

**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)**

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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 |
| 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):

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

| 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:

| 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

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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 ARB². 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 ARB³. 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 March 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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