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Modeling Evaluation Protocol J.R. Davis (Roseville) Rail Yard Study – Revised

prepared for:

Union Pacific Railroad

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1. INTRODUCTION

The purpose of this protocol is to describe the steps needed to evaluate modeled Diesel particulate matter (DPM) levels around the Union Pacific Railroad J.R. Davis (Roseville) Rail Yard compared to monitored DPM levels. This evaluation will help to quantify the level of potential bias in the air dispersion modeling conducted by the California Air Resources Board (ARB) in the Roseville Rail Yard Study (ARB, 2004), and in modeling conducted in support of other rail yard health risk assessments. In addition, this modeling evaluation may provide useful information regarding the interpretation of data collected in the Roseville Rail Yard Air Monitoring Program (RRAMP).

Air dispersion models are mathematical approximations of atmospheric processes that predict ambient concentrations based on emissions and meteorological inputs. The model used in the Roseville Study, Industrial Source Complex Short-Term Version 3 (ISCST3), was designed as a regulatory model to be used to demonstrate the impact of emission controls in efforts to achieve air quality standards, and to determine if a proposed facility complies with Prevention of Significant Deterioration (PSD) allowable ambient air quality increments. As such, its developers at the U.S. Environmental Protection Agency (EPA) sought a model that would not underestimate concentrations for averaging time periods of regulatory interest (i.e., 1 hour to 1 year). The resulting ISCST3 can both over- and underestimate concentrations under specific conditions. ISCST3 has now been replaced by the AERMOD[1] modeling system as EPA's preferred model. The AERMOD system includes enhancements in the preprocessing of meteorological, land-use and terrain data for characterizing dispersion, as well as in the dispersion calculations related to plume rise, downwash, and turbulent diffusion.

Under a Memorandum of Understanding (MOU) between ARB, Union Pacific Railroad (UPRR), and Burlington Northern Santa Fe (BNSF), dispersion modeling has been conducted for UPRR and BNSF rail yards throughout California. The results of this modeling were used by ARB to estimate population exposure and health risks associated with rail yard-related emissions. The objective of this modeling was to provide realistic estimates of actual potential exposure levels in the vicinity of rail yards. The RRAMP data provide a resource that may allow estimation of the level and direction of potential modeling bias, and identification of the conditions under which bias occurs.

Section 2 describes the emission inventory data, meteorological data, monitoring data, and other basic data that need to be assembled to conduct the evaluation. Section 3

[1] AERMOD = American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) Model.

describes the protocol by which modeling results comparable to those developed in ARB's Roseville Study will be generated and compared with monitoring data collected around the rail yard as part of the RRAMP study. Section 4 provides citations for references used herein.

2. DATA NEEDS

This section discusses the data that will be used to conduct the evaluation. Air quality data from the RRAMP study will be used along with data to develop modeling inputs covering the RRAMP study period. The modeling-related data include emissions, meteorological, land use, and terrain data. Because the RRAMP program also included nitric oxide (NO) and nitrogen dioxide (NO_2) concentration measurements, which were not addressed in the Roseville Study (i.e., the study only included locomotive PM emissions), estimates of locomotive emissions of both PM and nitrogen oxides (NOx) will be modeled. Due to the greater precision of ambient NO/NO_2 measurements as compared with surrogate ambient DPM measurements, a comparison of modeled versus monitored concentrations of these pollutants may provide a more accurate basis for model evaluation. The three types of data to be assembled are ambient air quality data, emissions data for air dispersion modeling, and meteorological data; each is discussed separately below.

2.1 Ambient Air Quality Data

In the RRAMP study, four monitoring stations, arranged as two pairs across the width of the Roseville rail yard, were operated between mid-June and mid-October of 2005, 2006, 2007, and 2008. Each station was equipped to measure the following air quality parameters:

- Black carbon (BC) (by aethalometer);
- $PM_{2.5}$ (by beta attenuation monitor and by 24-hour integrated gravimetric federal reference method);
- $PM_{2.5}$ elemental carbon (EC) (by thermal optical reflectance[2]);
- $PM_{2.5}$ organic carbon (OC) (by thermal optical reflectance);
- Nitric oxide (NO) (by chemiluminescence); and
- Nitrogen oxides ($NOx = NO + NO_2$) (by chemiluminescence).

The quality-assured data for these variables will be assembled for the four monitoring periods.

[2] Desert Research Institute. *DRI Standard Operating Procedure: Thermal/Optical Reflectance Carbon Analysis of Aerosol Filter Samples,* DRI SOP 2-204.6, Revised June 2000.

2.2 Modeling Data – Emissions

The Roseville Study developed DPM emission estimates for the 1999-2000 period on each type of locomotive activity within the railyard, and assigned to selected source locations within the yard for purposes of modeling. More detailed and automated procedures have been developed by UPRR in the course of its work supporting the ARB railyard MOU. These detailed procedures have been applied to DPM emissions from locomotive train and service activity data at the Roseville railyard for 1999-2000, 2005, 2006, and 2007 (Ireson, 2008). More recently, the procedures have been applied to calculate NOx emissions for these four one-year periods. The same procedures will also be applied to generate 2008 NOx and DPM estimates. These emissions estimates will be processed in the same manner as those supporting the ARB railyard MOU (e.g., Appendixes A, J, and K of Sierra Research, 2007b) to produce spatially and temporally resolved emission inputs for modeling. The emissions estimates reflect changes over time in the amount of freight handled, the number and types of trains, the distribution of locomotive models and emission control technologies, locomotive service and maintenance activity, and fuel quality.

For the four RRAMP monitoring periods, monthly, day of week, and diurnal activity profiles will be developed for train activity. Service and shop release data for these periods will be used to develop monthly activity profiles for each year, and they will be examined to determine if defensible higher resolution temporal activity profiles can be developed.

2.3 Meteorological Data

Meteorological data collected at the Roseville rail yard during the four RRAMP study periods will be assembled. The data were collected with sensors on a tower inside the yard that complied with PSD regulatory requirements. Wind speed and direction data were collected at each of the four monitoring sites. The meteorological and related data will be preprocessed to produce the required inputs for both ISCST3 and AERMOD. For ISCST3, the meteorological tower wind and temperature data will be organized into the required format using either the PCRAMMET ISCST3 preprocessor program or another approach that may better represent atmospheric stability and mixing heights, depending on the availability of concurrent data for sky cover. Concurrent upper air data from Oakland International Airport will be used in this preprocessing.

Inputs for AERMOD will be generated using the AERMET preprocessor program. This preprocessing will follow the protocol developed for modeling conducted under the ARB-UPRR MOU (Sierra Research, 2007a) with the exception that the primary source of surface meteorological data will be the RRAMP tower rather than a nearby National Weather Service station. Meteorological tower data include temperature, delta T (Δ_T, temperature difference between 2 m. and 10 m.), wind speed and direction, sigma theta (σ_Θ, variability in wind direction), relative humidity, barometric pressure, and solar radiation. These data will be used in conjunction with concurrent Oakland International

Airport upper air data in AERMET preprocessing. Terrain and land use data will be preprocessed according to the MOU protocol to provide Bowen ratio, surface albedo, and surface roughness inputs for modeling.

Concurrent vector wind data from the ARB Roseville station will be obtained and similarly processed into ISCST3- and AERMOD-ready files. For both sets of surface data, model inputs will be prepared only for the summer RRAMP monitoring periods.

For purposes of model evaluation, the same seven-hour periods (10PM – 5AM PST) used in the RRAMP data analysis (Campbell and Fujita, 2008) will be compared with model predictions. These periods were identified during the RRAMP data analysis as having the most consistent meteorology for detecting upwind-downwind concentration differences presumed to be attributable to rail yard emissions (i.e., light to moderate winds from the southeast).

3. EVALUATION PROTOCOL

3.1 Emission Scenarios

Five emission scenarios will be evaluated: the original 1999-2000 period, and the RRAMP monitoring periods during 2005, 2006, 2007, and 2008. For consistency, all five emission scenarios will be based on the methods described in Ireson (2008).

3.2 Receptors

The modeling domain will consist of a 20 km x 20 km area centered on the rail yard. Within that domain, a fine-resolution Cartesian receptor grid using 50 m spacing will be developed that covers the areas close to the yard, including the locations of the four RRAMP monitoring locations. A coarse-resolution Cartesian receptor grid (200–500 m spacing) will cover the rest of the domain. Discrete receptors will represent the four RRAMP monitoring locations, and a tier of four rows of closely-spaced receptors (i.e., 25 m between rows and between receptors) will be placed along the northwest yard boundary to more precisely determine maximum concentrations that commonly occur near the boundary.

3.3 Meteorological Scenarios

An ISCST3 simulation will be conducted for each emission scenario using the original meteorological scenario in the ARB study (ARB Roseville and McClellan AFB wind data), and a separate ISCST3 run will be made using the corresponding year inputs based on the RRAMP meteorological tower and ARB Roseville wind data. Separate simulations will be conducted with urban and rural dispersion coefficients. AERMOD simulations will be conducted for each emission scenario using AERMET-generated inputs for the corresponding year meteorological data from the RRAMP monitoring tower and the ARB Roseville monitoring station.

3.4 Model Setup and Runs

The base year (1999–2000) emission scenario will be modeled using all of the meteorological scenarios. Each of the 2005, 2006, 2007, and 2008 emission scenarios will be modeled using eight ISCST3 meteorological scenarios—the original Roseville

and McClellan data sets and the concurrent data from the RRAMP meteorological tower and ARB Roseville monitoring station, each using urban and then rural dispersion coefficients. Similarly, each of the four RRAMP emission scenarios will be modeled using two AERMOD meteorological scenarios—the concurrent year RRAMP meteorological tower and ARB Roseville monitoring station inputs.

Output options will be set to predict hourly concentrations at each receptor from each of various groups of sources (e.g., load testing, service and shop idling, ready track and departure yard idling, hump and trim). To assess spatial variability of predictions, period-average receptor grid concentrations for all receptors outside the rail yard boundary will be generated and plotted for selected nightly periods of interest. Comparisons between modeled and monitored concentrations will be based on the aggregate average of the nightly average values for those periods in which quality-assured ambient concentration data are available. A minimum of five hours of quality-assured ambient concentration and meteorological data will be used to develop a nightly data set. Comparisons between ISCST3 and AERMOD scenarios for each year and between years for each model will be made based on period-average concentration patterns (i.e., concentration isopleths).

3.5 Handling of the Air Quality Monitoring Data

To facilitate comparison of monitored and modeled concentrations, the black carbon concentration, measured by aethalometer and the $PM_{2.5}$ concentration measured by the two methods of beta attenuation and thermal optical reflectance will be tabulated side-by-side with concurrent model-predicted concentrations for nightly periods of interest, and for the underlying 1-hour averages during these periods. For the purposes of this comparison, the conversion equations relating estimated DPM to black carbon (BC) as developed in the RRAMP data analysis will be used (Campbell and Fujita, 2008, p. 3-3).

3.6 Comparison of Predictions and Observations

The combined model prediction and RRAMP observation data will be processed to produce a series of plots of predicted concentration difference vs. measured difference between upwind-downwind pairs of RRAMP data. Plots will include scatter plots of predicted and observed concentrations paired in time and space; quantile-quantile plots (ranked and paired in space) of predictions and observations; and means with error bars of all periods of interest for predictions and observations. Linear regression will be used to identify intercepts, slopes, and apparent bias in predictions relative to observations. All comparisons will be based on nightly (seven-hour) averages of model results and monitoring data.

3.7 Comparisons Between Models and Emission Scenarios

Domain-wide predicted concentration isopleths will be developed for each RRAMP period based on modeling results for all times of the day. Statistics will be developed describing these simulation results for receptors outside of the rail yard boundary, and will be compared both between years and between the three modeling approaches (ISCST3-urban, ISCST3-rural, and AERMOD). Statistics will include maxima, spatially averaged concentrations, and land area exposed at and above various concentration levels. If fine receptor grid results suggest that maximum values may be influenced by modeling artifacts (previously observed where model receptors and sources were in close proximity), then spatial averaging to a coarser resolution of 100 m will be used to minimize the potential for misinterpretation of results.

3.8 Documentation and Reporting

The plots described in Sections 3.6 and 3.7 will be assembled and reviewed for consistency and plausible interpretations. To the extent that a specific factor is critical to the findings (e.g., the use of ARB's Roseville monitoring station vector-averaged wind data versus use of scalar-averaged wind data from the on-site meteorological tower, or use of rural versus urban dispersion coefficients), further analysis of related inputs (e.g., stability roses for periods of interest) may be conducted. A brief technical memorandum will be prepared to present these plots, related analyses, and a summary of findings regarding possible bias in the Roseville modeling,

To the extent possible, the memorandum will discuss the implications of observed potential bias in similar modeling for other rail yards, and will identify possible methods to minimize, or at least identify and estimate, the magnitude of such potential biases in similar modeling studies.

4. REFERENCES

ARB (2004). "Roseville Rail Yard Study," California Air Resources Board, Sacramento, CA, October 14, 2004.

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