and water, where land-use types can vary by as much as three orders of magnitude in surface roughness as evidenced by Table 1 above. The assignment of surface parameters to such a mixed-use sector containing significant amounts of both land and water based on upwind surface characteristics can significantly over- or under-predict concentrations depending on the configuration of the land-use, source, and receptors (ENVIRON 2007). The approach adopted in Hanna and Britter (2002) only includes the effects of roughness downwind of the source, because the distance to achieve a new equilibrium boundary layer is typically much less than distances of interest, as is the case for the Bay-Wide Health Risk Assessment (BWHRA) where the modeling domain is 20 km by 20 km. Thus, for the Berth 47 Met Station, ENVIRON modified USEPA guidance and performed an evaluation of the assignment of upwind or downwind land-use patterns for each sector as recommended by Hanna and Britter (2002) to account for this physical factor.

Figure 1 shows the sectors ENVIRON defined around the Berth 47 Station for use in the AERMET processing and the USEPA land-use types within each sector. Before assigning surface parameters for each sector, ENVIRON evaluated the appropriateness of using land-use characteristics upwind of the source for estimating concentrations downwind of the source:

- **Sector 5:** Concentrations estimated in Sector 5 are based on winds flowing from Sector 2. Sector 2 is almost all water while Sector 5 is almost entirely urban in land use. Since the surface roughness differences between the upwind and downwind sectors are potentially more than two orders of magnitude in difference, concentrations in Sector 5 could be significantly overestimated if concentrations in these sectors were estimated using land-use upwind of the source. Thus, land-use characteristics for concentrations estimated for Sector 5 are based on land-use downwind of the source using the methodology of Hanna and Britter (2002).
- **Sectors 2 and 3:** Concentrations estimated in Sectors 2 and 3 are based on winds flowing from the Sectors 5 and 6, respectively. Sector 5 is almost entirely urban in land use while Sector 2 is almost all water. Sector 6 also has significant portion of land while Sector 3 is almost all water. Using land-use parameters upwind of the source to calculate concentrations at receptors downwind of the source could inappropriately take into account the amount of land in Sectors 5 and 6 and thus under-predict concentrations at potentially water-based receptors. Hence, land-use parameters downwind of the source are used to calculate concentrations at receptors in Sectors 2 and 3 using the methodology of Hanna and Britter (2002).
- **Sector comprised of Sub-sectors 6a through 6o [Assuming Hanna and Britter Distance-Weighted Analysis]:** Concentrations estimated in Sector 6 are based on winds flowing from Sector 3. Sub-sectors 6a through 6o have significant portions of land while Sector 3 is almost entirely water. Since the surface roughness differences between the upwind and downwind sectors are significant, concentrations in Sector 6 could be overestimated if concentrations in these sectors were estimated using land-use upwind of

the source. Thus, land-use characteristics for concentrations estimated for Sector 6 are based on land-use downwind of the source using the methodology of Hanna and Britter (2002). In addition, receptors representing populations being evaluated in the BWHRA are likely to be located beyond the outer parts of Sector 6. Winds going to this portion will have traveled over a significant stretch of land before reaching these receptors. Thus using downwind surface parameters for these receptors would take into account the land characteristics that the wind would travel across before reaching the receptors, as per the Hanna and Britter method (2002) discussed above.

- **Sectors comprised of Sub-sectors 1a through 1o, and Sub-sectors 4a through 4o [Assuming Hanna and Britter Distance-Weighted Analysis]:** Concentrations estimated in Sectors 1 and 4 are based on winds flowing from the Sectors 4 and 1, respectively. Land-use in Sector 1 and 4 are somewhat similar, with a stretch of water close to the center of the 3-km radius, a significant portion of in the middle of the sector, and area of water at the outer part of the sector. However a closer investigation revealed that the stretch of water close to the center of the 3-km radius in Sector 1 extends much further than that in Sector 4. Thus winds going to Sector 1 will have traveled over longer distance of water before reaching the receptors compared to Sector 4. Therefore using land-use characteristics downwind for these receptors would take into account the land-use characteristics that the wind would travel across before reaching the receptors, as per the Hanna and Britter method (2002) discussed above.

Another consideration made for the Berth 47 Met Station is that the division of the project area into radial sectors does not account for transitions in surface parameters that occur normal to the sector boundaries. Specifically, analyses of the effect of cross-wind transitions in surface roughness [the surface parameter that can influence AERMOD predicted airborne concentrations most significantly (ENVIRON 2005; Long et al. 2004)], indicate that changes more than two orders of magnitude (e.g., transitions between water and land) can result in significant over-estimates or under-estimates of concentrations (Hanna and Britter 2002). As discussed above, applying a distance-weighted average based on zones defined in the radial direction from the project area can result in surface roughness estimates which, when used for dispersion modeling applications, produce more representative results. The sectors comprised of sub-sectors 1a – 1o, 4a – 4o, and 5a – 5o are the three sectors in this analysis that have a significant transition in surface parameters that occurs normal to the sector boundaries and contains receptors such that concentrations predicted would be significantly impacted by this arrangement (i.e. downwind receptors). Thus, ENVIRON employed a distance-weighted average for the calculation of the surface roughness for these sectors using the methodology suggested by Hanna and Britter (2002) for sectors with surface roughness that varies a few orders of magnitude in the radial direction. Distance-weighting is not required for sectors that are relatively homogeneous or do not have surface roughness varying by a few orders of magnitude, as is the case for Sectors 2, 3, and 5 shown in Figure II-1.

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# Appendix B:

## Air Dispersion Modeling Supplemental Information

# Appendix B:

## Air Dispersion Modeling Supplemental Information

# Contents

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# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | American Meteorological Society/Environmental Protection Agency Regulatory Model |
| ARB | Air Resources Board |
| BWHRA | Bay-Wide Health Risk Assessment |
| CEQA | California Environmental Quality Act |
| CHE | Cargo Handling Equipment |
| DEM | Digital Elevation Maps |
| DPM | Diesel Particulate Matter |
| HDV | Heavy-duty Vehicle |
| HRA | Health Risk Assessment |
| MSA | Metropolitan Statistical Area |
| NAS | Naval Air Station |
| NED | National Elevation Dataset |
| NRC | National Research Council |
| NWS | National Weather Service |
| OGV | Ocean-going Vessels |
| POLA | Port of Los Angeles |
| POLB | Port of Long Beach |
| PMI | Point of Maximum Impact |
| Ports | Port of Los Angeles and Port of Long Beach |
| SCAQMD | South Coast Air Quality Management District |
| SPPS | St. Peter and Paul School |
| Starcrest | Starcrest Consulting, LLC |
| TITP | Terminal Island Treatment Plant |
| TWG | Technical Working Group |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |

# 1 Air Dispersion Modeling Supplemental Information

The Bay-Wide Health Risk Assessment (BWHRA) Tool is based on a Protocol developed specifically for this assessment (Appendix A), which describes the methodology that is used in the BWHRA Tool. Some details that were not available at the time the Protocol was developed, but which are necessary for the air dispersion modeling are discussed in this Appendix. In addition, deviations from the Protocol document are discussed briefly in Section 3 of the main report with further details provided in this Appendix. Finally, key uncertainties and crucial assumptions associated with the air dispersion modeling are discussed in this Appendix.

This Appendix includes details not included in the main report or the Protocol on source characterization and parameters, source placement (including variations between 2005 and 2020), temporal emission factors, terrain, and meteorological data requirements. This Appendix also includes a brief discussion of recent changes in AERMOD guidance and their potential impact on the BWHRA Tool results.

## 1.1 Source Characterization and Parameters

### 1.1.1 Description of Source Allocation

ENVIRON used information provided by Starcrest Consulting, LLC (Starcrest) and the Port of Los Angeles and Port of Long Beach (collectively referred to as the Ports) in order to spatially allocate the different emissions sources into configurations that are appropriate for the air dispersion modeling. The following is a summary of the spatial allocations and parameters used for each source group. The allocation for each source group is based on spatial information provided by Starcrest, which ENVIRON evaluated and confirmed with aerial photos. Table B-1 shows the specific source parameters (depending on the modeled source type these can include the following: stack heights, release heights, initial vertical dimension, initial lateral dimension, temperature, exit velocity, and diameter) used for each source category. Figures B-1 through B-23 present locations of the points/volumes/areas representing each source category in the air dispersion model for both the 2005 and 2020 scenarios.

#### 1.1.1.1 Ocean-Going Vessel

*OGV – At Berth (Figure B-1)*

The coordinates of the ocean-going vessel (OGV) berth locations were provided by Starcrest. The berth locations are all located within the Ports' harbors adjacent to land. ENVIRON used point sources to represent this stationary emissions source group. Source parameters are based on the California Air Resources Board (ARB) exposure assessment of the Ports (ARB 2006a).

*OGV – Anchorage (Figures B-2)*

ENVIRON used area sources to represent the OGV anchorage areas provided by Starcrest. These areas are located south and slightly east of the central Ports area. Source parameters are based on typical parameters for ships based on the ARB exposure assessment of the Ports (ARB 2006a)[1]. Initial vertical dimensions were calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

*OGV – Maneuvering (Figures B-3, B-4)*

ENVIRON used consecutive volume sources to represent the OGV maneuvering emissions from the Starcrest-provided maneuvering paths within the Ports. The volume sources serve the function of line sources in AERMOD. Following ARB guidance (2006a), ENVIRON spaced volume sources 160 meters apart throughout the in-Port maneuvering paths. For narrow maneuvering paths, volume sources are reduced in size to fit the channel widths and 160-meter spacing was retained. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

*OGV – Transit (Figures B-5, B-6)*

As with maneuvering sources, ENVIRON used consecutive volume sources to represent the OGV transit emissions from the Starcrest-provided shipping lanes outside of the Ports. Following ARB guidance, ENVIRON spaced volume sources 800 meters apart throughout the shipping lanes. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

#### 1.1.1.2 Harborcraft

*Harborcraft – Maneuvering (Figures B-7, B-8)*

ENVIRON used consecutive volume sources to represent the harborcraft maneuvering emissions from the Starcrest-provided maneuvering paths within the Ports. Following ARB guidance, ENVIRON spaced volume sources 160 meters apart throughout the in-Port maneuvering paths. For narrow maneuvering paths, volume sources are reduced in size to fit the channel widths and 160-meter spacing was retained. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

*Harborcraft – Transit (Figures B-9, B-10)*

As with maneuvering sources, ENVIRON used consecutive volume sources to represent the harborcraft transit emissions from the Starcrest-provided shipping lanes outside of the Ports. Following ARB guidance, ENVIRON spaced volume sources 800 meters apart throughout the shipping lanes. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

[1] OGV anchorage was not modeled for the ARB exposure assessment of the Ports. ENVIRON instead used source height for OGV maneuvering sources modeled in the ARB assessment.

*Harborcraft – Area (Figures B-11 through B-13)*

Certain types of harborcraft vessels do not travel in defined shipping lanes, rather these vessels can travel in a broad areas surrounding the ports. Starcrest-provided ENVIRON with specific areas over which these harborcraft vessels can operate. ENVIRON conservatively modeled these sources as area sources due to the undefined nature of their travel. The release height for the vessels is also provided by ARB (2006a). Initial vertical dimensions are calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

#### 1.1.1.3 Rail

*Rail – Off-Port, Port of Los Angeles (POLA) On-Port, Port of Long Beach (POLB) On-Port (Figures B-14 through B-16)*

ENVIRON used consecutive volume sources to represent the off-port and on-port rail emissions from the Starcrest-provided rail segments. When the given rail segments pass over an area with multiple separated rail tracks, volumes are placed over the individual tracks so as not to include the non-rail activity spaces between tracks. However, when the given rail segments pass over an area with multiple adjacent rail tracks with only small separation between tracks, a single set of larger volumes is used to cover the entire activity area.

The sizing and spacing of volume sources varied between rail segments. ENVIRON used volume sources sized to visually fit the width of the tracks and determined the spacing based on the volume sizes. Volumes are spaced a minimum of 50 meters apart, with spacing increasing in 25-meter increments above 50 meters. Each rail segment had constant spacing between volume sources although spacing varied between different segments. Thus, the spacing for each segment is determined by the largest volume source in that segment so that no sources overlapped.

ENVIRON based the release height on the ARB exposure assessment of the Ports (ARB 2006a). The initial vertical dimension is calculated based on the release height following AERMOD guidance for an elevated source not on or adjacent to a building. Following previous ENVIRON reports submitted to ARB, ENVIRON used a conversion factor of 4.3 to calculate the initial vertical dimension. Initial lateral dimensions are also calculated based on volume size divided by 4.3 following AERMOD guidance for a single volume source.

#### 1.1.1.4 On-Road Heavy-Duty Vehicles

*Off-Port and On-Port Road (Figures B-17 through B-19)*

ENVIRON used consecutive volume sources to represent the off-port and on-port on-road Heavy-duty Vehicle (HDV) emissions from the Starcrest-provided road segments. When the given road segments pass over an area with multiple separated roads, volumes are placed over the individual roads so as not to include the non-activity spaces between roads. However, when the given road segments included multiple vehicle lanes, a single set of larger volumes is used to cover the entire activity area.

The sizing of volume sources varies between road segments such that volume sources visually fit the widths of the roads. All volumes were spaced 50 meters apart. Release heights were provided by Starcrest. The initial vertical dimensions are calculated based on the release height following AERMOD guidance for an elevated source not on or adjacent to a building. Initial lateral dimensions are also calculated based on volume size divided by 4.3 following AERMOD guidance for a single volume source.

#### 1.1.1.5 Cargo Handling Equipment and On-Terminal Heavy-Duty Vehicles

*CHE and On-Terminal HDV (Figures B-20 through B-23)*

ENVIRON used area sources to represent the Cargo Handling Equipment (CHE) and HDV on-terminal activities. Terminal areas and specific CHE types and release heights were provided by Starcrest. The release height for the on-terminal HDV was also provided by Starcrest. Initial vertical dimensions are calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

# 2 Source Placement

As described in Section 3 of the report, ENVIRON defined four geographic areas over which the emissions sources operate – Inner Harbor Zone, Middle Harbor Zone, Outer Harbor Zone, and Beyond Breakwater Zone. ENVIRON conducted an in-depth analysis to select specific meteorological dataset for each of the four zones. A detailed description of the approach used to divide the Ports' operational areas into four zones over which individual meteorological stations are applicable is provided in the Sphere of Influence Report included as Attachment I of Appendix A of this report. Sources are then assigned to the areas representing the inner, middle, outer, and beyond breakwater meteorological zones. Sources that fall completely within one zone are assigned to that zone for modeling. If a source falls within multiple zones, ENVIRON uses a “90/10 percent” rule to determine how to assign the source to meteorological zones. The “90/10 percent rule” states that if the length/area of a source within a meteorological zone is less than 10 percent of the length/area of the entire source, this source is assigned to the same meteorological zone as the other 90%; otherwise the source is split at the border of the multiple zones and sub-segments of the source is modeled separately using different meteorological data.

# 3 Variation of Source Allocation between 2020 And 2005

## 3.1 Description of Spatial Changes from 2005 to 2020

Sources are assumed to have identical spatial allocation for both the 2005 and 2023 scenarios except for a few specific land changes associated with the following anticipated projects:

- Cruise Terminal upon entering the Port of Los Angeles (POLA)
- Pacific Energy marine Oil Terminal (POLA)
- China Shipping Addition (POLA)
- Vopak (Port of Long Beach, POLB)
- Pier S (POLB)
- Middle Harbor (Pier D, E, F) (POLB)
- Pier G (POLB)
- Pier J (POLB)
- Pier A (POLB)

In 2020, there are no significant spatial changes for rail (POLA, POLB, and off-port), on-road heavy-duty vehicles (on- and off-port), harborcraft transiting, ocean-going vessels transiting, and ocean-going vessels anchorage. For the sources that did change, this document describes the source spatial changes that result from expected additions, removals, expansions, and reductions of 2005 emissions sources in 2020. ENVIRON received all 2020 spatial allocations from Starcrest; this document describes the changes assumed based on ENVIRON's comparison of the 2020 and 2005 spatial allocations.

### 3.1.1 Ocean-Going Vessels

*OGV – At Berth*

The OGV berth locations are expected to change between 2005 and 2020, in part due to physical changes in the Port configurations. Figure B-1 shows these changes.

*OGV – Maneuvering*

The in-port OGV maneuvering paths are expected to change substantially between 2005 and 2020, in part due to physical changes in the Port configurations. For POLB, a maneuvering path travels through the POLA terminals to reach some POLB terminals. Figures B-3 and B-4 show these changes.

### 3.1.2 Harborcraft

*Harborcraft – Maneuvering*

The in-port harborcraft maneuvering paths are expected to change substantially between 2005 and 2020, in part due to physical changes in the Port configurations. For POLB, a maneuvering path travels through the POLA terminals to reach some POLB terminals. Figures B-7 and B-8 show these changes.

*Harborcraft – Operating Areas*

The harborcraft operating area beyond 50 miles from the port did not change between 2005 and 2020. The operating areas up to 50 miles from the port changed minimally, with a slight reduction in area within the port property. This is due to reconfigurations at POLB. Figures B-11 through B-13 show these changes.

### 3.1.3 Cargo-Handling Equipment and On-Terminal Heavy-Duty Vehicles

*CHE and On-Terminal HDV*

The cargo handling operating areas and on-terminal HDV areas changed due to reconfigurations. Figures B-20 through B-23 show these changes.

# 4 Temporal Emission Factors

Temporal emission factors are used to represent differences in the amount of emissions that occur at different hours or days for a given activity. This allows one to allocate the total emissions according to different times of the day. This is important since meteorological parameters can vary significantly depending on the time of day. ENVIRON observed that for all three stations used in the BWHRA Tool, wind speeds are significantly higher during the daytime hours between 6am and 6pm. The lower wind speeds at night means that there is less dispersion of pollutants and thus higher concentrations close to the emissions sources. During the day, however, higher wind speeds disperse pollutants farther from the sources.

Predominant wind directions also affect the spatial characteristics of concentration profiles. Main wind directions do not vary much at Berth 47, but are significantly different between day and night at the Saint Peter Paul School (SPPS) and Terminal Island Treatment Plant (TITP) stations. Pollutant concentrations will typically move in different patterns during the day and the night because of these wind direction differences. The temporal emission factors allow for more accurate concentration estimates by matching emissions weighting with the different day and night wind speed and direction patterns.

Original temporal emission factors for each source group were provided by ARB (2006a). ENVIRON scaled these proportionally so that the factors summed to 24 hours each day and averaged to 1. The resulting temporal emission factors used in the models are shown in Table B-2.

# 5 Meteorological

AERMOD requires a meteorological input file to characterize the transport and dispersion of pollutants in the atmosphere. Surface and upper air meteorological data inputs as well as surface parameter data describing the land use and surface characteristics near the site are first processed using AERMOD Meteorological Preprocessor (AERMET), the meteorological preprocessor to AERMOD. The output file generated by AERMET is the meteorological input file required by AERMOD. Details of AERMET and AERMOD meteorological data needs are described in United States Environmental Protection Agency (USEPA) guidance documents (USEPA 2004a,b). Since the meteorological data selection and processing methods described in the BWHRA Protocol and the Sphere of Influence Report included as Appendix A of this report, the remainder of this section only briefly describes the following two key aspects of the AERMET analysis: the surface and upper air meteorological data selected and the surface parameter evaluation for BWHRA Tool.

## 5.1 Surface and Upper Air Meteorological Data

The focus of the Health Risk Assessment (HRA) is the characterization of risk in the areas immediately surrounding the Ports and major freeways (i.e., Interstates 110 and 710 and Highways 47 and 103) and rail line (i.e., the Alameda Corridor) extending from the Ports north to approximately Interstate 405. As such, ENVIRON selected meteorological data for air dispersion modeling based upon their spatial and temporal representativeness of conditions in the immediate vicinity of the Ports and the freeways near the Ports. As described in BWHRA Protocol on meteorological data selection and processing methods, ENVIRON defined four geographic area over which the emissions sources operate – Inner Harbor Zone, Middle Harbor Zone, Outer Harbor Zone, and Beyond Breakwater Zone. A detailed description of the approach used to divide the Ports' operational areas into four zones over which individual meteorological stations is applicable is provided in the Sphere of Influence Report included as Attachment I of Appendix A of this report. Meteorological dataset from the following stations are used for modeling sources within each of the four zones:

- Inner harbor – SPPS;
- Middle harbor – TITP;
- Outer harbor – Berth 47; and
- Beyond the breakwater – Berth 47

The most representative available wind speed, wind direction, temperature, and pressure data from each station during the twelve-month period from July 2005 through June 2006 is used in the air dispersion analysis of the BWHRA Tool. ENVIRON used cloud cover data (as the three stations did not record cloud cover data) from the National Weather Service's (NWS's) Long Beach Daugherty Field station for the twelve-month period from July 2005 through June 2006. Upper air data from the San Diego Miramar Naval Air Station (NAS) is used in AERMET processing for the BWHRA Tool.

According to the USEPA, meteorological data used for air quality modeling purposes should be at least 90 percent complete before substitution and contain no data gaps greater than two weeks (USEPA 2000). Since the meteorological datasets meet these criteria and are not 100% complete, substitution of missing meteorological data to obtain a meteorological data file with 100 percent complete data was performed using procedures outlined in Atkinson and Lee (1992). Table B-3 presents the completeness summary of the selected meteorological datasets before substitution and all of the parameters met the completeness criteria. Figure B-24 shows overall wind directions and speeds for the three selected meteorological datasets after substitution.

### 5.1.1 Surface Parameters

Prior to running AERMET, it is necessary to specify the surface characteristics for the meteorological monitoring site and/or the project area. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004a) and require the evaluation of nearby land use and temporal impacts on these surface parameters. Surface parameters supplied to the model are specified for the area surrounding the surface meteorological monitoring sites (i.e., SPPS, TITP, and Berth 47 stations), rather than the project area (the Ports and vicinity area) as recommended by USEPA (2005) and ARB[2]. Because the selected meteorological stations are either on or in very close proximity to the Ports operations and the land use surrounding the meteorological stations is very similar to the land use in each operational zone the individual station is applicable to, surface parameters calculated for the meteorological stations are representative of the operational zone over which the meteorological station is used for modeling.

Detailed information on the process of surface parameter analysis used in this evaluation are described in ENVIRON's BWHRA Protocol (Appendix A of this report). Table B-4 summarizes the sector-specific surface parameters (surface roughness, Albedo, and Bowen ratio) determined for each of the three stations which wasn't available at the time the Protocol was developed.

[2] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

# 6 Terrain and Land Use

Another important consideration in an air dispersion modeling analysis is whether the terrain in the modeling area is simple or complex (i.e., terrain above the effective height of the emission point). ENVIRON used the following United States Geological Survey (USGS) 7.5 Minute digital elevation model (DEMs) information to identify terrain heights within the modeling domain:

- Long Beach (digital)
- Long Beach OES
- San Pedro
- Torrance
- Anaheim
- Inglewood
- La Habra
- Los Alamitos
- Newport
- Seal beach
- Southgate
- Whittier

ENVIRON provided terrain elevation data to the AERMOD model using version 06341 of AERMAP, AERMOD's terrain preprocessor. Due to discontinuities at the boundaries between some of the DEMs, AERMAP is not able to estimate the terrain elevations for 201 receptor locations. Using the known terrain elevation at adjacent receptors, ENVIRON estimated the terrain elevations at these 201 receptors using a linear interpolation methodology.

AERMOD can evaluate the effects of urban heat islands on atmospheric transport and dispersion using an urban boundary layer option. Due to the industrial, commercial, and dense residential land use at the impacted receptors, and consistent with ARB's Ports study (ARB 2006b) and South Coast Air Quality Management District (SCAQMD)'s past practices, the area in the vicinity of the Ports is considered urban. Accordingly, ENVIRON selected the urban boundary layer option. Use of the urban boundary layer option requires both population data and a surface roughness length. Published census data are used that correspond to the Metropolitan Division of the Los Angeles-Long Beach-Glendale area, as recommended by USEPA (2005). ENVIRON used the area-averaged roughness length calculated for a 3-kilometer fetch around each station to capture the influence of the water areas which have a significantly lower surface roughness.

# 7 Uncertainties in Air Dispersion Modeling

There is inherent uncertainty in all risk assessments, with the source(s) of that uncertainty dependent on the specific assumptions and models used to estimate risk (Council on Environmental Quality 1989). Understanding the degree of uncertainty associated with each component of a risk assessment is critical to interpreting the results of that assessment. As recommended by the National Research Council (NRC 1994), [a risk assessment should include] "a full and open discussion of uncertainties in the body of each … risk assessment, including prominent display of critical uncertainties in the risk characterization." The NRC (1994) further states that "when … [reporting] estimates of risk to decision-makers and the public, it should present not only point estimates of risk, but also the sources and magnitude of uncertainty associated with these estimates." Thus, to ensure an objective and balanced characterization of risk and to place the risk assessment results in the proper perspective, the results of a risk assessment should always be accompanied by a description of the uncertainties and critical assumptions that influence the key findings of the risk assessment.

In accordance with the recommendations described above, the key uncertainties and critical assumptions associated with the air dispersion modeling are described below. The uncertainties associated with the health risk estimation are described in Appendix C. The uncertainties associated with the emission estimations used in this BWHRA Tool are provided in Starcrest (2007a,b).

This section discusses the uncertainties associated with the air dispersion modeling performed as part of the BWHRA Tool. This includes uncertainties associated with estimates from air dispersion models, source placement and representation, meteorological data selection, and building downwash. Work on the BWHRA Tool was initiated prior to the release of new AERMOD guidance from USEPA (January 9, 2008 and March, 19, 2009). These guidance changes are not incorporated in the BWHRA Tool and the likely effect of these changes to the BWHRA Tool results are discussed above.

As discussed in Section 3, the USEPA-recommended dispersion model AERMOD was used to estimate diesel particulate matter (DPM) exposure concentrations at off-site receptor locations. This model uses the Gaussian plume equation to calculate ambient air concentrations from emission sources. For this model, the magnitude of error for the maximum concentration is estimated to range from 10 to 40% (USEPA 2005). Therefore, off-site exposure concentrations used in this assessment only represent approximate concentrations. As mentioned above, since the purpose of the BWHRA Tool is to characterize the difference between baseline and future forecast emissions, this does not introduce a large degree of uncertainty for the BWHRA Tool results.

As indicated in the BWHRA Protocol (Appendix A), the purpose of this assessment is to evaluate regional health risks from DPM sources related to Ports activities in order to inform development of the Standard. Therefore, unlike health risk assessments conducted for compliance with California Environmental Quality Act (CEQA), detailed spatial and temporal characteristics of the emissions sources are not used in the BWHRA Tool. Besides these uncertainties associated with source placement and representation, other uncertainties discussed in the following sections result in approximate predictions of DPM concentrations at receptors. Since neither the point of maximum impact (PMI) is needed for the BWHRA Tool nor can it be precisely located, the location of the PMI is not provided.

## 7.1 Source Placement and Representation

The sources in this HRA are generalized both in location and by restricting the analysis to a few major source categories with fleet average characteristics. Consequently, the representation of sources does not reflect the level of specific source category information that would be present in a project-specific HRA. The uncertainty introduced by the generalization of the sources is due to both the uncertainty in the placement of sources and the representation of the source parameters.

Because the BWHRA Tool evaluates only mobile sources, the distribution of emissions during movement in the operational areas is an important source of uncertainty. Unlike fixed stationary sources, emissions from moving sources would occur over a continuum rather than as discrete points. However, regulatory-approved models were originally developed for the evaluation of fixed stationary sources, and the use of a continuum of source locations to model source emissions during movement results in an unacceptably large number (in the tens of thousands) of sources and correspondingly long modeling run times (on the order of months rather than hours or days).

The source placement may introduce uncertainties to the modeled exposure concentrations. First, closer spacing between volume sources may impact the predicted concentrations at receptor locations near the Ports operational areas. Previous sensitivity analyses ENVIRON performed (see Appendix C of ENVIRON's BNSF Commerce/Mechanical Report [ENVIRON 2006]) indicated that concentrations at receptors nearest to the specific emission sources could be over-predicted by at least 10 percent. In addition, distributing on-terminal CHEs and HDVs emission over the entire area of each facility instead of the actual operational area of each facility may potentially increase or decrease the modeled exposure concentrations.

The source parameters (i.e., release velocity and release temperature) used to model OGV hotelling activities are sources of uncertainty. Due to a lack of information on source parameter configurations, ENVIRON followed the methodology of ARB's exposure assessment of the Ports (ARB 2006b) and used the fleet-average source parameters. The use of fleet-average source parameters for activities results in approximate predictions for these sources.

The release heights and vertical dimensions used for movement sources are also sources of uncertainty. ENVIRON followed ARB's exposure assessment of the Ports (ARB 2006b) for release heights of OGVs, HCs, and locomotives. ENVIRON also used typical equipment class-specific release heights of CHEs and HDVs provided by Starcrest. These equipment class-specific release heights can vary among individual pieces of equipment also. It was not clear to ENVIRON whether the adopted release heights had been adjusted to include nominal plume rise. Thus, the use of these release heights and associated vertical dimensions results in approximate predictions of receptor-specific DPM concentrations for these sources.

## 7.2 Meteorological Data Set

Uncertainty also exists in the meteorological data used in the AERMOD air dispersion model. These uncertainties are related to the use of multiple meteorological stations for the modeling, the combination of surface data from two meteorological stations, substitution of missing meteorological data, calculation of surface parameters for the meteorological station as opposed to the Ports operational areas, and use of a single year of meteorological data to calculate long-term average concentrations. Recent USEPA AERMOD guidance changes affect meteorological processing methodologies which were not included in this BWHRA Tool, in that the BWHRA Tool was partially completed at the time of the release of that guidance (January 9, 2008). The likely impact of these changes to guidance is discussed below.

AERMOD is not designed to use multiple meteorological datasets. However, due to the scale of this health risk assessment, the meteorological dataset from one station does not represent spatial and temporal conditions of all the emission sources. The geographical zones using different meteorological datasets are represented as having a fixed border. Two sources close to each other on different sides of a border would be modeled using different meteorological datasets. However in reality, a transition region likely exists in which either meteorological dataset is appropriate to use. The model can not account for the transition region, a fact which likely results in uncertainties in the modeled concentrations for this region.

AERMOD is designed to model near-field short-term dispersion for distances up to 50 kilometers. However, in this assessment, ENVIRON used AERMOD to simulate dispersion from emissions as far as 80 kilometers from the modeling domain. This may introduce inaccuracies into the modeled results. Since the emissions located beyond 50 kilometers are located far from the shore, they represent a small portion of the total risk calculated for the BWHRA Tool.

A complete set of surface meteorological data is not available at the SPPS, TITP, and Berth 47 stations. Therefore, wind speed, wind direction, temperature, and pressure data from the three stations are combined with cloud cover data from Long Beach Daugherty Field. In addition, meteorological surface measurements from the three stations and Long Beach Daugherty Field stations are not 100% complete for all modeled years, so missing data are substituted using procedures outlined in Atkinson and Lee (1992).

Surface parameters supplied to the model are specified for the area surrounding the surface meteorological monitoring sites, rather than the project area as recommended by USEPA (2005) and ARB[3]. Note that the new AERMOD Implementation Guide (USEPA 2008, 2009) requires the representativeness of the meteorological data as a prerequisite. Because of both

[3] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

the proximity of the selected meteorological stations to the modeled operations and the similarities of the land use surrounding the meteorological stations to that in each operational zone, surface parameters calculated for the meteorological stations are representative of the operational zone over which the meteorological station is used for modeling.

In accordance with the recommendation of guidance (see discussion and references in Section 3.4), ENVIRON used a full year of meteorological data from the selected meteorological stations to model long-term average DPM concentrations. Since the one-year dataset could potentially include short-term fluctuations of certain meteorological parameters, using one year's worth of data rather than five years' represents a source of uncertainty in the estimated exposure concentrations.

## 7.3 Building Downwash

ENVIRON did not account for building-induced aerodynamic downwash effects in this assessment. As most emission sources included in this assessment are mobile sources that were modeled as volume or area sources, the exclusion of building downwash effects is not likely to significantly impact air dispersion modeling results. However since the spacing and placement of point sources relative to buildings or structures results in impacts to building downwash parameters and resulting modeling concentrations, not including OGV structures when modeling OGV hotelling operations as point sources could potentially result in approximate predictions of concentrations near the source locations.

## 7.4 Recent Changes to AERMOD Guidance

ENVIRON performed the surface parameter analysis and meteorological data processing based on USEPA's AERMET User's guide (USEPA 2004a) and AERMOD Implementation Guide (USEPA 2005). However a new version (January 9, 2008) of the AERMOD Implementation Guide was released after the BWHRA Tool modeling analysis was already mainly completed. Later another version of the AERMOD Implementation Guide was released on Mach 19, 2009 after the BWHRA Tool was completed. Revisions from the original Implementation Guide (USEPA 2005) include the following:

*Meteorological Data Processing Change*

- Determining surface characteristics
- Processing site-specific meteorological data for urban applications
- Meteorological data selections for urban applications
- Selecting upper air sounding levels
- Optional urban roughness length

*Modeling Change*

- Modeling sources with terrain-following plumes in sloping terrain
- Urban/rural determination

- Selecting population data for AERMOD's urban mode
- Terrain elevation data source

ENVIRON performed a review of these changes and determined that either the modeling practice for BWHRA Tool is consistent with the guidance, or some of the revisions will not likely have a noticeable effect on the modeling results, as discussed below.

The processing of site-specific meteorological data for urban applications has been clarified in the newer Implementation Guides (USEPA 2008, 2009). Site-specific turbulence measurements are not used and the urban option is employed in the BWHRA Tool modeling, consistent with the newer Implementation Guides. Recommendations for meteorological data selections for urban applications have also been clarified. Meteorological processing for data on this project is consistent with the recommendations. The recommendations on the selection of upper air sounding levels in the newer Implementation Guides explicitly describes which levels of upper air data to extract are acceptable. As the upper air data are extracted at "all levels" for this project, the BWHRA Tool modeling is consistent with the Guide.

The current Implementation Guide recommends that for the urban/rural determination, in general, all sources within an urban complex have the "urban" option selected, even if some individual sources may be considered rural using a land use procedure. The "urban" option is selected for all sources, consistent with the Guide. Recommendations for terrain-following plumes are not applicable for the BWHRA Tool modeling.

The recommendation for selecting population data for AERMOD's urban mode is slightly different from the approach used in the BWHRA Tool modeling. As recommended, published census data are used to determine population density. However since the Metropolitan Statistical Area (MSA) for the Ports contains two Metropolitan Divisions, ENVIRON conservatively uses population data for the Metropolitan Division that covers the Ports' area to avoid overestimating of urban heat island effect. Therefore, the methodology used in BWHRA Tool modeling results in more conservative results.

For the optional urban roughness length, the current guidance (USEPA 2008, 2009) recommends a surface roughness of one meter when using the urban option. ENVIRON used a different surface roughness for each meteorological zone based on an area-averaged roughness length calculated within a 3-km buffer of each meteorological station. Naturally, some of the meteorological zones cover a higher percentage of water than other meteorological zones and have a lower surface roughness. Use of this lower surface roughness results in a more conservative result.

Recent changes to AERMAP have allowed for the use of the National Elevation Dataset (NED) and therefore it is recommended that this dataset be used rather than the USGS, DEM data. DEM files are used in the BWHRA Tool modeling since modeling had begun before the release of the new AERMAP. This change in dataset will not likely have a noticeable effect on the modeling results.

The most significant change is with the determination of surface characteristics in the processing of meteorological data. According to the latest Implementation Guide (USEPA 2008, 2009), the surface roughness is generally the most important consideration. The Guide specifies that the surface roughness length should be based on an inverse-distance weighted geometric mean for the default upwind distance of 1 kilometer relative to the meteorological station. The surface roughness parameter may be varied by sector, but the sector widths should be no smaller than 30 degrees.

In ENVIRON's meteorological data processing of Port data using USEPA guidance in effect at the time, the surface roughness length was based on an upwind fetch of 3 kilometers and surface roughness values were taken as the arithmetic mean, rather than the inverse-distance weighted geometric mean, within each sector as per the original USEPA guidance, except for Berth 47. Surface roughness length at Berth 47 was taken as the inverse-distance weighting using either up-wind or down-wind land use patterns determined on a sector-by-sector basis. A qualitative review of the three selected Port stations indicates that the potential impact of this guidance revision could be as follows:

- It is likely that a greater surface roughness would result for Saint Peter and Paul School and Terminal Island Treatment Plant meteorological sites for most sectors as this will capture less water. Greater surface roughness will result in greater dispersion of pollutants (i.e., lower concentrations).
- It is likely that a lower surface roughness for four sectors would result for the Berth 47 meteorological site overall due to the higher percentage of water captured in the 1-kilometer fetch. Lower surface roughness will result in less dispersion of pollutants (i.e., higher concentrations).

Methodologies used to determine Bowen ratio and albedo in the processing of meteorological data are also changed. However, the changes in Bowen ratio and albedo do not have a significant impact on the modeling results (Laffoon et al. 2005; Long et al. 2004).

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# Appendix B:
## Air Dispersion Modeling Supplemental Information

# Appendix B:

## Air Dispersion Modeling Supplemental Information

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# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| AERMET | AERMOD Meteorological Preprocessor |
| AERMOD | American Meteorological Society/Environmental Protection Agency Regulatory Model |
| ARB | Air Resources Board |
| BWHRA | Bay-Wide Health Risk Assessment |
| CEQA | California Environmental Quality Act |
| CHE | Cargo Handling Equipment |
| DEM | Digital Elevation Maps |
| DPM | Diesel Particulate Matter |
| HDV | Heavy-duty Vehicle |
| HRA | Health Risk Assessment |
| MSA | Metropolitan Statistical Area |
| NAS | Naval Air Station |
| NED | National Elevation Dataset |
| NRC | National Research Council |
| NWS | National Weather Service |
| OGV | Ocean-going Vessels |
| POLA | Port of Los Angeles |
| POLB | Port of Long Beach |
| PMI | Point of Maximum Impact |
| Ports | Port of Los Angeles and Port of Long Beach |
| SCAQMD | South Coast Air Quality Management District |
| SPPS | St. Peter and Paul School |
| Starcrest | Starcrest Consulting, LLC |
| TITP | Terminal Island Treatment Plant |
| TWG | Technical Working Group |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |

# 1 Air Dispersion Modeling Supplemental Information

The Bay-Wide Health Risk Assessment (BWHRA) Tool is based on a Protocol developed specifically for this assessment (Appendix A), which describes the methodology that is used in the BWHRA Tool. Some details that were not available at the time the Protocol was developed, but which are necessary for the air dispersion modeling are discussed in this Appendix. In addition, deviations from the Protocol document are discussed briefly in Section 3 of the main report with further details provided in this Appendix. Finally, key uncertainties and crucial assumptions associated with the air dispersion modeling are discussed in this Appendix.

This Appendix includes details not included in the main report or the Protocol on source characterization and parameters, source placement (including variations between 2005 and 2020), temporal emission factors, terrain, and meteorological data requirements. This Appendix also includes a brief discussion of recent changes in AERMOD guidance and their potential impact on the BWHRA Tool results.

## 1.1 Source Characterization and Parameters

### 1.1.1 Description of Source Allocation

ENVIRON used information provided by Starcrest Consulting, LLC (Starcrest) and the Port of Los Angeles and Port of Long Beach (collectively referred to as the Ports) in order to spatially allocate the different emissions sources into configurations that are appropriate for the air dispersion modeling. The following is a summary of the spatial allocations and parameters used for each source group. The allocation for each source group is based on spatial information provided by Starcrest, which ENVIRON evaluated and confirmed with aerial photos. Table B-1 shows the specific source parameters (depending on the modeled source type these can include the following: stack heights, release heights, initial vertical dimension, initial lateral dimension, temperature, exit velocity, and diameter) used for each source category. Figures B-1 through B-23 present locations of the points/volumes/areas representing each source category in the air dispersion model for both the 2005 and 2020 scenarios.

#### 1.1.1.1 Ocean-Going Vessel

*OGV – At Berth (Figure B-1)*

The coordinates of the ocean-going vessel (OGV) berth locations were provided by Starcrest. The berth locations are all located within the Ports' harbors adjacent to land. ENVIRON used point sources to represent this stationary emissions source group. Source parameters are based on the California Air Resources Board (ARB) exposure assessment of the Ports (ARB 2006a).

*OGV – Anchorage (Figures B-2)*

ENVIRON used area sources to represent the OGV anchorage areas provided by Starcrest. These areas are located south and slightly east of the central Ports area. Source parameters are based on typical parameters for ships based on the ARB exposure assessment of the Ports (ARB 2006a)[1]. Initial vertical dimensions were calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

*OGV – Maneuvering (Figures B-3, B-4)*

ENVIRON used consecutive volume sources to represent the OGV maneuvering emissions from the Starcrest-provided maneuvering paths within the Ports. The volume sources serve the function of line sources in AERMOD. Following ARB guidance (2006a), ENVIRON spaced volume sources 160 meters apart throughout the in-Port maneuvering paths. For narrow maneuvering paths, volume sources are reduced in size to fit the channel widths and 160-meter spacing was retained. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

*OGV – Transit (Figures B-5, B-6)*

As with maneuvering sources, ENVIRON used consecutive volume sources to represent the OGV transit emissions from the Starcrest-provided shipping lanes outside of the Ports. Following ARB guidance, ENVIRON spaced volume sources 800 meters apart throughout the shipping lanes. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

#### 1.1.1.2 Harborcraft

*Harborcraft – Maneuvering (Figures B-7, B-8)*

ENVIRON used consecutive volume sources to represent the harborcraft maneuvering emissions from the Starcrest-provided maneuvering paths within the Ports. Following ARB guidance, ENVIRON spaced volume sources 160 meters apart throughout the in-Port maneuvering paths. For narrow maneuvering paths, volume sources are reduced in size to fit the channel widths and 160-meter spacing was retained. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

*Harborcraft – Transit (Figures B-9, B-10)*

As with maneuvering sources, ENVIRON used consecutive volume sources to represent the harborcraft transit emissions from the Starcrest-provided shipping lanes outside of the Ports. Following ARB guidance, ENVIRON spaced volume sources 800 meters apart throughout the shipping lanes. Other source parameters are also based on the ARB exposure assessment of the Ports (ARB 2006a).

[1] OGV anchorage was not modeled for the ARB exposure assessment of the Ports. ENVIRON instead used source height for OGV maneuvering sources modeled in the ARB assessment.

*Harborcraft – Area (Figures B-11 through B-13)*

Certain types of harborcraft vessels do not travel in defined shipping lanes, rather these vessels can travel in a broad areas surrounding the ports. Starcrest-provided ENVIRON with specific areas over which these harborcraft vessels can operate. ENVIRON conservatively modeled these sources as area sources due to the undefined nature of their travel. The release height for the vessels is also provided by ARB (2006a). Initial vertical dimensions are calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

#### 1.1.1.3 Rail

*Rail – Off-Port, Port of Los Angeles (POLA) On-Port, Port of Long Beach (POLB) On-Port (Figures B-14 through B-16)*

ENVIRON used consecutive volume sources to represent the off-port and on-port rail emissions from the Starcrest-provided rail segments. When the given rail segments pass over an area with multiple separated rail tracks, volumes are placed over the individual tracks so as not to include the non-rail activity spaces between tracks. However, when the given rail segments pass over an area with multiple adjacent rail tracks with only small separation between tracks, a single set of larger volumes is used to cover the entire activity area.

The sizing and spacing of volume sources varied between rail segments. ENVIRON used volume sources sized to visually fit the width of the tracks and determined the spacing based on the volume sizes. Volumes are spaced a minimum of 50 meters apart, with spacing increasing in 25-meter increments above 50 meters. Each rail segment had constant spacing between volume sources although spacing varied between different segments. Thus, the spacing for each segment is determined by the largest volume source in that segment so that no sources overlapped.

ENVIRON based the release height on the ARB exposure assessment of the Ports (ARB 2006a). The initial vertical dimension is calculated based on the release height following AERMOD guidance for an elevated source not on or adjacent to a building. Following previous ENVIRON reports submitted to ARB, ENVIRON used a conversion factor of 4.3 to calculate the initial vertical dimension. Initial lateral dimensions are also calculated based on volume size divided by 4.3 following AERMOD guidance for a single volume source.

#### 1.1.1.4 On-Road Heavy-Duty Vehicles

*Off-Port and On-Port Road (Figures B-17 through B-19)*

ENVIRON used consecutive volume sources to represent the off-port and on-port on-road Heavy-duty Vehicle (HDV) emissions from the Starcrest-provided road segments. When the given road segments pass over an area with multiple separated roads, volumes are placed over the individual roads so as not to include the non-activity spaces between roads. However, when the given road segments included multiple vehicle lanes, a single set of larger volumes is used to cover the entire activity area.

The sizing of volume sources varies between road segments such that volume sources visually fit the widths of the roads. All volumes were spaced 50 meters apart. Release heights were provided by Starcrest. The initial vertical dimensions are calculated based on the release height following AERMOD guidance for an elevated source not on or adjacent to a building. Initial lateral dimensions are also calculated based on volume size divided by 4.3 following AERMOD guidance for a single volume source.

#### 1.1.1.5 Cargo Handling Equipment and On-Terminal Heavy-Duty Vehicles

*CHE and On-Terminal HDV (Figures B-20 through B-23)*

ENVIRON used area sources to represent the Cargo Handling Equipment (CHE) and HDV on-terminal activities. Terminal areas and specific CHE types and release heights were provided by Starcrest. The release height for the on-terminal HDV was also provided by Starcrest. Initial vertical dimensions are calculated based on the release heights following AERMOD guidance for an elevated source not on or adjacent to a building.

## 2 Source Placement

As described in Section 3 of the report, ENVIRON defined four geographic areas over which the emissions sources operate – Inner Harbor Zone, Middle Harbor Zone, Outer Harbor Zone, and Beyond Breakwater Zone. ENVIRON conducted an in-depth analysis to select specific meteorological dataset for each of the four zones. A detailed description of the approach used to divide the Ports' operational areas into four zones over which individual meteorological stations are applicable is provided in the Sphere of Influence Report included as Attachment I of Appendix A of this report. Sources are then assigned to the areas representing the inner, middle, outer, and beyond breakwater meteorological zones. Sources that fall completely within one zone are assigned to that zone for modeling. If a source falls within multiple zones, ENVIRON uses a "90/10 percent" rule to determine how to assign the source to meteorological zones. The "90/10 percent rule" states that if the length/area of a source within a meteorological zone is less than 10 percent of the length/area of the entire source, this source is assigned to the same meteorological zone as the other 90%; otherwise the source is split at the border of the multiple zones and sub-segments of the source is modeled separately using different meteorological data.

# 3 Variation of Source Allocation between 2020 And 2005

## 3.1 Description of Spatial Changes from 2005 to 2020

Sources are assumed to have identical spatial allocation for both the 2005 and 2023 scenarios except for a few specific land changes associated with the following anticipated projects:

- Cruise Terminal upon entering the Port of Los Angeles (POLA)
- Pacific Energy marine Oil Terminal (POLA)
- China Shipping Addition (POLA)
- Vopak (Port of Long Beach, POLB)
- Pier S (POLB)
- Middle Harbor (Pier D, E, F) (POLB)
- Pier G (POLB)
- Pier J (POLB)
- Pier A (POLB)

In 2020, there are no significant spatial changes for rail (POLA, POLB, and off-port), on-road heavy-duty vehicles (on- and off-port), harborcraft transiting, ocean-going vessels transiting, and ocean-going vessels anchorage. For the sources that did change, this document describes the source spatial changes that result from expected additions, removals, expansions, and reductions of 2005 emissions sources in 2020. ENVIRON received all 2020 spatial allocations from Starcrest; this document describes the changes assumed based on ENVIRON's comparison of the 2020 and 2005 spatial allocations.

### 3.1.1 Ocean-Going Vessels

*OGV – At Berth*

The OGV berth locations are expected to change between 2005 and 2020, in part due to physical changes in the Port configurations. Figure B-1 shows these changes.

*OGV – Maneuvering*

The in-port OGV maneuvering paths are expected to change substantially between 2005 and 2020, in part due to physical changes in the Port configurations. For POLB, a maneuvering path travels through the POLA terminals to reach some POLB terminals. Figures B-3 and B-4 show these changes.

### 3.1.2 Harborcraft

*Harborcraft – Maneuvering*

The in-port harborcraft maneuvering paths are expected to change substantially between 2005 and 2020, in part due to physical changes in the Port configurations. For POLB, a maneuvering path travels through the POLA terminals to reach some POLB terminals. Figures B-7 and B-8 show these changes.

*Harborcraft – Operating Areas*

The harborcraft operating area beyond 50 miles from the port did not change between 2005 and 2020. The operating areas up to 50 miles from the port changed minimally, with a slight reduction in area within the port property. This is due to reconfigurations at POLB. Figures B-11 through B-13 show these changes.

### 3.1.3 Cargo-Handling Equipment and On-Terminal Heavy-Duty Vehicles

*CHE and On-Terminal HDV*

The cargo handling operating areas and on-terminal HDV areas changed due to reconfigurations. Figures B-20 through B-23 show these changes.

# 4 Temporal Emission Factors

Temporal emission factors are used to represent differences in the amount of emissions that occur at different hours or days for a given activity. This allows one to allocate the total emissions according to different times of the day. This is important since meteorological parameters can vary significantly depending on the time of day. ENVIRON observed that for all three stations used in the BWHRA Tool, wind speeds are significantly higher during the daytime hours between 6am and 6pm. The lower wind speeds at night means that there is less dispersion of pollutants and thus higher concentrations close to the emissions sources. During the day, however, higher wind speeds disperse pollutants farther from the sources.

Predominant wind directions also affect the spatial characteristics of concentration profiles. Main wind directions do not vary much at Berth 47, but are significantly different between day and night at the Saint Peter Paul School (SPPS) and Terminal Island Treatment Plant (TITP) stations. Pollutant concentrations will typically move in different patterns during the day and the night because of these wind direction differences. The temporal emission factors allow for more accurate concentration estimates by matching emissions weighting with the different day and night wind speed and direction patterns.

Original temporal emission factors for each source group were provided by ARB (2006a). ENVIRON scaled these proportionally so that the factors summed to 24 hours each day and averaged to 1. The resulting temporal emission factors used in the models are shown in Table B-2.

# 5 Meteorological

AERMOD requires a meteorological input file to characterize the transport and dispersion of pollutants in the atmosphere. Surface and upper air meteorological data inputs as well as surface parameter data describing the land use and surface characteristics near the site are first processed using AERMOD Meteorological Preprocessor (AERMET), the meteorological preprocessor to AERMOD. The output file generated by AERMET is the meteorological input file required by AERMOD. Details of AERMET and AERMOD meteorological data needs are described in United States Environmental Protection Agency (USEPA) guidance documents (USEPA 2004a,b). Since the meteorological data selection and processing methods described in the BWHRA Protocol and the Sphere of Influence Report included as Appendix A of this report, the remainder of this section only briefly describes the following two key aspects of the AERMET analysis: the surface and upper air meteorological data selected and the surface parameter evaluation for BWHRA Tool.

## 5.1 Surface and Upper Air Meteorological Data

The focus of the Health Risk Assessment (HRA) is the characterization of risk in the areas immediately surrounding the Ports and major freeways (i.e., Interstates 110 and 710 and Highways 47 and 103) and rail line (i.e., the Alameda Corridor) extending from the Ports north to approximately Interstate 405. As such, ENVIRON selected meteorological data for air dispersion modeling based upon their spatial and temporal representativeness of conditions in the immediate vicinity of the Ports and the freeways near the Ports. As described in BWHRA Protocol on meteorological data selection and processing methods, ENVIRON defined four geographic area over which the emissions sources operate – Inner Harbor Zone, Middle Harbor Zone, Outer Harbor Zone, and Beyond Breakwater Zone. A detailed description of the approach used to divide the Ports' operational areas into four zones over which individual meteorological stations is applicable is provided in the Sphere of Influence Report included as Attachment I of Appendix A of this report. Meteorological dataset from the following stations are used for modeling sources within each of the four zones:

- Inner harbor – SPPS;
- Middle harbor – TITP;
- Outer harbor – Berth 47; and
- Beyond the breakwater – Berth 47

The most representative available wind speed, wind direction, temperature, and pressure data from each station during the twelve-month period from July 2005 through June 2006 is used in the air dispersion analysis of the BWHRA Tool. ENVIRON used cloud cover data (as the three stations did not record cloud cover data) from the National Weather Service's (NWS's) Long Beach Daugherty Field station for the twelve-month period from July 2005 through June 2006. Upper air data from the San Diego Miramar Naval Air Station (NAS) is used in AERMET processing for the BWHRA Tool.

According to the USEPA, meteorological data used for air quality modeling purposes should be at least 90 percent complete before substitution and contain no data gaps greater than two weeks (USEPA 2000). Since the meteorological datasets meet these criteria and are not 100% complete, substitution of missing meteorological data to obtain a meteorological data file with 100 percent complete data was performed using procedures outlined in Atkinson and Lee (1992). Table B-3 presents the completeness summary of the selected meteorological datasets before substitution and all of the parameters met the completeness criteria. Figure B-24 shows overall wind directions and speeds for the three selected meteorological datasets after substitution.

### 5.1.1 Surface Parameters

Prior to running AERMET, it is necessary to specify the surface characteristics for the meteorological monitoring site and/or the project area. The surface parameters include surface roughness, Albedo, and Bowen ratio, and are used to compute fluxes and stability of the atmosphere (USEPA 2004a) and require the evaluation of nearby land use and temporal impacts on these surface parameters. Surface parameters supplied to the model are specified for the area surrounding the surface meteorological monitoring sites (i.e., SPPS, TITP, and Berth 47 stations), rather than the project area (the Ports and vicinity area) as recommended by USEPA (2005) and ARB[2]. Because the selected meteorological stations are either on or in very close proximity to the Ports operations and the land use surrounding the meteorological stations is very similar to the land use in each operational zone the individual station is applicable to, surface parameters calculated for the meteorological stations are representative of the operational zone over which the meteorological station is used for modeling.

Detailed information on the process of surface parameter analysis used in this evaluation are described in ENVIRON's BWHRA Protocol (Appendix A of this report). Table B-4 summarizes the sector-specific surface parameters (surface roughness, Albedo, and Bowen ratio) determined for each of the three stations which wasn't available at the time the Protocol was developed.

[2] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

# 6 Terrain and Land Use

Another important consideration in an air dispersion modeling analysis is whether the terrain in the modeling area is simple or complex (i.e., terrain above the effective height of the emission point). ENVIRON used the following United States Geological Survey (USGS) 7.5 Minute digital elevation model (DEMs) information to identify terrain heights within the modeling domain:

- Long Beach (digital)
- Long Beach OES
- San Pedro
- Torrance
- Anaheim
- Inglewood
- La Habra
- Los Alamitos
- Newport
- Seal beach
- Southgate
- Whittier

ENVIRON provided terrain elevation data to the AERMOD model using version 06341 of AERMAP, AERMOD's terrain preprocessor. Due to discontinuities at the boundaries between some of the DEMs, AERMAP is not able to estimate the terrain elevations for 201 receptor locations. Using the known terrain elevation at adjacent receptors, ENVIRON estimated the terrain elevations at these 201 receptors using a linear interpolation methodology.

AERMOD can evaluate the effects of urban heat islands on atmospheric transport and dispersion using an urban boundary layer option. Due to the industrial, commercial, and dense residential land use at the impacted receptors, and consistent with ARB's Ports study (ARB 2006b) and South Coast Air Quality Management District (SCAQMD)'s past practices, the area in the vicinity of the Ports is considered urban. Accordingly, ENVIRON selected the urban boundary layer option. Use of the urban boundary layer option requires both population data and a surface roughness length. Published census data are used that correspond to the Metropolitan Division of the Los Angeles-Long Beach-Glendale area, as recommended by USEPA (2005). ENVIRON used the area-averaged roughness length calculated for a 3-kilometer fetch around each station to capture the influence of the water areas which have a significantly lower surface roughness.

# 7 Uncertainties in Air Dispersion Modeling

There is inherent uncertainty in all risk assessments, with the source(s) of that uncertainty dependent on the specific assumptions and models used to estimate risk (Council on Environmental Quality 1989). Understanding the degree of uncertainty associated with each component of a risk assessment is critical to interpreting the results of that assessment. As recommended by the National Research Council (NRC 1994), [a risk assessment should include] "a full and open discussion of uncertainties in the body of each … risk assessment, including prominent display of critical uncertainties in the risk characterization." The NRC (1994) further states that "when … [reporting] estimates of risk to decision-makers and the public, it should present not only point estimates of risk, but also the sources and magnitude of uncertainty associated with these estimates." Thus, to ensure an objective and balanced characterization of risk and to place the risk assessment results in the proper perspective, the results of a risk assessment should always be accompanied by a description of the uncertainties and critical assumptions that influence the key findings of the risk assessment.

In accordance with the recommendations described above, the key uncertainties and critical assumptions associated with the air dispersion modeling are described below. The uncertainties associated with the health risk estimation are described in Appendix C. The uncertainties associated with the emission estimations used in this BWHRA Tool are provided in Starcrest (2007a,b).

This section discusses the uncertainties associated with the air dispersion modeling performed as part of the BWHRA Tool. This includes uncertainties associated with estimates from air dispersion models, source placement and representation, meteorological data selection, and building downwash. Work on the BWHRA Tool was initiated prior to the release of new AERMOD guidance from USEPA (January 9, 2008 and March, 19, 2009). These guidance changes are not incorporated in the BWHRA Tool and the likely effect of these changes to the BWHRA Tool results are discussed above.

As discussed in Section 3, the USEPA-recommended dispersion model AERMOD was used to estimate diesel particulate matter (DPM) exposure concentrations at off-site receptor locations. This model uses the Gaussian plume equation to calculate ambient air concentrations from emission sources. For this model, the magnitude of error for the maximum concentration is estimated to range from 10 to 40% (USEPA 2005). Therefore, off-site exposure concentrations used in this assessment only represent approximate concentrations. As mentioned above, since the purpose of the BWHRA Tool is to characterize the difference between baseline and future forecast emissions, this does not introduce a large degree of uncertainty for the BWHRA Tool results.

As indicated in the BWHRA Protocol (Appendix A), the purpose of this assessment is to evaluate regional health risks from DPM sources related to Ports activities in order to inform development of the Standard. Therefore, unlike health risk assessments conducted for compliance with California Environmental Quality Act (CEQA), detailed spatial and temporal characteristics of the emissions sources are not used in the BWHRA Tool. Besides these uncertainties associated with source placement and representation, other uncertainties discussed in the following sections result in approximate predictions of DPM concentrations at receptors. Since neither the point of maximum impact (PMI) is needed for the BWHRA Tool nor can it be precisely located, the location of the PMI is not provided.

## 7.1 Source Placement and Representation

The sources in this HRA are generalized both in location and by restricting the analysis to a few major source categories with fleet average characteristics. Consequently, the representation of sources does not reflect the level of specific source category information that would be present in a project-specific HRA. The uncertainty introduced by the generalization of the sources is due to both the uncertainty in the placement of sources and the representation of the source parameters.

Because the BWHRA Tool evaluates only mobile sources, the distribution of emissions during movement in the operational areas is an important source of uncertainty. Unlike fixed stationary sources, emissions from moving sources would occur over a continuum rather than as discrete points. However, regulatory-approved models were originally developed for the evaluation of fixed stationary sources, and the use of a continuum of source locations to model source emissions during movement results in an unacceptably large number (in the tens of thousands) of sources and correspondingly long modeling run times (on the order of months rather than hours or days).

The source placement may introduce uncertainties to the modeled exposure concentrations. First, closer spacing between volume sources may impact the predicted concentrations at receptor locations near the Ports operational areas. Previous sensitivity analyses ENVIRON performed (see Appendix C of ENVIRON's BNSF Commerce/Mechanical Report [ENVIRON 2006]) indicated that concentrations at receptors nearest to the specific emission sources could be over-predicted by at least 10 percent. In addition, distributing on-terminal CHEs and HDVs emission over the entire area of each facility instead of the actual operational area of each facility may potentially increase or decrease the modeled exposure concentrations.

The source parameters (i.e., release velocity and release temperature) used to model OGV hotelling activities are sources of uncertainty. Due to a lack of information on source parameter configurations, ENVIRON followed the methodology of ARB's exposure assessment of the Ports (ARB 2006b) and used the fleet-average source parameters. The use of fleet-average source parameters for activities results in approximate predictions for these sources.

The release heights and vertical dimensions used for movement sources are also sources of uncertainty. ENVIRON followed ARB's exposure assessment of the Ports (ARB 2006b) for release heights of OGVs, HCs, and locomotives. ENVIRON also used typical equipment class-specific release heights of CHEs and HDVs provided by Starcrest. These equipment class-specific release heights can vary among individual pieces of equipment also. It was not clear to ENVIRON whether the adopted release heights had been adjusted to include nominal plume rise. Thus, the use of these release heights and associated vertical dimensions results in approximate predictions of receptor-specific DPM concentrations for these sources.

## 7.2 Meteorological Data Set

Uncertainty also exists in the meteorological data used in the AERMOD air dispersion model. These uncertainties are related to the use of multiple meteorological stations for the modeling, the combination of surface data from two meteorological stations, substitution of missing meteorological data, calculation of surface parameters for the meteorological station as opposed to the Ports operational areas, and use of a single year of meteorological data to calculate long-term average concentrations. Recent USEPA AERMOD guidance changes affect meteorological processing methodologies which were not included in this BWHRA Tool, in that the BWHRA Tool was partially completed at the time of the release of that guidance (January 9, 2008). The likely impact of these changes to guidance is discussed below.

AERMOD is not designed to use multiple meteorological datasets. However, due to the scale of this health risk assessment, the meteorological dataset from one station does not represent spatial and temporal conditions of all the emission sources. The geographical zones using different meteorological datasets are represented as having a fixed border. Two sources close to each other on different sides of a border would be modeled using different meteorological datasets. However in reality, a transition region likely exists in which either meteorological dataset is appropriate to use. The model can not account for the transition region, a fact which likely results in uncertainties in the modeled concentrations for this region.

AERMOD is designed to model near-field short-term dispersion for distances up to 50 kilometers. However, in this assessment, ENVIRON used AERMOD to simulate dispersion from emissions as far as 80 kilometers from the modeling domain. This may introduce inaccuracies into the modeled results. Since the emissions located beyond 50 kilometers are located far from the shore, they represent a small portion of the total risk calculated for the BWHRA Tool.

A complete set of surface meteorological data is not available at the SPPS, TITP, and Berth 47 stations. Therefore, wind speed, wind direction, temperature, and pressure data from the three stations are combined with cloud cover data from Long Beach Daugherty Field. In addition, meteorological surface measurements from the three stations and Long Beach Daugherty Field stations are not 100% complete for all modeled years, so missing data are substituted using procedures outlined in Atkinson and Lee (1992).

Surface parameters supplied to the model are specified for the area surrounding the surface meteorological monitoring sites, rather than the project area as recommended by USEPA (2005) and ARB[3]. Note that the new AERMOD Implementation Guide (USEPA 2008, 2009) requires the representativeness of the meteorological data as a prerequisite. Because of both

[3] Personal communication, J. Yuan of ARB by e-mail to D. Daugherty of ENVIRON on August 3, 2006.

the proximity of the selected meteorological stations to the modeled operations and the similarities of the land use surrounding the meteorological stations to that in each operational zone, surface parameters calculated for the meteorological stations are representative of the operational zone over which the meteorological station is used for modeling.

In accordance with the recommendation of guidance (see discussion and references in Section 3.4), ENVIRON used a full year of meteorological data from the selected meteorological stations to model long-term average DPM concentrations. Since the one-year dataset could potentially include short-term fluctuations of certain meteorological parameters, using one year's worth of data rather than five years' represents a source of uncertainty in the estimated exposure concentrations.

## 7.3 Building Downwash

ENVIRON did not account for building-induced aerodynamic downwash effects in this assessment. As most emission sources included in this assessment are mobile sources that were modeled as volume or area sources, the exclusion of building downwash effects is not likely to significantly impact air dispersion modeling results. However since the spacing and placement of point sources relative to buildings or structures results in impacts to building downwash parameters and resulting modeling concentrations, not including OGV structures when modeling OGV hotelling operations as point sources could potentially result in approximate predictions of concentrations near the source locations.

## 7.4 Recent Changes to AERMOD Guidance

ENVIRON performed the surface parameter analysis and meteorological data processing based on USEPA's AERMET User's guide (USEPA 2004a) and AERMOD Implementation Guide (USEPA 2005). However a new version (January 9, 2008) of the AERMOD Implementation Guide was released after the BWHRA Tool modeling analysis was already mainly completed. Later another version of the AERMOD Implementation Guide was released on Mach 19, 2009 after the BWHRA Tool was completed. Revisions from the original Implementation Guide (USEPA 2005) include the following:

*Meteorological Data Processing Change*

- Determining surface characteristics
- Processing site-specific meteorological data for urban applications
- Meteorological data selections for urban applications
- Selecting upper air sounding levels
- Optional urban roughness length

*Modeling Change*

- Modeling sources with terrain-following plumes in sloping terrain
- Urban/rural determination

- Selecting population data for AERMOD's urban mode
- Terrain elevation data source

ENVIRON performed a review of these changes and determined that either the modeling practice for BWHRA Tool is consistent with the guidance, or some of the revisions will not likely have a noticeable effect on the modeling results, as discussed below.

The processing of site-specific meteorological data for urban applications has been clarified in the newer Implementation Guides (USEPA 2008, 2009). Site-specific turbulence measurements are not used and the urban option is employed in the BWHRA Tool modeling, consistent with the newer Implementation Guides. Recommendations for meteorological data selections for urban applications have also been clarified. Meteorological processing for data on this project is consistent with the recommendations. The recommendations on the selection of upper air sounding levels in the newer Implementation Guides explicitly describes which levels of upper air data to extract are acceptable. As the upper air data are extracted at "all levels" for this project, the BWHRA Tool modeling is consistent with the Guide.

The current Implementation Guide recommends that for the urban/rural determination, in general, all sources within an urban complex have the "urban" option selected, even if some individual sources may be considered rural using a land use procedure. The "urban" option is selected for all sources, consistent with the Guide. Recommendations for terrain-following plumes are not applicable for the BWHRA Tool modeling.

The recommendation for selecting population data for AERMOD's urban mode is slightly different from the approach used in the BWHRA Tool modeling. As recommended, published census data are used to determine population density. However since the Metropolitan Statistical Area (MSA) for the Ports contains two Metropolitan Divisions, ENVIRON conservatively uses population data for the Metropolitan Division that covers the Ports' area to avoid overestimating of urban heat island effect. Therefore, the methodology used in BWHRA Tool modeling results in more conservative results.

For the optional urban roughness length, the current guidance (USEPA 2008, 2009) recommends a surface roughness of one meter when using the urban option. ENVIRON used a different surface roughness for each meteorological zone based on an area-averaged roughness length calculated within a 3-km buffer of each meteorological station. Naturally, some of the meteorological zones cover a higher percentage of water than other meteorological zones and have a lower surface roughness. Use of this lower surface roughness results in a more conservative result.

Recent changes to AERMAP have allowed for the use of the National Elevation Dataset (NED) and therefore it is recommended that this dataset be used rather than the USGS, DEM data. DEM files are used in the BWHRA Tool modeling since modeling had begun before the release of the new AERMAP. This change in dataset will not likely have a noticeable effect on the modeling results.

The most significant change is with the determination of surface characteristics in the processing of meteorological data. According to the latest Implementation Guide (USEPA 2008, 2009), the surface roughness is generally the most important consideration. The Guide specifies that the surface roughness length should be based on an inverse-distance weighted geometric mean for the default upwind distance of 1 kilometer relative to the meteorological station. The surface roughness parameter may be varied by sector, but the sector widths should be no smaller than 30 degrees.

In ENVIRON's meteorological data processing of Port data using USEPA guidance in effect at the time, the surface roughness length was based on an upwind fetch of 3 kilometers and surface roughness values were taken as the arithmetic mean, rather than the inverse-distance weighted geometric mean, within each sector as per the original USEPA guidance, except for Berth 47. Surface roughness length at Berth 47 was taken as the inverse-distance weighting using either up-wind or down-wind land use patterns determined on a sector-by-sector basis. A qualitative review of the three selected Port stations indicates that the potential impact of this guidance revision could be as follows:

- It is likely that a greater surface roughness would result for Saint Peter and Paul School and Terminal Island Treatment Plant meteorological sites for most sectors as this will capture less water. Greater surface roughness will result in greater dispersion of pollutants (i.e., lower concentrations).
- It is likely that a lower surface roughness for four sectors would result for the Berth 47 meteorological site overall due to the higher percentage of water captured in the 1-kilometer fetch. Lower surface roughness will result in less dispersion of pollutants (i.e., higher concentrations).

Methodologies used to determine Bowen ratio and albedo in the processing of meteorological data are also changed. However, the changes in Bowen ratio and albedo do not have a significant impact on the modeling results (Laffoon et al. 2005; Long et al. 2004).

# 8 References

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USEPA. 2008. AERMOD Implementation Guide. Research Triangle Park, North Carolina. January 9.

USEPA. 2009. AERMOD Implementation Guide. Research Triangle Park, North Carolina. March 19.

# Tables

**Table B-1**
**Modeled Source Parameters**
**Baywide HRA**

| Source | | Modeled Source Type | Source Parameters[7] Release Height or Stack Height (m) | Initial Vertical Dimesion[6] (m) | Initial Lateral Dimension (m) | Temperature (K) | Exit Velocty (m/s) | Diameter (m) |
|---|---|---|---|---|---|---|---|---|
| Ocean-Going Vessels[1] | Anchorage | Area | 50 | 11.6 | --- | --- | --- | --- |
| | At Berth | Point | 43 | --- | --- | 618 | 16 | 0.5 |
| | Maneuvering | Volume | 50 | 11.6 | 74.4 | --- | --- | --- |
| | Transit | | 50 | 11.6 | 372.1 | --- | --- | --- |
| Harborcraft[2] | Maneuvering | Volume | 6 | 1.4 | 32.6 - 74.4 | --- | --- | --- |
| | Transit | | 6 | 1.4 | 372.1 | --- | --- | --- |
| Rail[3] | On-Port | Volume | 5 | 1.2 | 0.7 - 18.6 | --- | --- | --- |
| | Off-Port | | 5 | 1.2 | 1.9 - 13.0 | --- | --- | --- |
| Heavy-Duty Vehicles[4] | On-Port Road | Volume | 3.7 | 0.9 | 2.3 - 9.3 | --- | --- | --- |
| | Off-Port Road | | 5 | 1.2 | 4.7 - 9.3 | --- | --- | --- |
| | On-Terminal | Area | 3.7 | 0.9 | --- | --- | --- | --- |
| Cargo Handling Equipment[5] | Bulldozer | Area | 3.7 - 4.9 | 0.9 - 1.1 | --- | --- | --- | --- |
| | Crane | | 4.9 | 1.1 | --- | --- | --- | --- |
| | Dump Truck | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Electric Pallet Jack | | 2.4 | 0.6 | --- | --- | --- | --- |
| | Excavator | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Forklift | | 2.4 - 3 | 0.6 - 0.7 | --- | --- | --- | --- |
| | Fuel Truck | | 3 - 3.7 | 0.7 - 0.9 | --- | --- | --- | --- |
| | Loader | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Man Lift | | 3 | 0.7 | --- | --- | --- | --- |
| | Propane Truck | | 3 | 0.7 | --- | --- | --- | --- |
| | Rail Pusher | | 4.9 | 1.1 | --- | --- | --- | --- |
| | Reach Stacker | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Roller | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Rubber-tired gantry crane | | 18.3 | 4.3 | --- | --- | --- | --- |
| | Side pick | | 3 | 0.7 | --- | --- | --- | --- |
| | Skid Steer Loader | | 3 | 0.7 | --- | --- | --- | --- |
| | Sweeper | | 3 | 0.7 | --- | --- | --- | --- |
| | Top handler | | 3 - 3.7 | 0.7 - 0.9 | --- | --- | --- | --- |
| | Tractor | | 3.7 | 0.9 | --- | --- | --- | --- |
| | Truck | | 2.4 - 3.7 | 0.6 - 0.9 | --- | --- | --- | --- |
| | Utility | | 3 | 0.7 | --- | --- | --- | --- |
| | Vacuum Truck | | 3 | 0.7 | --- | --- | --- | --- |
| | Water Truck | | 3 | 0.7 | --- | --- | --- | --- |
| | Yard tractor | | 3.7 | 0.9 | --- | --- | --- | --- |

**Notes:**
1. Source parameters for ocean-going vessels are based on ARB values.
2. Release height for harborcraft is based on ARB values. Initial lateral dimensions are also based on ARB values and adjusted based on channel widths.
3. Release height for rail is based on ARB values. Initial lateral dimensions are based on visual inspection of aerial photos; dimensions are selected to ensure that volume sources fit over rail tracks.
4. Release heights for heavy-duty vehicles are provided by Starcrest. Initial lateral dimensions are based on visual inspection of aerial photos; dimensions are selected to ensure that volume sources fit over roads.
5. Release heights for cargo handling equipment are provided by Starcrest for specific equipment types.
6. Initial vertical dimensions are calculated following AERMOD guidance for an elevated source not on or adjacent to a building.
7. The "---" in the table signifies the parameter is not applicable to this source.

**References:**

Air Resources Board (ARB). Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach. Final Report. April 2006.
USEPA. User's Guide for the AMS/EPA Regulatory Model - AERMOD. EPA-454/B-03-001. September 2004.

**Table B-2**
**POLA and POLB Temporal Emission Factors**
**Baywide HRA**

| Source | | Temporal Emission Factor[1] | Hours[2] |
|---|---|---|---|
| Cargo-Handling Equipment | | 0.36 | 5pm - 3am |
| | | 0.23 | 3am - 8am |
| | | 2.13 | 8am - 5pm |
| Harborcraft | | 0.40 | 6pm - 6am |
| | | 1.60 | 6am - 6pm |
| Ocean-Going Vessels | Anchorage | 1.00 | 24 hrs/day |
| | At Berth | 1.00 | 24 hrs/day |
| | Maneuvering | 0.60 | 8pm - 4am |
| | | 1.20 | 4am - 8pm |
| | Transit | 0.60 | 8pm - 4am |
| | | 1.20 | 4am - 8pm |
| Rail | | 1.00 | 24 hrs/day |
| Heavy-Duty Vehicles | | 0.40 | 6pm - 6am |
| | | 1.60 | 6am - 6pm |

**Notes:**
1. Original emission factors were provided by ARB. ENVIRON scaled these emission factors so that each category sums to 24 hours.
2. Day is designated as 6am - 6pm; night is designated as 6pm - 6am.

**References:**

Air Resources Board (ARB). Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach. Final Report. April 2006.

**Table B-3**
**Data Completeness Statistics**
**Bay-wide HRA**

| Station | Date Range | | | Wind Speed | | Wind Direction | | Temperature | | Cloud Cover | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start Date | End Date | Actual Hours | # Missing Hours | % Complete[1] | # Missing Hours | % Complete[1] | # Missing Hours | % Complete[1] | # Missing Hours | % Complete[1] |
| **TITP** | 7/1/2005 | 6/30/2006 | 8760 | 12 | 99.16% | 12 | 99.16% | 12 | 99.16% | --- | --- |
| **Berth47** | 7/1/2005 | 6/30/2006 | 8760 | 509 | 94.19% | 492 | 94.38% | 518 | 94.09% | --- | --- |
| **SPPS** | 7/1/2005 | 6/30/2006 | 8760 | 332 | 94.95% | 331 | 94.97% | 366 | 94.57% | --- | --- |
| **Long Beach Daugherty Field** | 7/1/2005 | 6/30/2006 | 8760 | --- | --- | --- | --- | --- | --- | 7 | 99.92% |

**Notes:**
1. Includes skipped records as well as invalid data. For wind speed invalid data includes < 0 mph and > 100 mph;
For Temperature invalid data includes < -20 F and > 150 F

**Table B-4**
**Sector-Specific Surface Roughness, Bowen Ratio, and Albedo**
**Bay-wide HRA**

**SPPS**

| Month | SEASON | Sector No. | July 2005- June 2006 | | |
|---|---|---|---|---|---|
| | | | Albedo | Bowen Ratio | Surface Roughness |
| January | Autumn | 1 | 0.180 | 2.000 | 1.000 |
| February | Spring | | 0.140 | 1.000 | 1.000 |
| March | Spring | | 0.140 | 1.000 | 1.000 |
| April | Summer | | 0.160 | 2.000 | 1.000 |
| May | Summer | | 0.160 | 2.000 | 1.000 |
| June | Summer | | 0.160 | 2.000 | 1.000 |
| July | Summer/Autumn | | 0.170 | 1.000 | 1.000 |
| August | Summer/Autumn | | 0.170 | 1.000 | 1.000 |
| September | Summer/Autumn | | 0.170 | 1.000 | 1.000 |
| October | Summer/Autumn | | 0.170 | 1.000 | 1.000 |
| November | Autumn | | 0.180 | 2.000 | 1.000 |
| December | Autumn | | 0.180 | 2.000 | 1.000 |
| January | Autumn | 2 | 0.174 | 1.698 | 0.841 |
| February | Spring | | 0.137 | 0.857 | 0.841 |
| March | Spring | | 0.137 | 0.857 | 0.841 |
| April | Summer | | 0.151 | 1.698 | 0.841 |
| May | Summer | | 0.151 | 1.698 | 0.841 |
| June | Summer | | 0.151 | 1.698 | 0.841 |
| July | Summer/Autumn | | 0.162 | 0.857 | 0.841 |
| August | Summer/Autumn | | 0.162 | 0.857 | 0.841 |
| September | Summer/Autumn | | 0.162 | 0.857 | 0.841 |
| October | Summer/Autumn | | 0.162 | 0.857 | 0.841 |
| November | Autumn | | 0.174 | 1.698 | 0.841 |
| December | Autumn | | 0.174 | 1.698 | 0.841 |
| January | Autumn | 3 | 0.169 | 1.477 | 0.722 |
| February | Spring | | 0.135 | 0.752 | 0.722 |
| March | Spring | | 0.135 | 0.752 | 0.722 |
| April | Summer | | 0.143 | 1.475 | 0.722 |
| May | Summer | | 0.143 | 1.475 | 0.722 |
| June | Summer | | 0.143 | 1.475 | 0.722 |
| July | Summer/Autumn | | 0.156 | 0.751 | 0.722 |
| August | Summer/Autumn | | 0.156 | 0.751 | 0.722 |
| September | Summer/Autumn | | 0.156 | 0.751 | 0.722 |
| October | Summer/Autumn | | 0.156 | 0.751 | 0.722 |
| November | Autumn | | 0.169 | 1.477 | 0.722 |
| December | Autumn | | 0.169 | 1.477 | 0.722 |
| January | Autumn | 4 | 0.182 | 1.954 | 0.936 |
| February | Spring | | 0.143 | 0.971 | 0.938 |
| March | Spring | | 0.143 | 0.971 | 0.938 |
| April | Summer | | 0.162 | 1.934 | 0.941 |
| May | Summer | | 0.162 | 1.934 | 0.941 |
| June | Summer | | 0.162 | 1.934 | 0.941 |
| July | Summer/Autumn | | 0.172 | 0.969 | 0.938 |
| August | Summer/Autumn | | 0.172 | 0.969 | 0.938 |
| September | Summer/Autumn | | 0.172 | 0.969 | 0.938 |
| October | Summer/Autumn | | 0.172 | 0.969 | 0.938 |
| November | Autumn | | 0.182 | 1.954 | 0.936 |
| December | Autumn | | 0.182 | 1.954 | 0.936 |
| January | Autumn | 5 | 0.178 | 1.859 | 0.927 |
| February | Spring | | 0.139 | 0.931 | 0.928 |
| March | Spring | | 0.139 | 0.931 | 0.928 |
| April | Summer | | 0.158 | 1.856 | 0.929 |
| May | Summer | | 0.158 | 1.856 | 0.929 |
| June | Summer | | 0.158 | 1.856 | 0.929 |
| July | Summer/Autumn | | 0.168 | 0.932 | 0.928 |
| August | Summer/Autumn | | 0.168 | 0.932 | 0.928 |
| September | Summer/Autumn | | 0.168 | 0.932 | 0.928 |
| October | Summer/Autumn | | 0.168 | 0.932 | 0.928 |
| November | Autumn | | 0.178 | 1.859 | 0.927 |
| December | Autumn | | 0.178 | 1.859 | 0.927 |
| January | Autumn | 6 | 0.180 | 2.003 | 0.996 |
| February | Spring | | 0.140 | 1.001 | 0.996 |
| March | Spring | | 0.140 | 1.001 | 0.996 |
| April | Summer | | 0.160 | 1.999 | 0.996 |
| May | Summer | | 0.160 | 1.999 | 0.996 |
| June | Summer | | 0.160 | 1.999 | 0.996 |
| July | Summer/Autumn | | 0.170 | 0.999 | 0.996 |
| August | Summer/Autumn | | 0.170 | 0.999 | 0.996 |
| September | Summer/Autumn | | 0.170 | 0.999 | 0.996 |
| October | Summer/Autumn | | 0.170 | 0.999 | 0.996 |
| November | Autumn | | 0.180 | 2.003 | 0.996 |
| December | Autumn | | 0.180 | 2.003 | 0.996 |

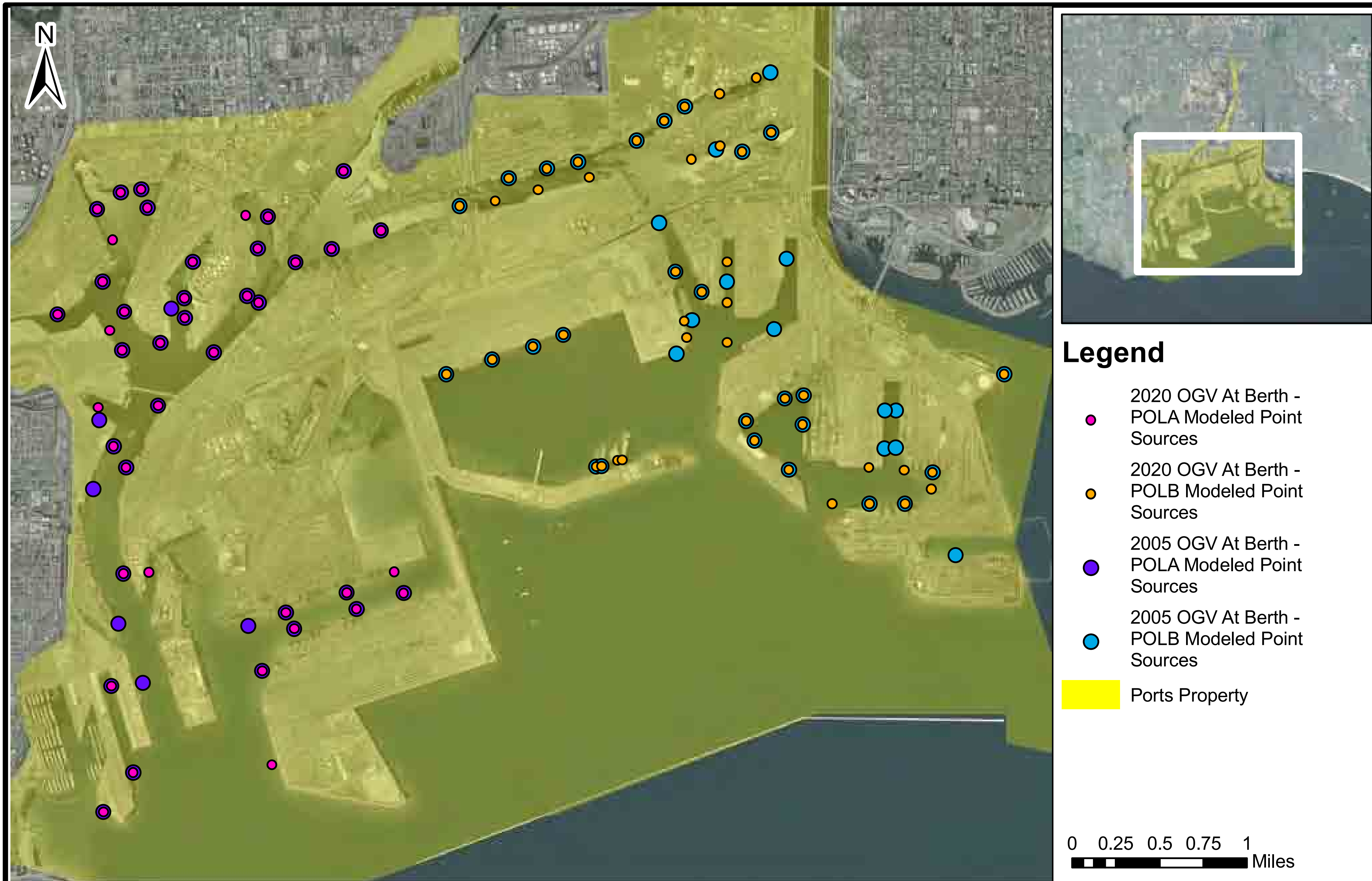
**TITP**

| Month | SEASON | Sector No. | July 2005- June 2006 | | |
|---|---|---|---|---|---|
| | | | Albedo | Bowen Ratio | Surface Roughness |
| January | Autumn | 1 | 0.176 | 1.811 | 0.896 |
| February | Spring | | 0.138 | 0.911 | 0.896 |
| March | Spring | | 0.138 | 0.911 | 0.896 |
| April | Summer | | 0.154 | 1.808 | 0.896 |
| May | Summer | | 0.154 | 1.808 | 0.896 |
| June | Summer | | 0.154 | 1.808 | 0.896 |
| July | Summer/Autumn | | 0.165 | 0.909 | 0.896 |
| August | Summer/Autumn | | 0.165 | 0.909 | 0.896 |
| September | Summer/Autumn | | 0.165 | 0.909 | 0.896 |
| October | Summer/Autumn | | 0.165 | 0.909 | 0.896 |
| November | Autumn | | 0.176 | 1.811 | 0.896 |
| December | Autumn | | 0.176 | 1.811 | 0.896 |
| January | Autumn | 2 | 0.151 | 0.640 | 0.284 |
| February | Spring | | 0.126 | 0.356 | 0.284 |
| March | Spring | | 0.126 | 0.356 | 0.284 |
| April | Summer | | 0.117 | 0.640 | 0.284 |
| May | Summer | | 0.117 | 0.640 | 0.284 |
| June | Summer | | 0.117 | 0.640 | 0.284 |
| July | Summer/Autumn | | 0.134 | 0.356 | 0.284 |
| August | Summer/Autumn | | 0.134 | 0.356 | 0.284 |
| September | Summer/Autumn | | 0.134 | 0.356 | 0.284 |
| October | Summer/Autumn | | 0.134 | 0.356 | 0.284 |
| November | Autumn | | 0.151 | 0.640 | 0.284 |
| December | Autumn | | 0.151 | 0.640 | 0.284 |
| January | Autumn | 3 | 0.170 | 1.504 | 0.736 |
| February | Spring | | 0.135 | 0.764 | 0.736 |
| March | Spring | | 0.135 | 0.764 | 0.736 |
| April | Summer | | 0.145 | 1.502 | 0.736 |
| May | Summer | | 0.145 | 1.502 | 0.736 |
| June | Summer | | 0.145 | 1.502 | 0.736 |
| July | Summer/Autumn | | 0.157 | 0.764 | 0.736 |
| August | Summer/Autumn | | 0.157 | 0.764 | 0.736 |
| September | Summer/Autumn | | 0.157 | 0.764 | 0.736 |
| October | Summer/Autumn | | 0.157 | 0.764 | 0.736 |
| November | Autumn | | 0.170 | 1.504 | 0.736 |
| December | Autumn | | 0.170 | 1.504 | 0.736 |
| January | Autumn | 4 | 0.156 | 0.846 | 0.394 |
| February | Spring | | 0.128 | 0.454 | 0.394 |
| March | Spring | | 0.128 | 0.454 | 0.394 |
| April | Summer | | 0.124 | 0.846 | 0.394 |
| May | Summer | | 0.124 | 0.846 | 0.394 |
| June | Summer | | 0.124 | 0.846 | 0.394 |
| July | Summer/Autumn | | 0.140 | 0.454 | 0.394 |
| August | Summer/Autumn | | 0.140 | 0.454 | 0.394 |
| September | Summer/Autumn | | 0.140 | 0.454 | 0.394 |
| October | Summer/Autumn | | 0.140 | 0.454 | 0.394 |
| November | Autumn | | 0.156 | 0.846 | 0.394 |
| December | Autumn | | 0.156 | 0.846 | 0.394 |
| January | Autumn | 5 | 0.174 | 1.736 | 0.861 |
| February | Spring | | 0.137 | 0.875 | 0.861 |
| March | Spring | | 0.137 | 0.875 | 0.861 |
| April | Summer | | 0.152 | 1.736 | 0.861 |
| May | Summer | | 0.152 | 1.736 | 0.861 |
| June | Summer | | 0.152 | 1.736 | 0.861 |
| July | Summer/Autumn | | 0.163 | 0.875 | 0.861 |
| August | Summer/Autumn | | 0.163 | 0.875 | 0.861 |
| September | Summer/Autumn | | 0.163 | 0.875 | 0.861 |
| October | Summer/Autumn | | 0.163 | 0.875 | 0.861 |
| November | Autumn | | 0.174 | 1.736 | 0.861 |
| December | Autumn | | 0.174 | 1.736 | 0.861 |
| January | Autumn | 6 | 0.168 | 1.436 | 0.700 |
| February | Spring | | 0.134 | 0.733 | 0.700 |
| March | Spring | | 0.134 | 0.733 | 0.700 |
| April | Summer | | 0.142 | 1.434 | 0.700 |
| May | Summer | | 0.142 | 1.434 | 0.700 |
| June | Summer | | 0.142 | 1.434 | 0.700 |
| July | Summer/Autumn | | 0.155 | 0.732 | 0.700 |
| August | Summer/Autumn | | 0.155 | 0.732 | 0.700 |
| September | Summer/Autumn | | 0.155 | 0.732 | 0.700 |
| October | Summer/Autumn | | 0.155 | 0.732 | 0.700 |
| November | Autumn | | 0.168 | 1.436 | 0.700 |
| December | Autumn | | 0.168 | 1.436 | 0.700 |

**Berth 47**

| Month | SEASON | Sector No. | July 2005- June 2006 | | |
|---|---|---|---|---|---|
| | | | Albedo | Bowen Ratio | Surface Roughness |
| January | Autumn | 1 | 0.161 | 1.042 | 0.211 |
| February | Spring | | 0.131 | 0.545 | 0.215 |
| March | Spring | | 0.131 | 0.545 | 0.215 |
| April | Summer | | 0.131 | 1.039 | 0.217 |
| May | Summer | | 0.131 | 1.039 | 0.217 |
| June | Summer | | 0.131 | 1.039 | 0.217 |
| July | Summer/Autumn | | 0.146 | 0.545 | 0.215 |
| August | Summer/Autumn | | 0.146 | 0.545 | 0.215 |
| September | Summer/Autumn | | 0.146 | 0.545 | 0.215 |
| October | Summer/Autumn | | 0.146 | 0.545 | 0.215 |
| November | Autumn | | 0.161 | 1.042 | 0.211 |
| December | Autumn | | 0.161 | 1.042 | 0.211 |
| January | Autumn | 2 | 0.178 | 1.897 | 0.945 |
| February | Spring | | 0.139 | 0.951 | 0.945 |
| March | Spring | | 0.139 | 0.951 | 0.945 |
| April | Summer | | 0.157 | 1.897 | 0.945 |
| May | Summer | | 0.157 | 1.897 | 0.945 |
| June | Summer | | 0.157 | 1.897 | 0.945 |
| July | Summer/Autumn | | 0.167 | 0.951 | 0.945 |
| August | Summer/Autumn | | 0.167 | 0.951 | 0.945 |
| September | Summer/Autumn | | 0.167 | 0.951 | 0.945 |
| October | Summer/Autumn | | 0.167 | 0.951 | 0.945 |
| November | Autumn | | 0.178 | 1.897 | 0.945 |
| December | Autumn | | 0.178 | 1.897 | 0.945 |
| January | Autumn | 3 | 0.161 | 1.111 | 0.054 |
| February | Spring | | 0.131 | 0.579 | 0.054 |
| March | Spring | | 0.131 | 0.579 | 0.054 |
| April | Summer | | 0.132 | 1.111 | 0.054 |
| May | Summer | | 0.132 | 1.111 | 0.054 |
| June | Summer | | 0.132 | 1.111 | 0.054 |
| July | Summer/Autumn | | 0.147 | 0.579 | 0.054 |
| August | Summer/Autumn | | 0.147 | 0.579 | 0.054 |
| September | Summer/Autumn | | 0.147 | 0.579 | 0.054 |
| October | Summer/Autumn | | 0.147 | 0.579 | 0.054 |
| November | Autumn | | 0.161 | 1.111 | 0.054 |
| December | Autumn | | 0.161 | 1.111 | 0.054 |
| January | Autumn | 4 | 0.159 | 0.994 | 0.095 |
| February | Spring | | 0.130 | 0.522 | 0.099 |
| March | Spring | | 0.130 | 0.522 | 0.099 |
| April | Summer | | 0.129 | 0.992 | 0.101 |
| May | Summer | | 0.129 | 0.992 | 0.101 |
| June | Summer | | 0.129 | 0.992 | 0.101 |
| July | Summer/Autumn | | 0.144 | 0.523 | 0.100 |
| August | Summer/Autumn | | 0.144 | 0.523 | 0.100 |
| September | Summer/Autumn | | 0.144 | 0.523 | 0.100 |
| October | Summer/Autumn | | 0.144 | 0.523 | 0.100 |
| November | Autumn | | 0.159 | 0.994 | 0.095 |
| December | Autumn | | 0.159 | 0.994 | 0.095 |
| January | Autumn | 5 | 0.141 | 0.155 | 0.003 |
| February | Spring | | 0.122 | 0.127 | 0.003 |
| March | Spring | | 0.122 | 0.127 | 0.003 |
| April | Summer | | 0.102 | 0.137 | 0.003 |
| May | Summer | | 0.102 | 0.137 | 0.003 |
| June | Summer | | 0.102 | 0.137 | 0.003 |
| July | Summer/Autumn | | 0.122 | 0.116 | 0.003 |
| August | Summer/Autumn | | 0.122 | 0.116 | 0.003 |
| September | Summer/Autumn | | 0.122 | 0.116 | 0.003 |
| October | Summer/Autumn | | 0.122 | 0.116 | 0.003 |
| November | Autumn | | 0.141 | 0.155 | 0.003 |
| December | Autumn | | 0.141 | 0.155 | 0.003 |
| January | Autumn | 6 | 0.141 | 0.131 | 0.016 |
| February | Spring | | 0.120 | 0.115 | 0.016 |
| March | Spring | | 0.120 | 0.115 | 0.016 |
| April | Summer | | 0.101 | 0.129 | 0.016 |
| May | Summer | | 0.101 | 0.129 | 0.016 |
| June | Summer | | 0.101 | 0.129 | 0.016 |
| July | Summer/Autumn | | 0.121 | 0.114 | 0.016 |
| August | Summer/Autumn | | 0.121 | 0.114 | 0.016 |
| September | Summer/Autumn | | 0.121 | 0.114 | 0.016 |
| October | Summer/Autumn | | 0.121 | 0.114 | 0.016 |
| November | Autumn | | 0.141 | 0.131 | 0.016 |
| December | Autumn | | 0.141 | 0.131 | 0.016 |

# Figures




ENVIRON

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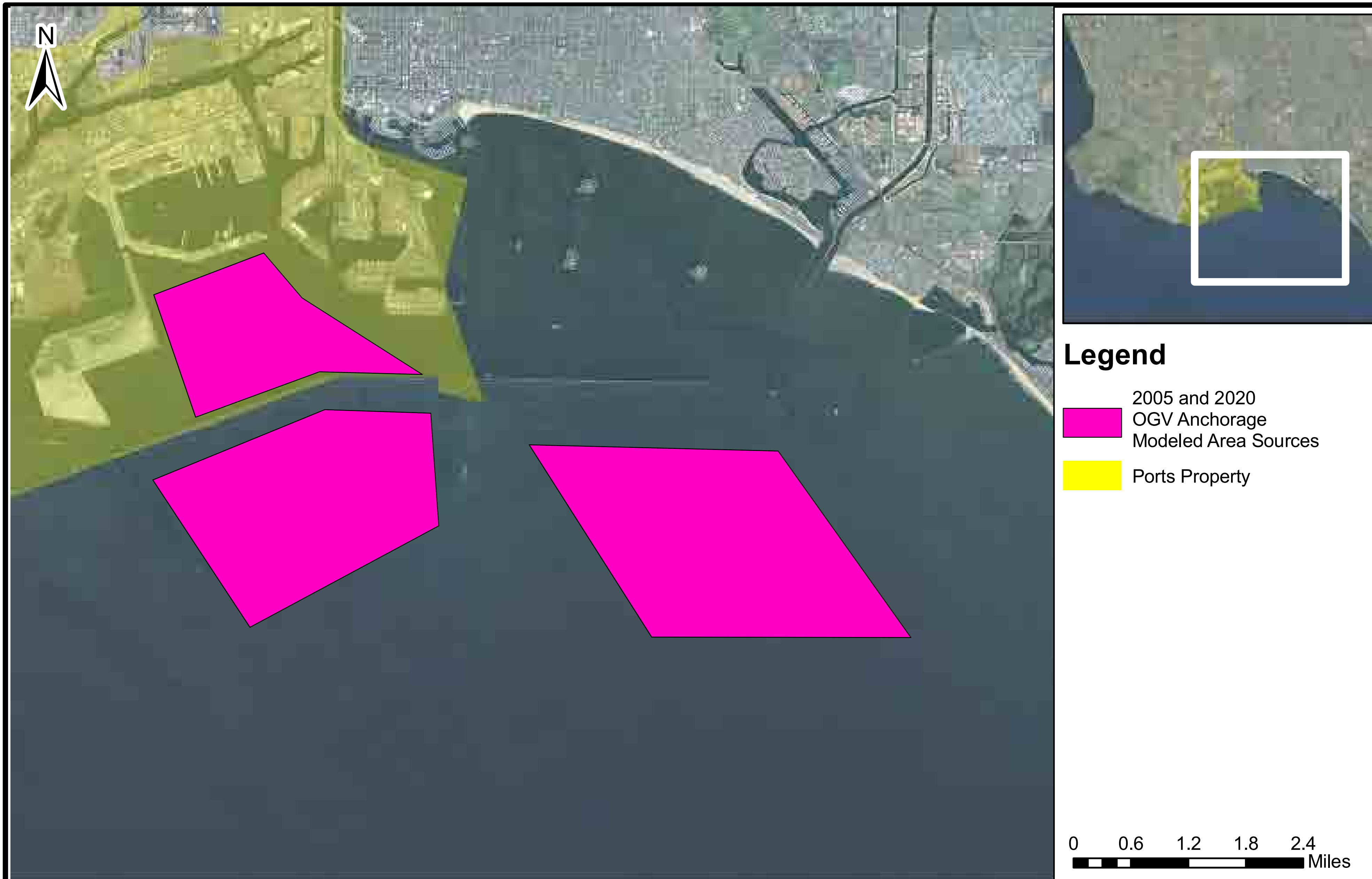
**Locations of Modeled Sources**
**Ocean-Going Vessels At Berth Modeled Point Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-1

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**Locations of Modeled Sources**
**Ocean-Going Vessels Anchorage Modeled Area Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-2


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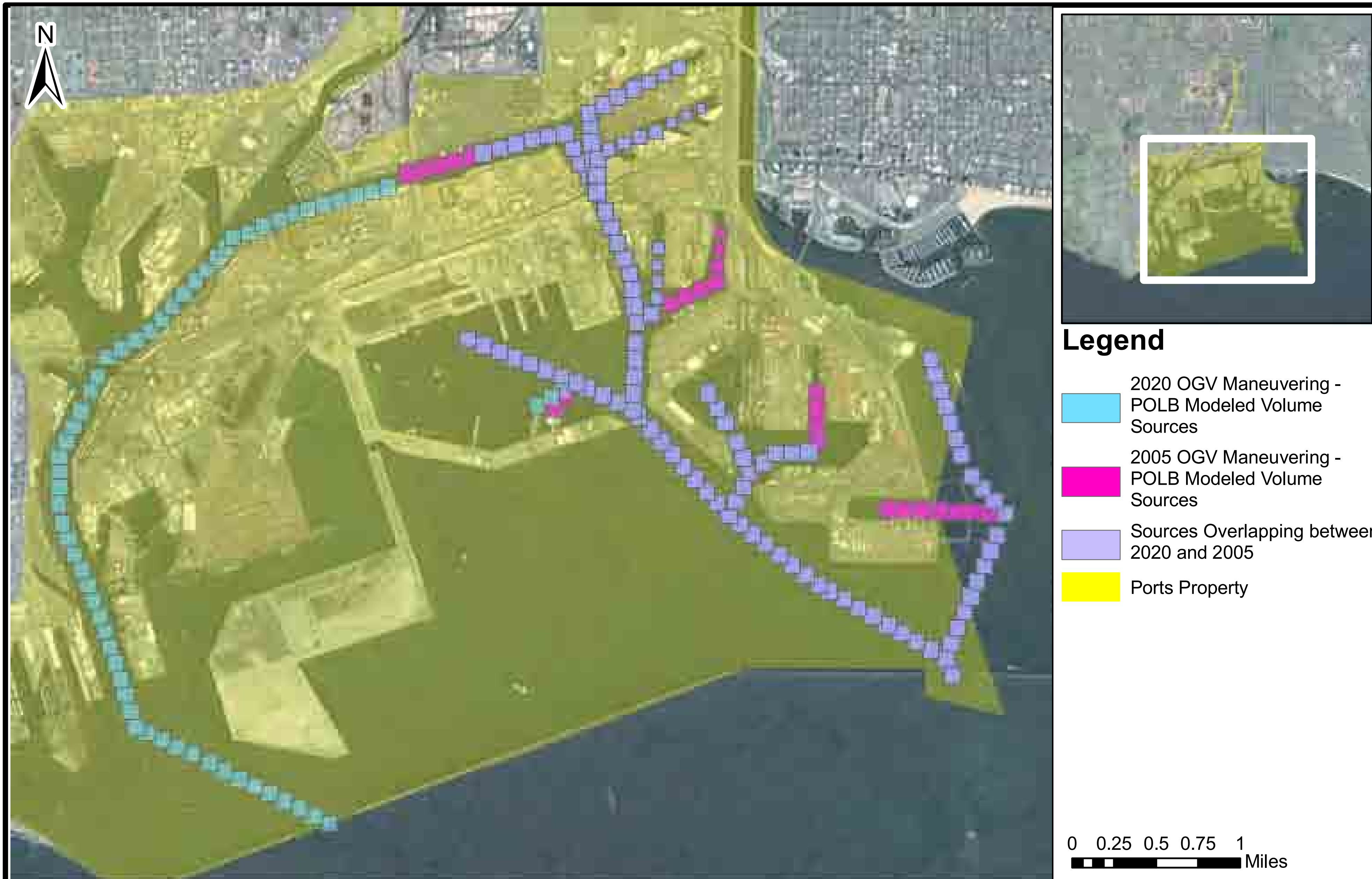
**Locations of Modeled Sources**
**Ocean-Going Vessels POLA Maneuvering Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-3

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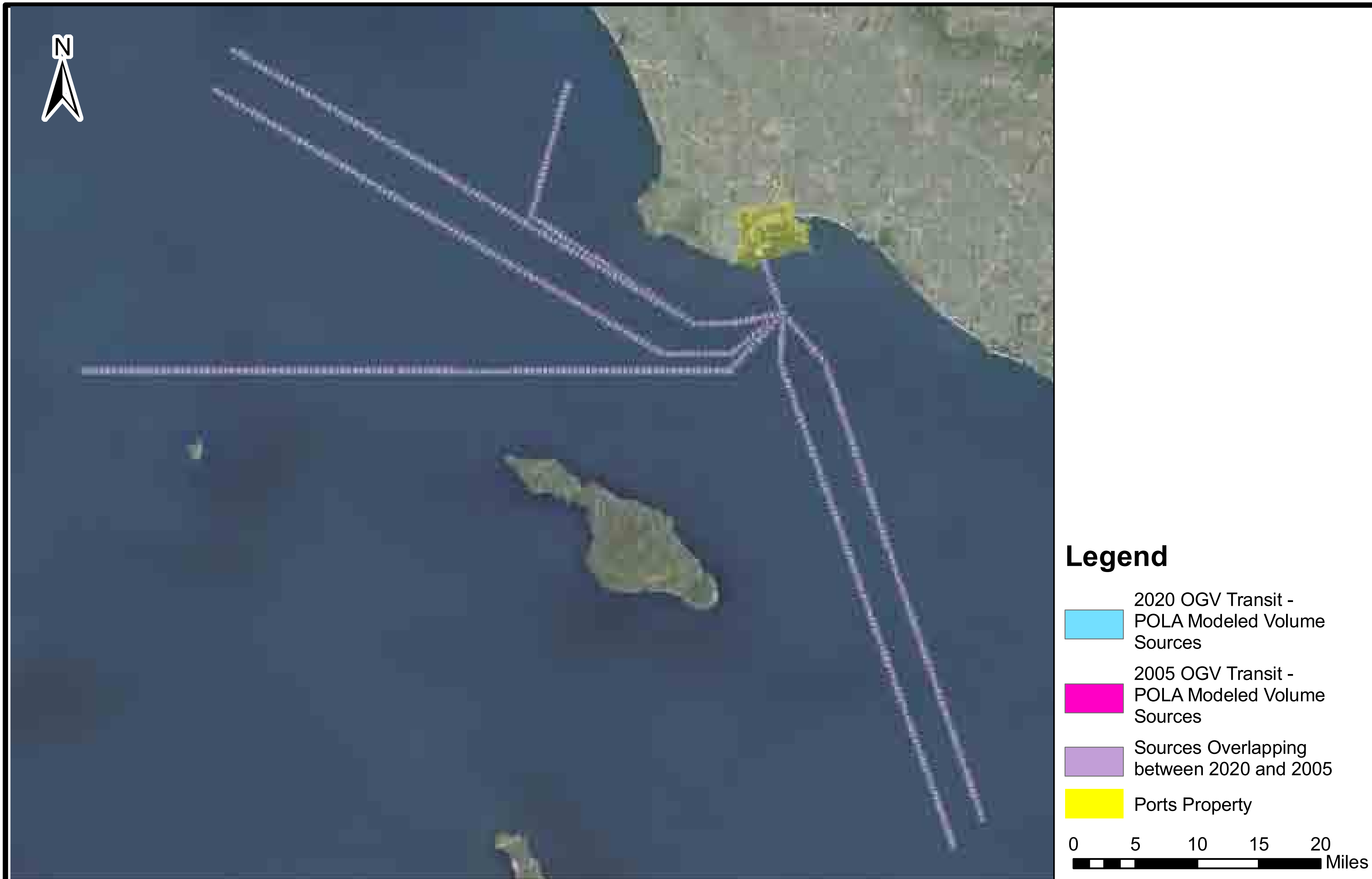
**Locations of Modeled Sources**
**Ocean-Going Vessels POLB Maneuvering Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-4

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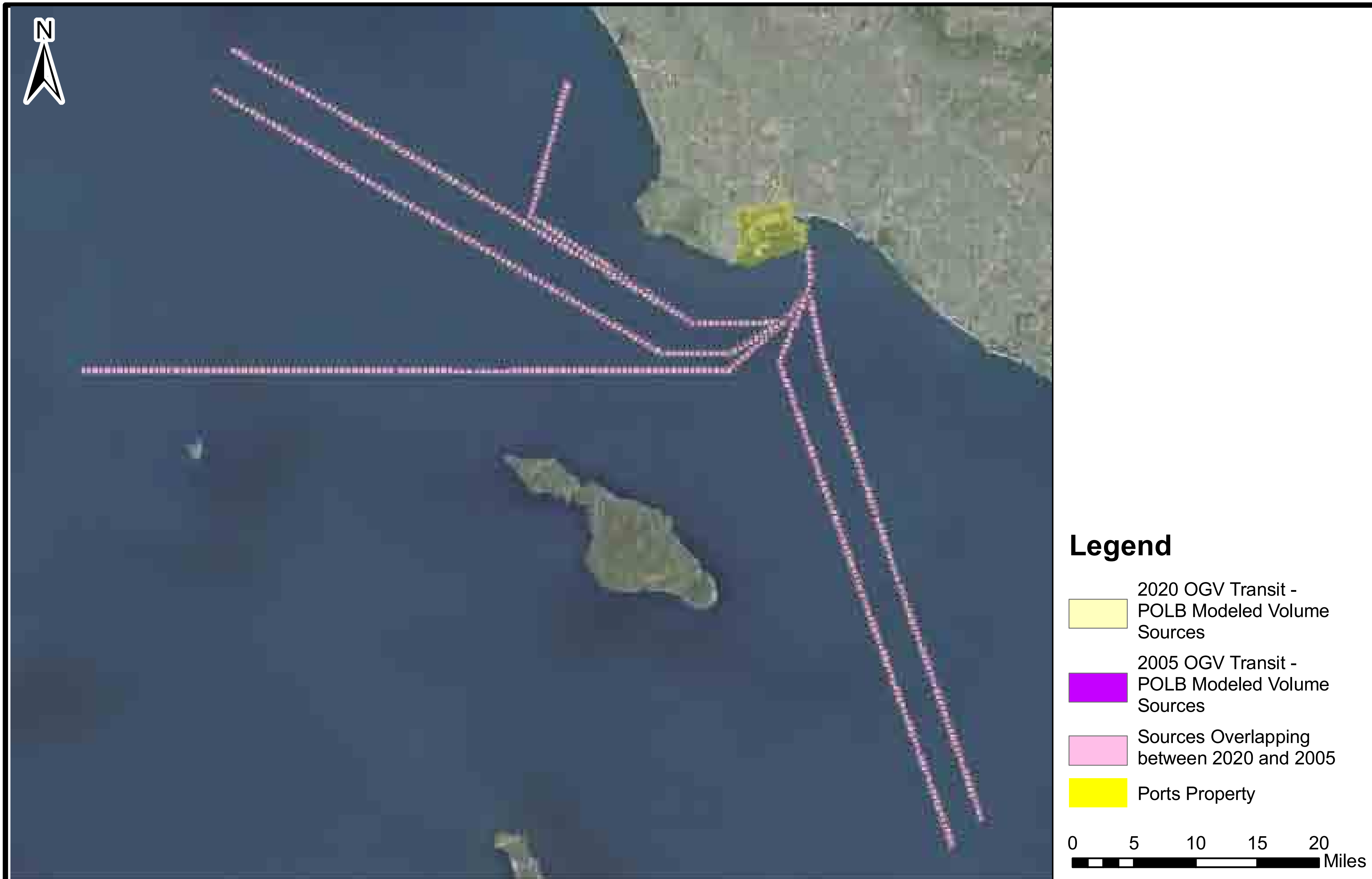
**Locations of Modeled Sources**
**Ocean-Going Vessels POLA Transit Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-5

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**Locations of Modeled Sources**
**Ocean-Going Vessels POLB Transit Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-6


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**Locations of Modeled Sources**
**Harborcraft POLA Maneuvering Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-7


ENVIRON

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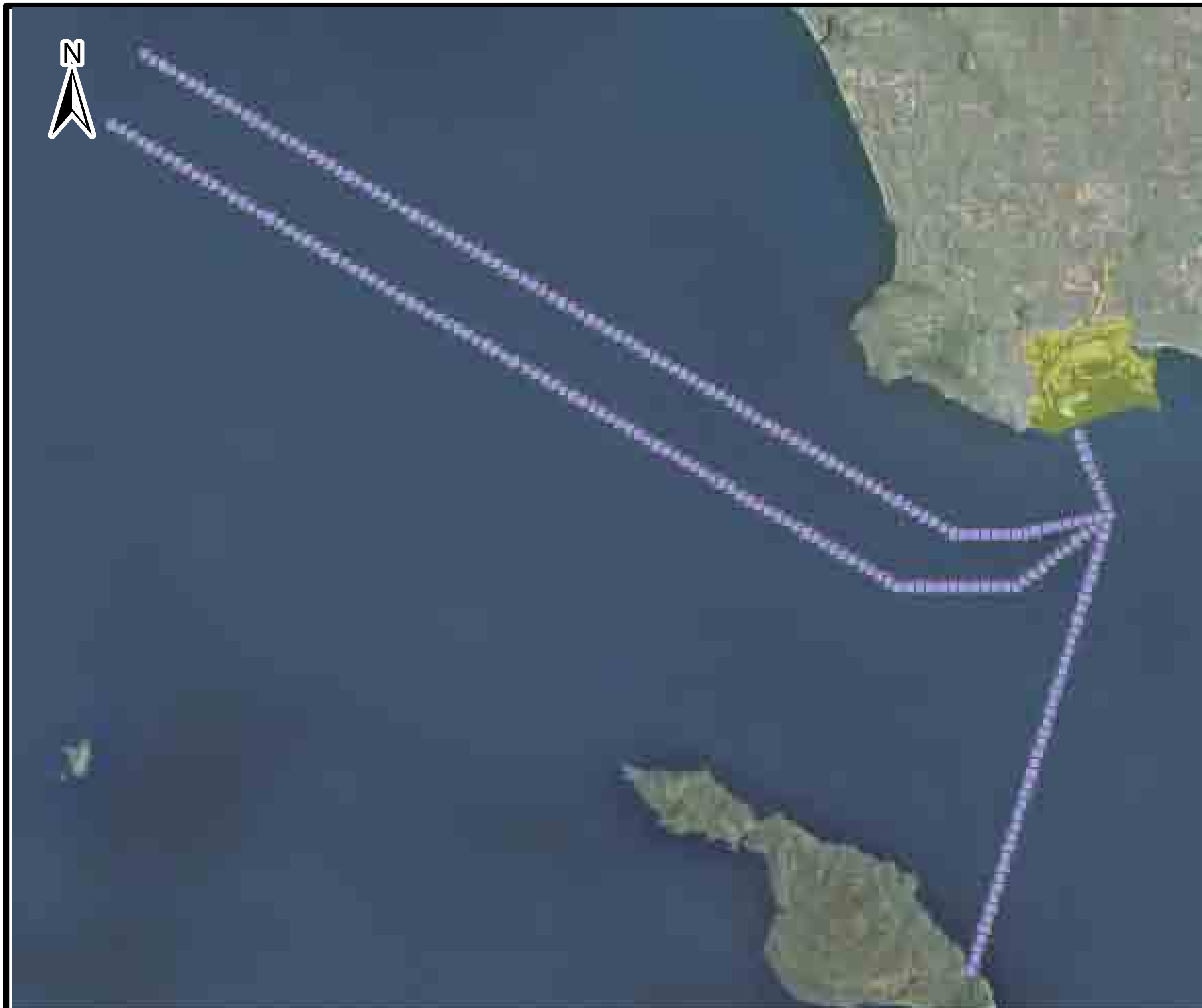
**Locations of Modeled Sources**
**Harborcraft POLB Maneuvering Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-8




## Legend

- 2020 Harborcraft Transit - POLA Modeled Volume Sources
- 2005 Harborcraft Transit - POLA Modeled Volume Sources
- Sources Overlapping between 2020 and 2005
- Ports Property

0 3 6 9 12 Miles

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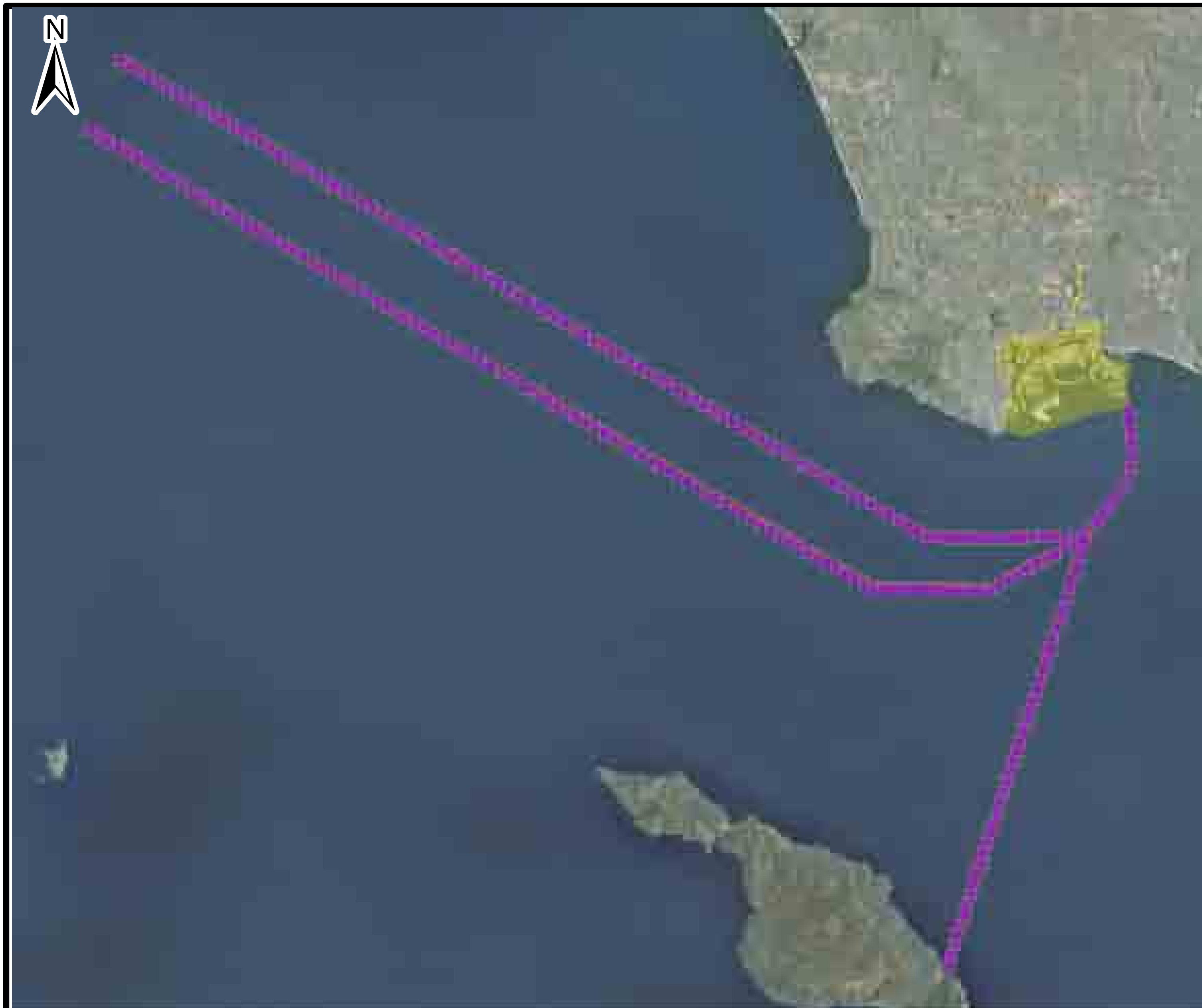
**Locations of Modeled Sources**
**Harborcraft POLA Transit Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-9




**Legend**

- 2020 Harborcraft Transit - POLB Modeled Volume Sources
- 2005 Harborcraft Transit - POLB Modeled Volume Sources
- Sources Overlapping between 2020 and 2005
- Ports Property

0 3 6 9 12 Miles

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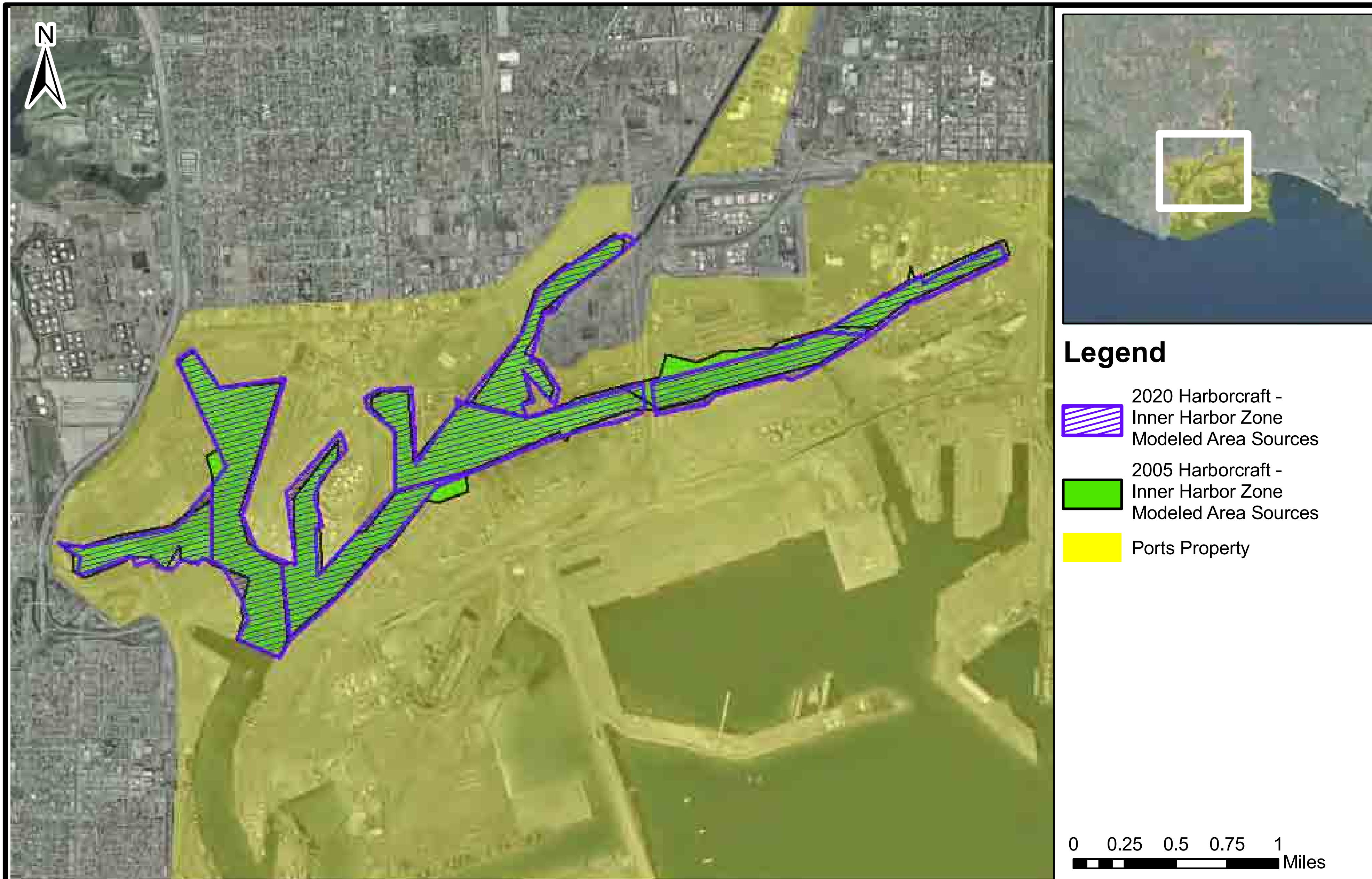
**Locations of Modeled Sources**
**Harborcraft POLB Transit Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-10

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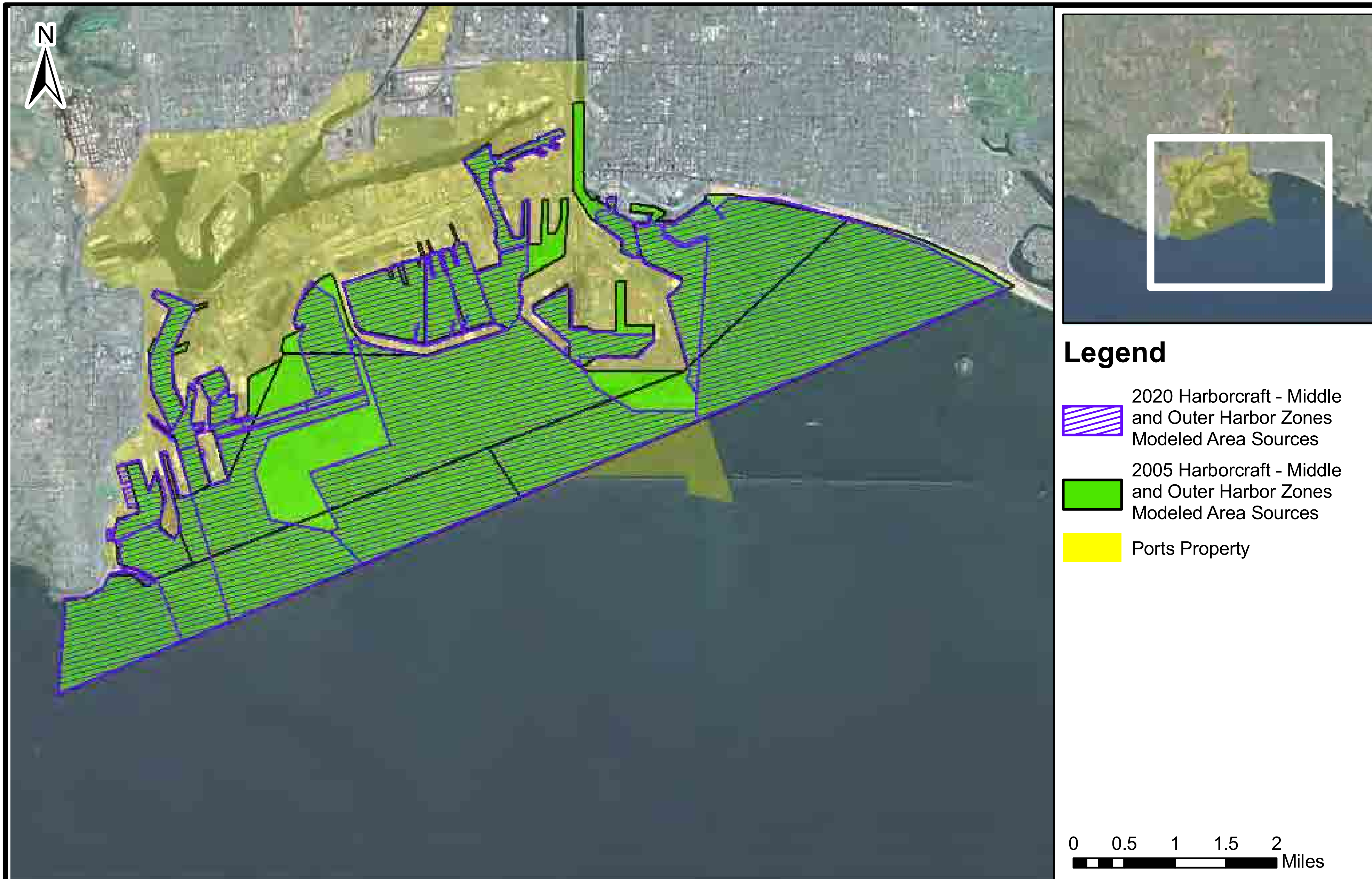
**Locations of Modeled Sources**
**Harborcraft Near Ports Modeled Area Sources: Inner Harbor Zone**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-11

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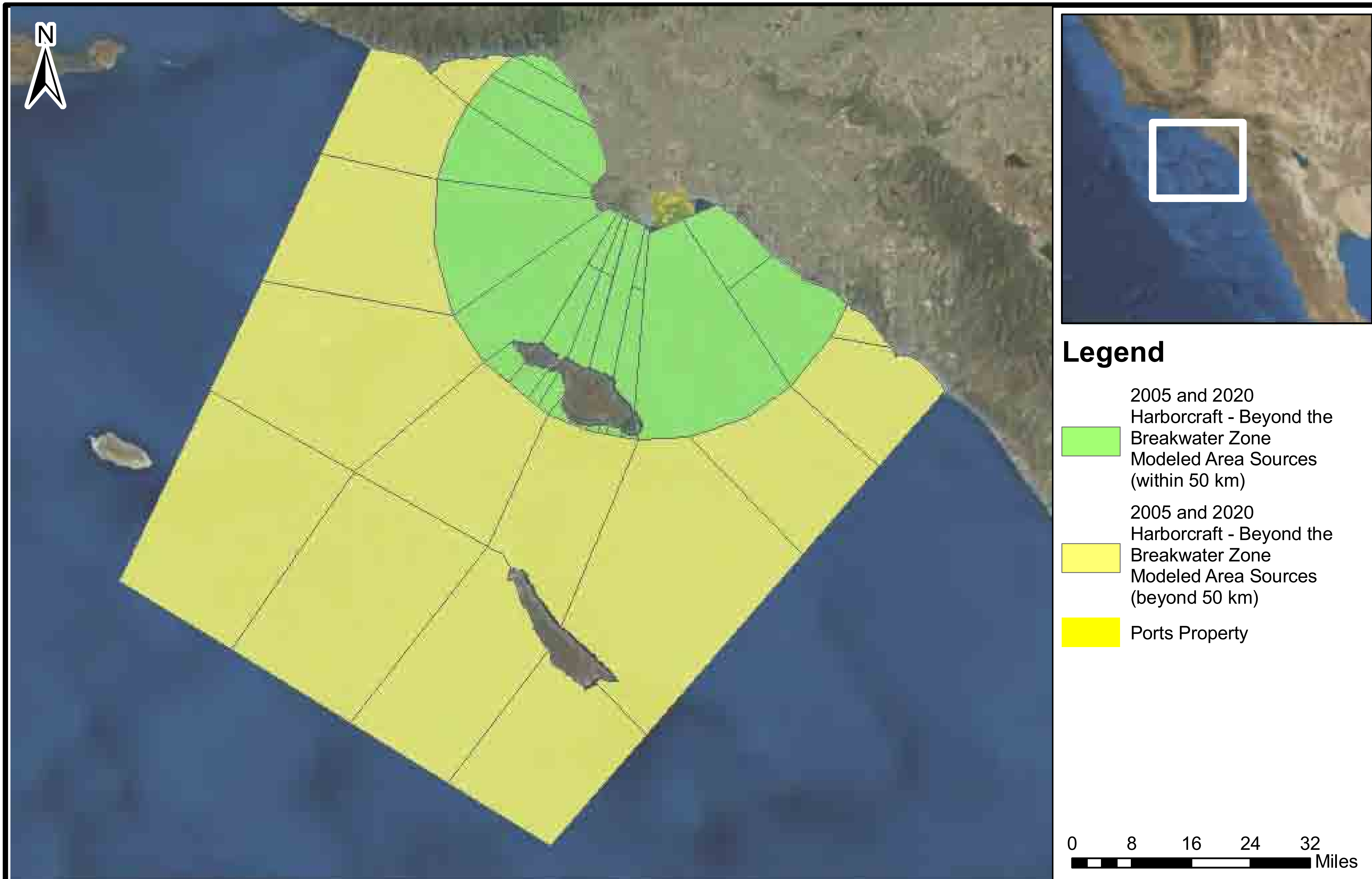
**Locations of Modeled Sources**
**Harborcraft Near Ports Modeled Area Sources: Middle and Outer Harbor Zones**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-12

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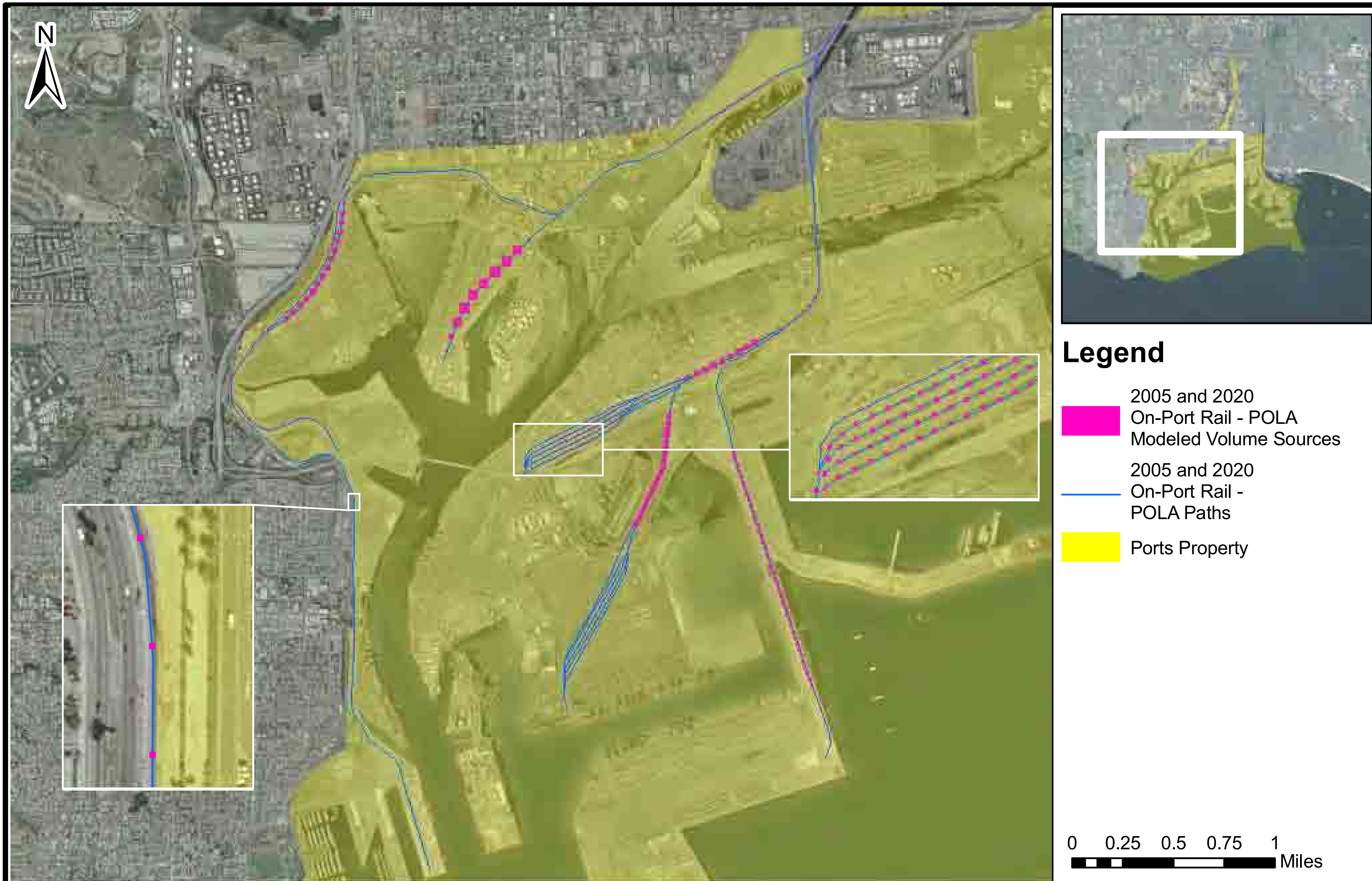
**Locations of Modeled Sources**
**Harborcraft Within and Beyond 50 Kilmeters from the Ports**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-13

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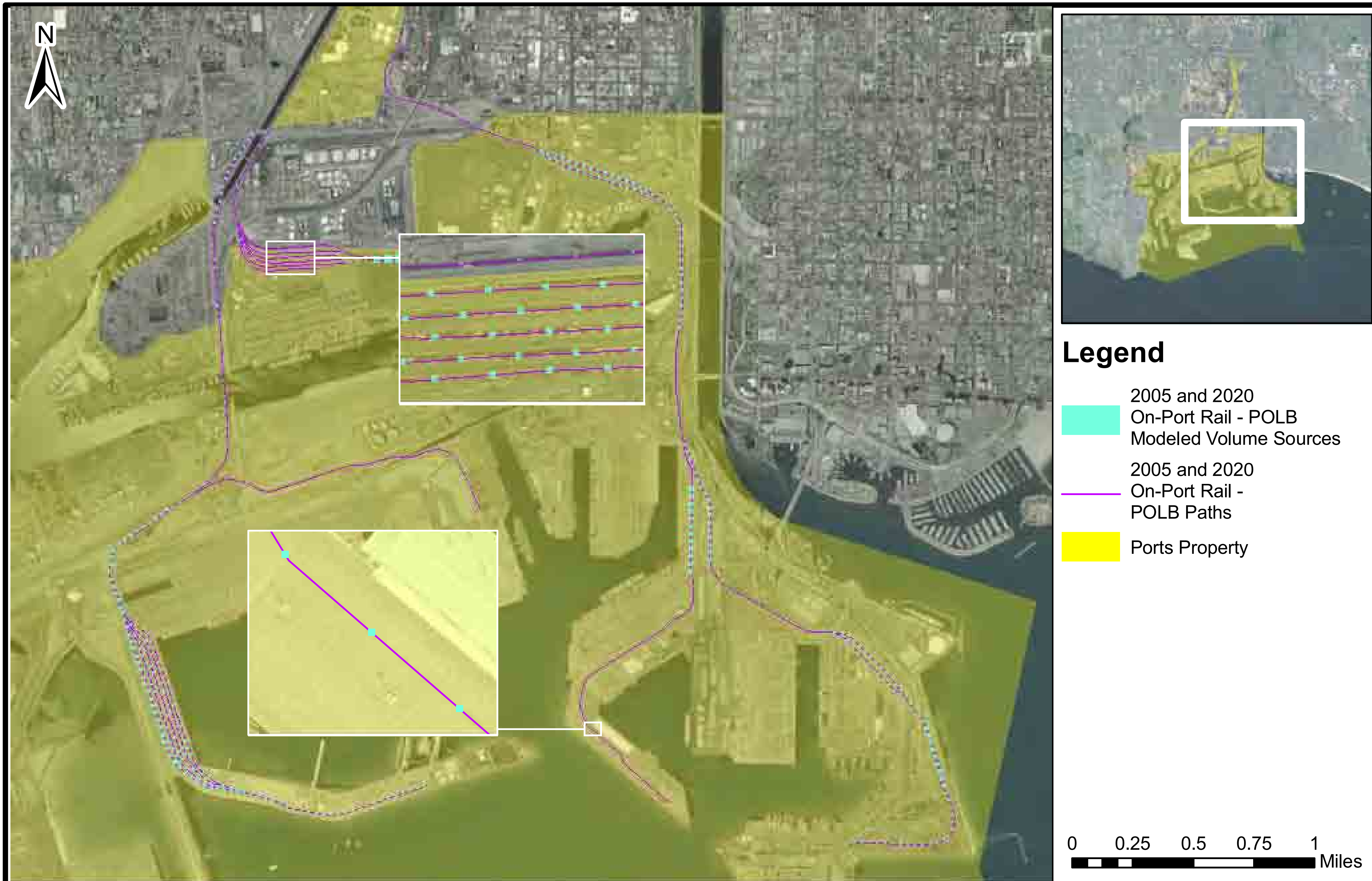
**Locations of Modeled Sources**
**On-Port Rail POLA Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-14

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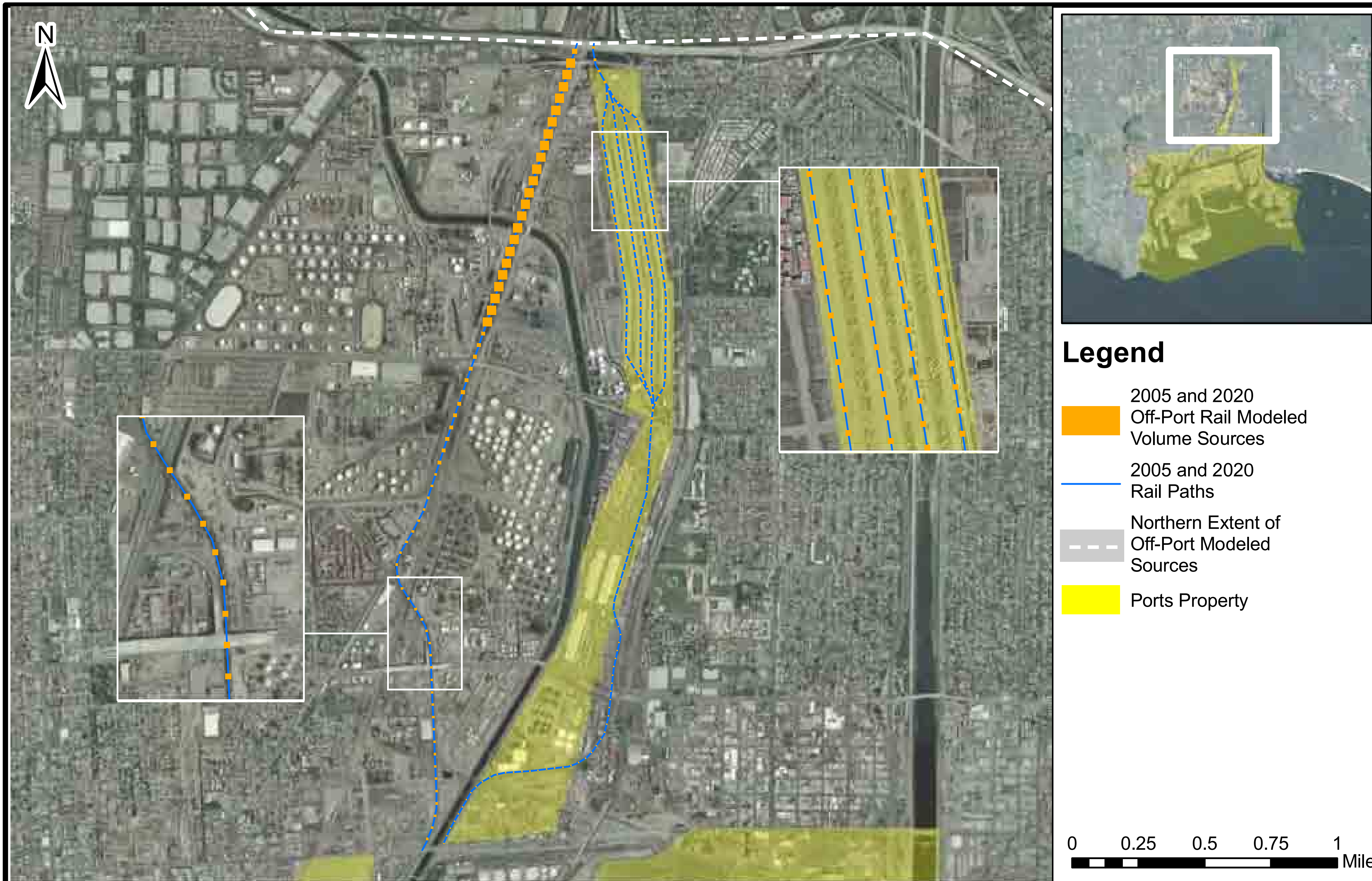
**Locations of Modeled Sources**
**On-Port Rail POLB Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-15

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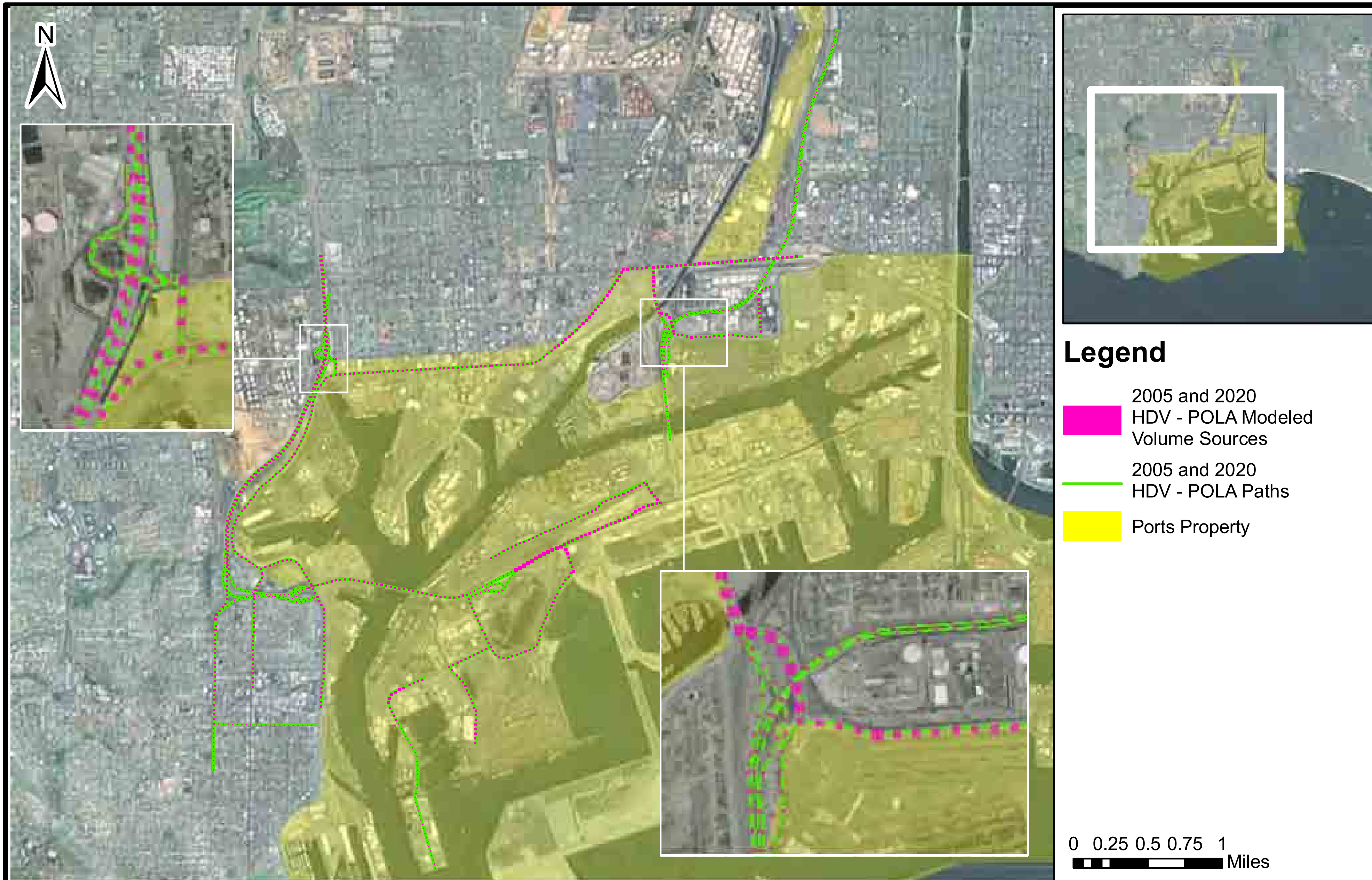
**Locations of Modeled Sources**
**On-Port and Off-Port Rail Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-16

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**Locations of Modeled Sources**
**Heavy Duty Vehicles On-Port, On-Road POLA Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure
B-17


## Legend

- 2005 and 2020 HDV - POLB Modeled Volume Sources
- 2005 and 2020 HDV - POLB Paths
- Ports Property

0 0.25 0.5 0.75 1 Miles

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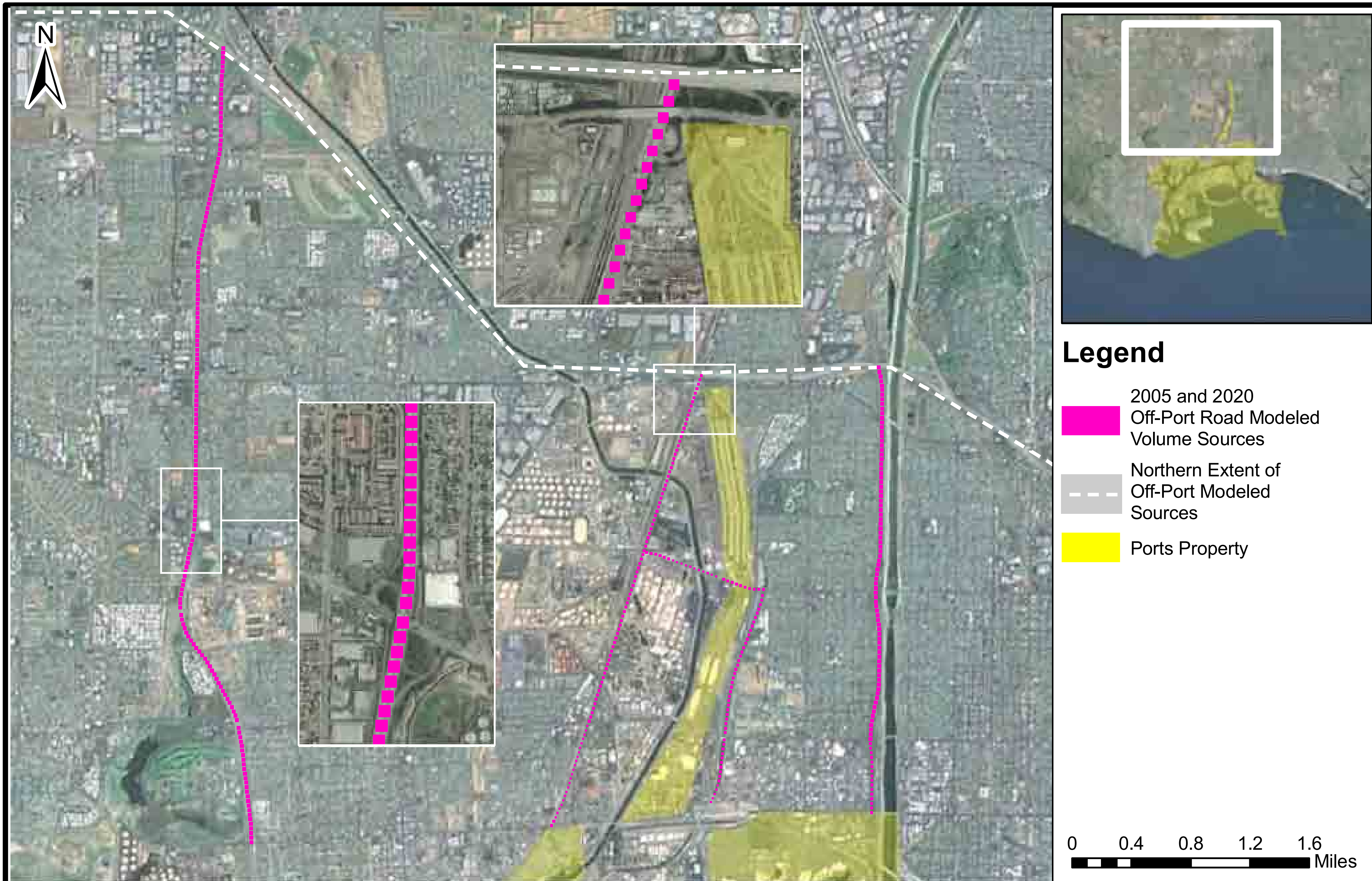
**Locations of Modeled Sources**
**Heavy Duty Vehicles On-Port, On-Road POLB Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro By Ports, California**

Figure

B-18

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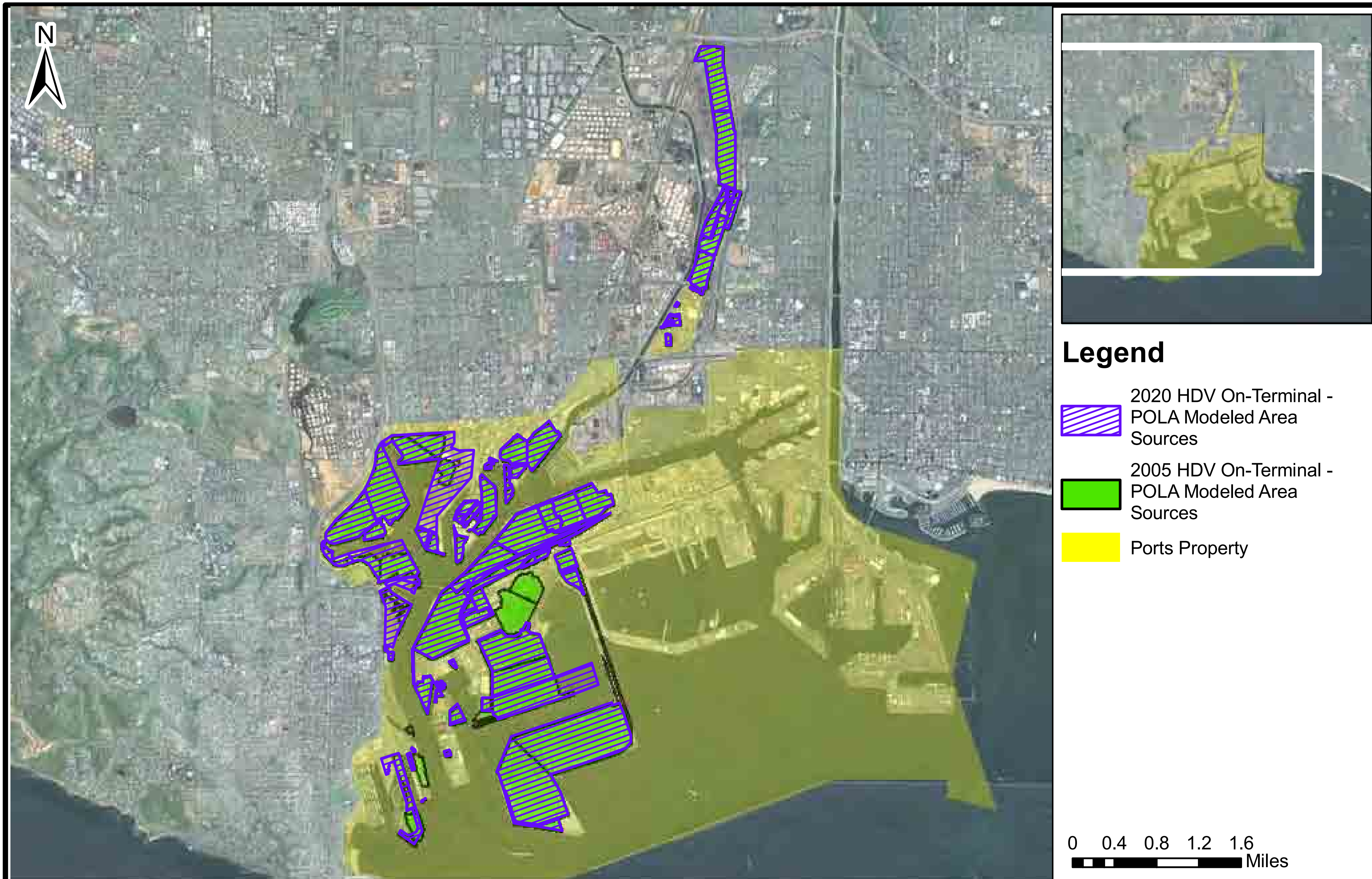
**Locations of Modeled Sources**
**Heavy Duty Vehicles Off-Port Road Modeled Volume Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-19

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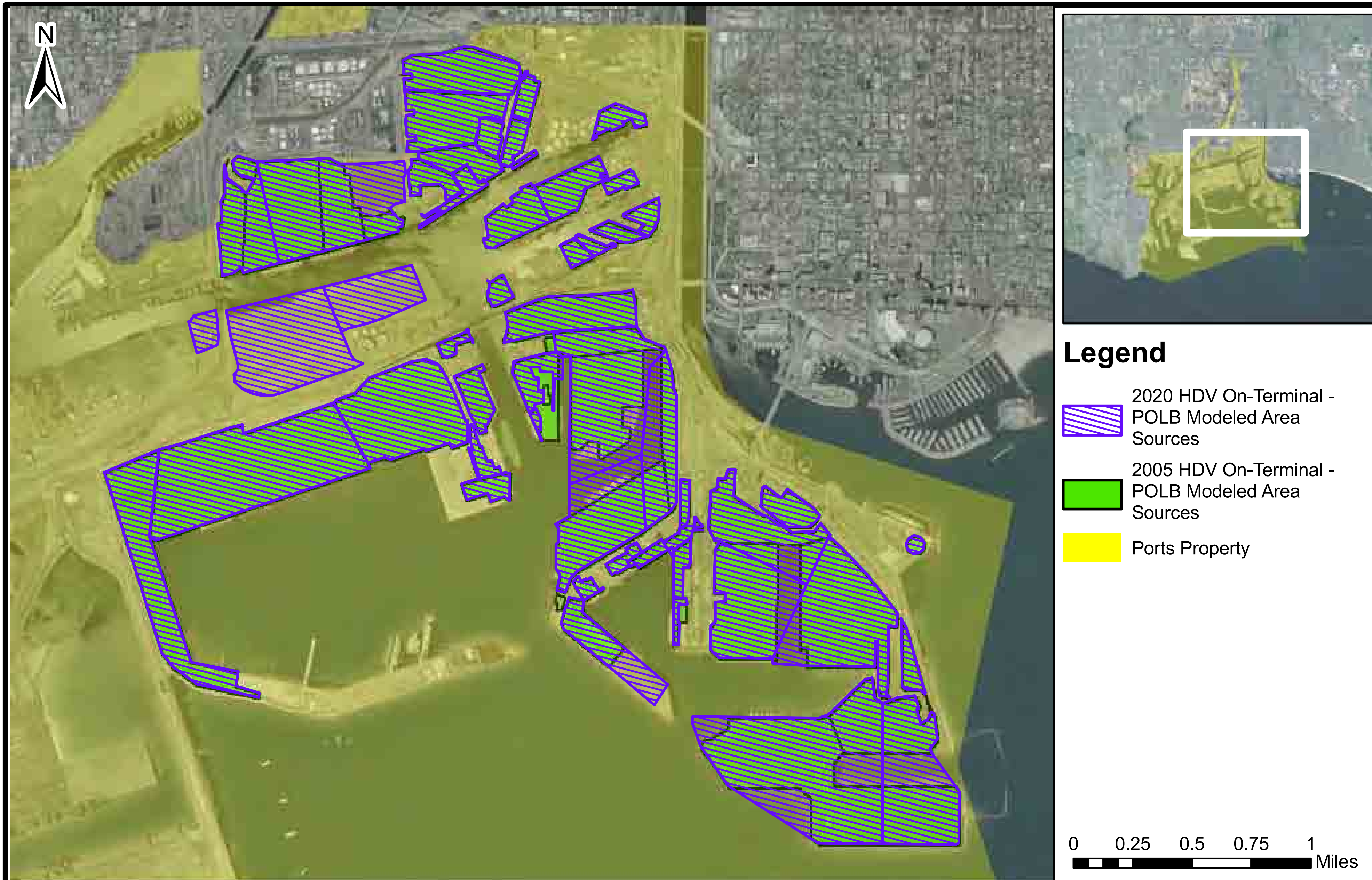
**Locations of Modeled Sources**
**Heavy Duty Vehicles On-Terminal POLA Modeled Area Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-20

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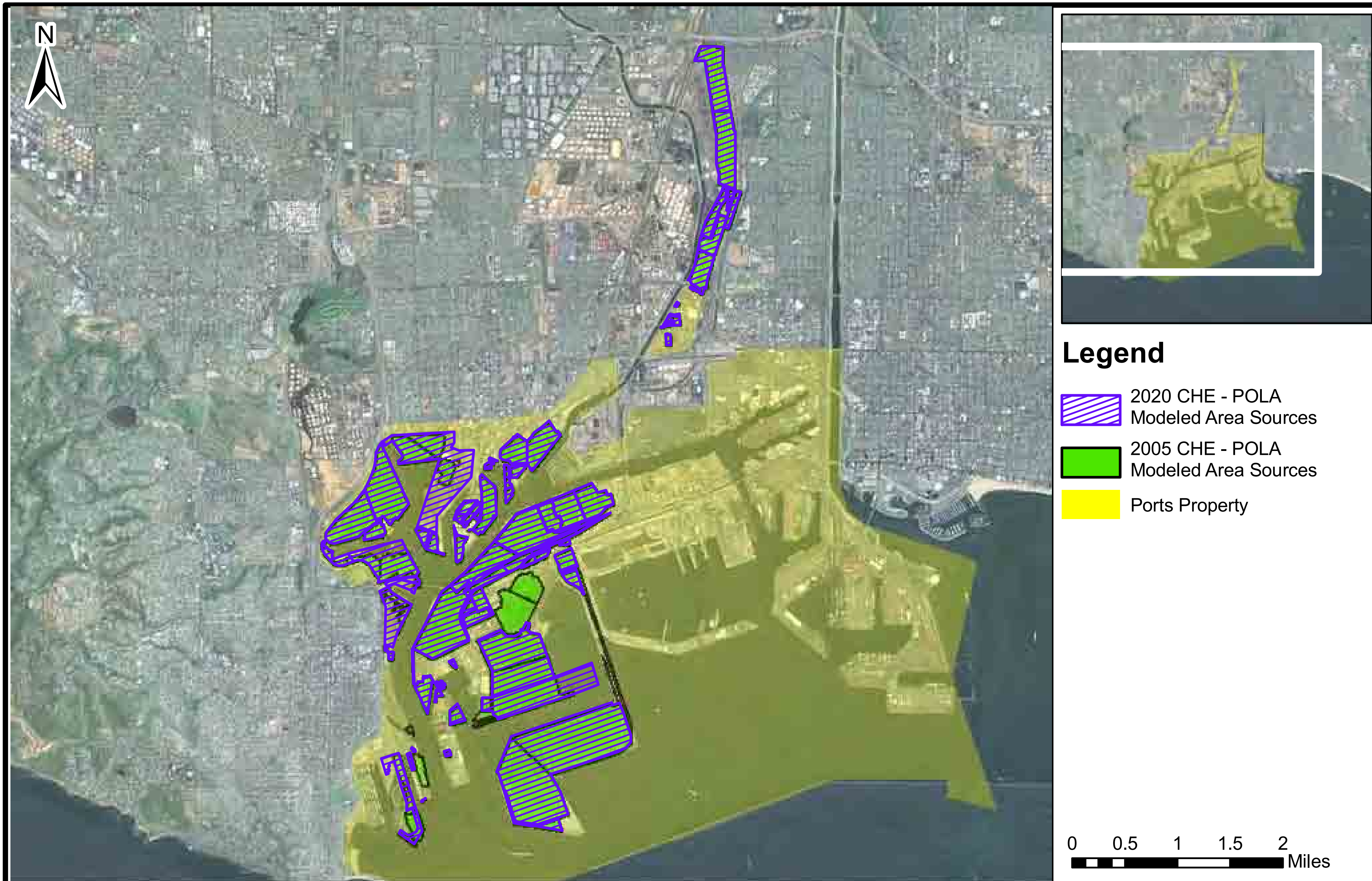
**Locations of Modeled Sources**
**Heavy Duty Vehicles On-Terminal POLB Modeled Area Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-21

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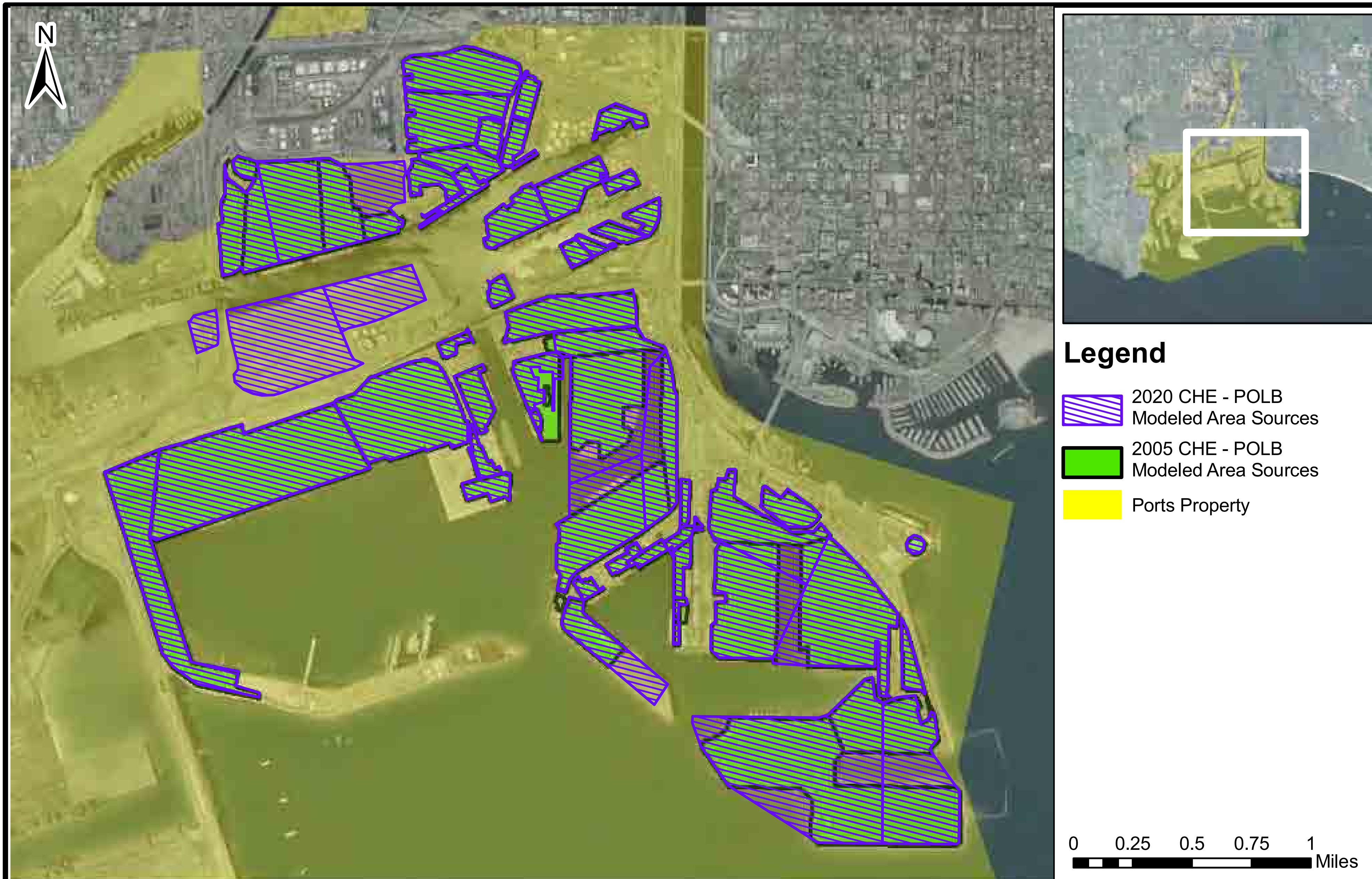
**Locations of Modeled Sources**
**Cargo Handling Equipment POLA Modeled Area Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-22

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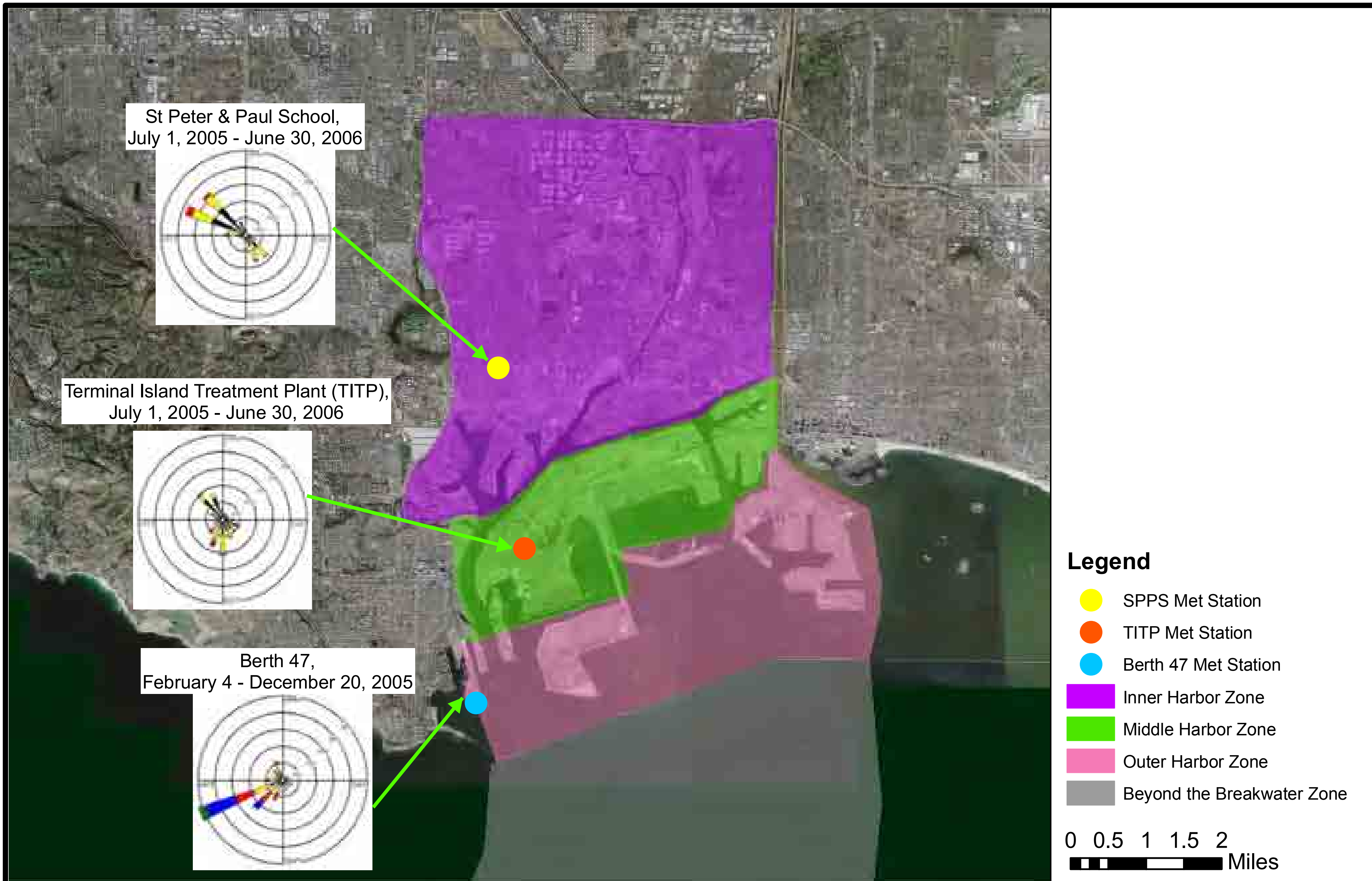
**Locations of Modeled Sources**
**Cargo Handling Equipment POLB Modeled Area Sources**
**2005 and 2020 Spatial Allocation**
**San Pedro Bay Ports, California**

Figure

B-23

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**Wind Patterns for Surface Meteorological Stations and Zones of Operations**
**San Pedro Bay Ports, California**

Figure

B-24

# Appendix C:
## Health Risk Assessment Methodology
## Supplemental Information

## Appendix C:

### Health Risk Assessment Methodology, Supplemental Information

# Contents



# ACRONYMS and ABBREVIATIONS

| | |
|---|---|
| ARB | Air Resources Board |
| BWHRA | Bay-Wide Health Risk Assessment |
| Cal/EPA | California Environmental Protection Agency |
| CEQ | Council on Environmental Quality |
| CEQA | California Environmental Quality Act |
| CSF | Cancer Slope Factor |
| DPM | Diesel Exhaust Particulate Matter |
| EC | Elemental Carbon |
| HEI | Health Effects Institute |
| kg | Kilogram |
| km | Kilometer |
| L | Liter |
| $m^3$ | Cubic Meter |
| mg | Milligram |
| NRC | National Research Council |
| OEHHA | California's Office of Environmental Health Hazard Assessment |
| SCAQMD | South Coast Air Quality Management District |
| SRP | Scientific Review Panel |
| µg | Microgram |
| URF | Unit Risk Factor |
| USEPA | US Environmental Protection Agency |
| USGS | United States Geological Survey |
| WHO | World Health Organization |

# 1 Health Risk Assessment Methodology, Supplemental Information

This Appendix provides details of the methodology used in the Bay Wide Health Risk Assessment (BWHRA) Tool to calculate exposure, individual cancer risk, and population-weighted cancer risk from Ports-associated sources of diesel exhaust particulate matter (DPM). Information is also provided regarding the basis of the DPM cancer slope factor (CSF). The Appendix concludes with a discussion of some of the key uncertainties of the health risk assessment.

## 1.1 Calculation of Exposure

In the BWHRA Tool, exposure of residential receptors to DPM in ambient air was calculated from the following equation:

$$Exposure = \frac{Ca \times BR \times EF \times ED \times CF}{AT} \qquad \text{(Eq. C-1)}$$

$C_a$ = Concentration of DPM in Air (mg/ $m^3$)
BR = Breathing Rate (302 L/kg-day)
EF = Exposure Frequency (350 days/year)
ED = Exposure Duration (70 years)
CF = Conversion Factor (1000 L/$m^3$).
AT = Averaging Time (25,550 days)

Exposures were calculated using discrete DPM emission rates estimated for 2005 and 2020 and held constant over the subsequent respective 70-year averaging periods (see Appendix B).

### 1.1.1 Calculation of Individual Cancer-Risk Attributable to DPM

Individual cancer risk was estimated by calculating the upper-bound incremental probability that an individual will develop cancer over a lifetime as a direct result of exposure to DPM. The equation used to calculate potential excess cancer risk is:

$$Risk = Exposure \times CSF \qquad \text{(Eq. C-2)}$$

*Exposure = Exposure to DPM in air (*mg/kg-d)
*CSF = DPM cancer slope factor* 1.1 $(mg/kg\text{-}d)^{-1}$.

### 1.1.2 Calculation of Population-Weighted Cancer-Risk Attributable to DPM

Cancer risks were also analyzed by calculating population-weighted average risk associated with Ports DPM sources for the baseline year of 2005 and for predicted emissions in 2020. Population-weighted risk was calculated as:

$$\text{Risk}_{\text{population-weighted}} = \frac{\sum \text{Risk}_i \times \text{Population}_i}{\sum \text{Population}_i} \qquad \text{(Eq. C-3.)}$$

Where:

*$Risk_i$ = estimated cancer risk at receptor* i*;*
*$Population_i$ = population of area around receptor* i.

In the context of population-weighted average risk, receptors represent point locations on two Cartesian grids distributed throughout the modeling domain. The spacing of the receptors within the grids, and the basis for that spacing, are described in section 3.5 of the main BWHRA Tool report. United States Census Bureau data for the year 2000 were used to calculate the population for both 2005 and 2020. Cancer risk for the population within the vicinity of each receptor was estimated by first calculating DPM-attributable cancer risk (Eq. C-2) and then multiplying that risk by the population in the area around the specific modeled receptor ($Risk_i \times Population_i$). Population-weighted average residential cancer risk for the modeling domain was calculated by summing all receptor-related risks and dividing by the population within the modeling domain as shown in Eq.C-3.

## 1.2 OEHHA's Cancer Slope Factor for Diesel Exhaust Particulate Matter

In 1998, the Scientific Review Panel (SRP) of the California Environmental Protection Agency (Cal/EPA) determined that diesel exhaust is carcinogenic to humans (Office of Environmental Health Hazard Assessment [OEHHA] 1998b), and the Air Resources Board (ARB) subsequently listed diesel exhaust as a toxic air contaminant (1998c). A key supporting document for the SRP determination was a human health risk assessment of diesel exhaust conducted by the OEHHA (1998a). OEHHA's assessment focused on evaluating epidemiologic evidence of the relationship between exposure to diesel exhaust and the likelihood of developing lung cancer. Although multiple epidemiologic studies were considered by OEHHA (1998a), a study of railroad workers (Garshick et al. 1988) served as the primary basis for OEHHA's unit risk factor (URF). Cal/EPA's analysis (OEHHA 1999, 2002) resulted in a range of URFs for DPM, $1.3 \times 10^{-4}$ to $2.4 \times 10^{-3}$ $(\mu g/m^3)^{-1}$, with a "reasonable estimate" recommended by the SRP of $3.4 \times 10^{-3}$ $(\mu g/m^3)^{-1}$. That URF translates to a CSF of 1.1 $(mg/kg)^{-1}$.

At approximately the time the OEHHA diesel exhaust risk assessment was finalized, the Diesel Epidemiology Expert Panel was formed by the Health Effects Institute (HEI) – a group that was jointly funded by the United States Environmental Protection Agency (USEPA) and by industry (HEI 1999). One of the specific goals of this Panel was to evaluate the Garshick et al. (1988)

data and to determine its suitability for quantitative risk assessment. Relying in part on the findings of the HEI Panel as well as on an independent analysis of the Garshick et al. (1988) data by Crump et al. (1991), the USEPA concluded that the existing epidemiological data on diesel exhaust were not adequate to support a quantitative assessment of the relationship between exposure and effect. As a consequence of this determination, the USEPA opted not to develop or otherwise identify a CSF or URF for diesel exhaust (USEPA 2002; 2004). This conclusion does not affect the USEPA's classification of diesel exhaust as a probable human carcinogen, but rather, only addresses the adequacy of available data to quantify the relationship between exposure and cancer in humans.

The limitations of the Garshick et al. (1988) data as identified by the HEI Panel (1999), Crump (1991), and the USEPA (2002, 2004) included: inadequate information on exposure to diesel exhaust (i.e., assigning who was exposed and who was not exposed); lack of knowledge of when workers first began working with diesel equipment; and lack of information on smoking and other lifestyle correlates of lung cancer risk. Of particular note, and a fact acknowledged by Garshick in a follow-up publication, is that lung cancer risks among the exposed cohort decreased with increasing length of exposure – the opposite trend from what is expected for a carcinogen. The results of a subsequent study (Garshick et al. 2004), in which the study cohort were followed for a longer period of time, found the same trend (Garshick et al. 2004). This suggests that the original observation of a negative correlation between exposure and lung cancer risk was not an artifact attributable to a truncated follow-up period. Nonetheless, OEHHA has retained its original recommendation for the URF for diesel exhaust of $3.4 \times 10^{-3}$ $(\mu g/m^3)^{-1}$. Those values are recommended for use in risk assessments conducted to support Proposition 65, the California Environmental Quality Act (CEQA), and various air toxics programs in California. Consistent with this usage, cancer risks in the BWHRA Tool associated with exposure to DPM are calculated based on the CSF derived from OEHHA's URF for DPM.

# 2 Uncertainties Associated with Health Risk Assessment

There is inherent uncertainty in all health risk assessments, with the source(s) of that uncertainty dependent on the specific assumptions and models used to estimate risk (Council on Environmental Quality [CEQ] 1989).

In accordance with recommendations for an uncertainty analysis described in CEQ (1989) and the National Research Council (NRC 1994), the key uncertainties and critical assumptions associated with the health risk estimation of the BWHRA Tool are described below. The uncertainties associated with air dispersion modeling used in the BWHRA Tool are discussed in Appendix B.

## 2.1 Uncertainty in the Carcinogenicity of DPM

Although there is general agreement among key US and European regulatory agencies (e.g., the World Health Organization [WHO] 1996) that DPM is a likely human carcinogen, there is considerable uncertainty in the nature of the relationship between DPM exposure and the likelihood of developing cancer. That uncertainty stems in part from a "general lack of understanding" of the mechanism(s) by which DPM elicits toxicity in humans (USEPA 2002). Additionally, it is not understood whether health effects linked to diesel emissions from older diesel engines are relevant to current emission profiles and their effects (USEPA 2002). There are also specific and significant questions regarding the appropriateness of the epidemiologic data used by OEHHA (1998a) to develop the CSF for DPM. Each of these factors, alone or in combination, have the potential to significantly affect the dose-response relationship – and thus the DPM CSF – and as a consequence, the level of risk attributed to DPM exposure. To illustrate the magnitude of potential uncertainty in risk estimates of DPM, it is informative to consider risk levels for DPM calculated using the component-based methodology contained in the USEPA's *Guidelines for the Health Risk Assessment of Chemical Mixtures* (USEPA 1986) and the subsequent *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures* (USEPA 2000). Distinct from the approach taken in the BWHRA Tool, this methodology involves the identification of key toxicologically-significant components of a mixture, and the estimation of risk attributable to each component. Estimates of total risk are developed by assuming additivity of risk from all component carcinogens. Although the approach contained in these USEPA (1986, 2000) guidance documents is typically recommended for relatively simple mixtures with approximately a dozen or fewer components (USEPA 2000), use of this methodology may be appropriate when information is lacking on the health effects of a mixture. Risk assessments of DPM performed using this component type of approach have calculated health risks that were one to two orders of magnitude lower than the risk estimated using OEHHA's CSF developed from that value (Muller 2002; ENVIRON 2006). Since completion of these analyses, both the USEPA and OEHHA have identified naphthalene, a DPM component, as a carcinogen. Had Muller (2002) and ENVIRON (2006) included naphthalene in the cancer risk calculated using the components-based approach, the difference in estimated risks between that method and that of the OEHHA CSF would likely decrease.

## 2.2 Uncertainty in the Role of DPM in Health Effects from Exposure to Particulate Matter Pollution

The evidence that links particulate matter (PM) to adverse health effects is substantial; reports have consistently demonstrated a correlation between long-term exposure to either $PM_{10}$ or $PM_{2.5}$ (PM with aerodynamic diameters of 10 or 2.5 microns or less, respectively) to non-cancer adverse health effects (see review by Pope and Dockery 2006). Documented health effects from chronic exposure to PM include premature mortality (Pope et al. 1995; Krewski et al. 2000; Laden et al. 2006), respiratory disease (Abbey et al. 1995), and impaired lung development in children (Gauderman et al. 2007). A recent review and analysis of PM health effects (ARB 2008a) cited evidence that premature mortality is associated with chronic exposure to $PM_{2.5}$ levels as low as 5µg/$m^3$, and the World Health Organization (2005) has concluded that adverse health effects from $PM_{2.5}$ can occur from chronic exposure to 3-5 µg/$m^3$ - levels that are at (or just above) background for the US and Europe.

Determining the contribution of DPM to these effects requires identifying the extent to which health effects attributable to $PM_{10}$ or $PM_{2.5}$ are due to the DPM fraction of PM. This question is the source of significant controversy and uncertainty, due in large part to the fact that there is no currently-available method to measure and attribute DPM's contribution to the PM fractions in ambient air. DPM is emitted from the combustion of diesel fuel by on-road and off-road vehicles and equipment, becoming a component of ambient PM; however, estimates of DPM as a percentage of the PM inventory vary widely. The primary component of DPM, elemental carbon (EC) (USEPA 2002), is often measured as a surrogate for DPM. However, EC is also a combustion product of gasoline-fueled engines, barbeques, fuel wood, and other lesser sources, making it a highly inaccurate surrogate. While there have been efforts to identify specific and quantifiable indicators of DPM as a component of PM, these efforts have not yielded definitive results. Consequently, while DPM emissions contribute to PM levels, and likely contribute to health effects other than cancer, the uncertainties in current estimation methods of these effects (e.g., ARB 2008b) remain substantial.

## 2.3 Uncertainties in Exposure Assumptions

Consistent with OEHHA and South Coast Air Quality Management District (SCAQMD) guidance (OEHHA 2003; SCAQMD 2005), individual cancer risks were estimated assuming that residents at the receptor points spend 70 years at one location. Use of the 70-year exposure duration in risk assessments is intended to produce a hypothetical estimate of risk that does not underestimate actual risks and that can be viewed as an upper-bound estimate. To illustrate the conservative nature of the 70-year assumption, it is worth noting that the USEPA has estimated that 50% of the U.S. population lives in the same residence for only nine years, while only 10% remain in the same house for 30 years (USEPA 1997). Adults, moreover, spend only 68-73% of their total daily time at home (USEPA 1997), rather than the 100% assumed in the BWHRA Tool. In addition, due to potential filtration provided by building envelopes and ventilation systems, indoor DPM concentrations resulting from Ports operations are likely to be lower than the outdoor concentrations assumed in this analysis (OEHHA 2003). Accordingly, the actual risks to hypothetical residential receptors are likely to be significantly lower than those calculated in this assessment.

## 2.4 Uncertainties in Population-weighted Average Risk

The population weighted risk calculations were based on 2000 census data that was applied to both 2005 and 2020. Although this assumption is likely to be reasonably accurate for the 2005 calculations of population-weighted average risk, in introduces uncertainty into the 2020 risk estimates. Notwithstanding that fact, predicting 2020 populations within the modeling domain would have likely introduced greater uncertainty into risk estimates, although the magnitude of that uncertainty cannot be readily quantified.

An additional component of uncertainty in the population-weighted average risk calculations is attributable to the fact that census tracts were divided in order to approximate the population of the receptor grid used to calculate population-weighted risk for each receptor location. This approach likely does not reflect actual population distributions, nor does it address potential changes in population distribution over time.

## 2.5 Summary

The risks calculated in the BWHRA Tool were estimated using a series of conservative assumptions regarding exposure concentrations, magnitude and duration of exposure, and carcinogenic potency of DPM. These assumptions, applied in a manner consistent with current guidance (OEHHA 2003; ARB 2003), tend to produce upper-bound estimates of risk, ensuring that these values do not underestimate the actual risks posed by DPM emissions from the ports. It is important to note that the risks calculated in the BWHRA Tool do not necessarily represent the actual risks experienced by populations in the modeling domain. By using standardized conservative assumptions in a risk assessment, the USEPA (1989) has noted that:

> *"These values [risk estimates] are upper-bound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero."*

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