AERMOD and CAL3QHCR: Dispersion Models for PM Hot-spot Analyses

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Completing a PM Hot-spot Analysis

**Step 1** Determine Need for Analysis

**Step 2** Determine Approach, Models, and Data

**Step 3** Estimate On-Road Motor Vehicle Emissions
- Is project located in California?
  - Yes: Estimate using MOVES
  - No: Estimate using EMFAC

**Step 4** Estimate Emissions from Road Dust, Construction, and Additional Sources

**Step 5** Select Air Quality Model, Data Inputs, and Receptors

**Step 6** Determine Background Concentrations

**Step 7** Calculate Design Values and Determine Conformity

**Step 8** Consider Mitigation or Control Measures

**Step 9** Document Analysis
Dispersion Modeling Resources

http://www.epa.gov/ttn/scram/displacement_prefrec.htm

Preferred/Recommended Models

These refined dispersion models are listed in Appendix W and are required to be used for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. The models in this section include the following:

AERMOD Modeling System - A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

CALPUFF Modeling System - A non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

Other Models - Other dispersion models including BLP, CALINE, CALINOX, CALINOC, CIMPUS, and OOD.

AERMOD Modeling System

The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMMC) was formed to introduce state-of-the-art modeling concepts into the EPA's air quality models. Through AERMMC, a modeling system, AERMOD, was introduced that incorporated air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMOD, a meteorological data processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERCPF, a terrain data processor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include: AERPROC, a screening version of AERMOD; APRESURF, a surface characteristics processor, and BERTPRT, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

At this time, AERMOD does not calculate design values for the lead NAAQS (rolling 3-month averages). A post-processing tool, LEADPOST, is available to calculate design values from monthly AERMOD output. This tool calculates and outputs the rolling cumulative (all sources) 3-month average concentration at each modeled receptor with source group contributions and the maximum cumulative (all sources) rolling 3-month average concentration by receptor.

Below is the model code and documentation for AERMOD Version 11/03. The model code and supporting documents are not static but evolve to accommodate the best available science. Please check this website often for updates to model code and associated documents. As of December 9, 2000, AERMOD is fully promulgated as a replacement to ISC3. In accordance with Appendix W.

AERMOD Implementation Guide
AERMOD Implementation Guide (PDF) - Provides information on the recommended use of AERMOD for particular applications and is an evolving document. (Updated March 19, 2009.)

Model Code
README (txt)
Executable (80K, dp)
Source Code (2MB, dp)
Test Cases (21 MB, dp)

Model Documentation
README (txt)
Model Change Bulletin #1 (txt)
Model Change Bulletin #2 (txt)
Model Change Bulletin #3 (txt)
Model Change Bulletin #4 (txt)
User's Guide and Addendum (zip)
Model Formulation Document (PDF)
Addendum To the AERMOD Model Formulation Document (PDF) - PVMX technical description
PVMX and OLM Sensitivity Analysis (PDF)
Performance Evaluation of the AERMOD User Interface and Building Emission Model (PDF)
AERMOD and CAL3QHCR Models

Atmospheric Scale: Project-level

Exposure Scale: Short-term and Long-term

Pollutant Applicability: Inert Pollutants

Regulatory Applicability: Highways and Transit (AERMOD)
Highways (CAL3QHCR)

Mathematical Class: Gaussian

Level of Sophistication: Refined
Project-Level Atmospheric Scale

Wind Direction

Pollutant Concentration

Increasing

Background & Local Component

Background

Highway

Distance Normal to Highway
Air Dispersion Model Conception

**Meteorology**
- Wind Speed
- Wind Direction
- Atmospheric Stability
- Mixing Height

**Emissions**
- Highway Configuration
- Traffic Parameters
- Emission Factors

**Air Dispersion Model**
- Traffic-induced turbulence
- Transport
- Diffusion

**Receptor Concentration**
Physical Representation of Transport and Diffusion of Emissions

AERMOD and CAL3QHCR are steady-state Gaussian dispersion models

- Emission rate, wind speed and direction, and atmospheric stability are constant during the life of the plume
- Concentrations are assumed to follow a Gaussian distribution in the cross-wind horizontal and vertical directions

adapted from Turner, 1970
Plume Dispersion and Atmospheric Stability

AERMOD
- Cross-wind plume dimensions are a continuous function of ambient turbulence

CAL3QHCR
- Cross-wind plume dimensions are a function of 6 discrete stability categories from Slade, 1968
AERMOD Area Source / Receptor Configuration

Location Coordinates
- Xs, Ys = Area source vertex
- Xcoord, Ycoord = Receptor

- Xinit = Length of X side
- Yinit = Length of Y side
- Angle = Orientation angle
AERMOD Volume Source / Receptor Configuration

Location Coordinates
- \(X_s, Y_s = \) Center of volume source
- \(X_{\text{coord}}, Y_{\text{coord}} = \) Receptor

\[X_s, Y_s\]

Note: Adjacent rows of volume sources centered on each lane could be used to represent different lanes.

\[\text{Wind}\]

\[\text{Syinit}\]

\[X_{\text{coord}}, Y_{\text{coord}}\]

- \(W = \) Highway width
- \(\text{Syinit} = \) Initial lateral dimension \((W / 2.15)\)
CAL3QHCR Link / Receptor Configuration

Location Coordinates

- XL1, YL1 = Link centerline start
- XL2, YL2 = Link centerline end
- XR, YR, ZR = Receptor

- WL = Mixing zone width
- SH = Source height
Traffic-Induced Turbulence

**AERMOD**
- Determined manually, may be specified by hour of day

**CAL3QHCR**
- Algorithm included in the model

from Benson, 1979
Met Data Processing Steps

Data can be obtained from a variety of sources
- May require pre-processing
  - AERMINUTE: 1-min surface data
  - Mixing height program: radisonde data

QA / QC procedures
- http://www.epa.gov/ttn/scram/surface/missdata.txt

Converting data formats may be required

AERMET / MPRM met data processors
- Stage 1: Extract and quality assurance
- Stage 2: Merge
- Stage 3: Process and create files for use in dispersion models
Modifications to CAL3QHCR*

Increase the limit on numbers of receptors from 60 to 5,000

Increase the limit on numbers of links from 120 to 5,000

Eliminate the internal rounding of 1-hour average concentration predictions (formerly a 0.1 µg/m3 or 0.1 ppm)

Increase the precision of the concentration predictions reported in the model output to 6 significant figures

*40 CFR 51, App W, Section 3.1.2 (b) allows for modifications to CAL3QHCR provided that the concentration estimates remain unaffected
Modifications to CAL3QHCR*

Include the highest, 6th highest 24-hour average concentration predictions in the model output

Add the ability to create plot files of the highest, 6th highest 24-hour average and period average PM concentrations

*40 CFR 51, App W, Section 3.1.2 (b) allows for modifications to CAL3QHCR provided that the concentration estimates remain unaffected.
CAL3i Functions

Integrates EPA’s CALINE3, CAL3QHC, and CAL3QHCR models into one computer program package

Provides interactive graphical forms for entering data

Extends the utility of the models

Facilitates model operation in a Microsoft® Windows® environment
Data Forms

Data entered via forms organized by:
1. Program control
2. Receptors
3. Links
4. Emissions
5. Meteorology

[Image of a computer interface with data entry forms and a graph showing data analysis]
### Application Description
- **Job Title:** Metro Transit Facility
- **Run Title:** Northside Interchange Access

### Model Selection
- CALINE3
- CAL3QHC
- CAL3QHCR

### Screening Level
- **User Enters All**
- EPA Default Data Values
- Tier I Approach
- Tier II Approach

### Input / Output Control
- **Length Units of Input Data:** Feet
- **Specify the Scale Conversion Factor to Meters:**
- **Length Units in Output:** Feet
- **Model Output Options:**
  - Link Contributions
  - Add Background
- **Pollutant (Concentration Units):** PM-2.5 (μg/m3)

### Generate a Simplified Receptor / Highway Layout for Screening - Optional
- **Add Travel Lanes**
  - Northbound/Southbound: 6
  - Eastbound/Westbound: 6
- **Total Number of Lanes:**
- **Refine the Receptor / Highway Layout**
- **Change the Traffic Signal Data**

### Receptor / Highway Layout Map (feet)

| 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8  | 7  | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9  | 8  | 7  | 6  | 5  | 4  | 3  | 2  | 1  | 0  |

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Program Control

Application Description

Model Selection

Screening Level
• Tier approach

Input / Output Control

Generate a Simplified Receptor / Highway Layout for Screening
Receptors

Data Record View

Controls Provided for Navigating through Records
### Receptors

**Data Grid View**

**Controls Provided for Navigating through Records**

<table>
<thead>
<tr>
<th>RCP - Receptor Name</th>
<th>XR (feet)</th>
<th>YR (feet)</th>
<th>ZR (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Leg, E Side-Corner</td>
<td>46.0</td>
<td>46.0</td>
<td>5.9</td>
</tr>
<tr>
<td>N Leg, E Side - 25 m</td>
<td>46.0</td>
<td>118.0</td>
<td>5.9</td>
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<tr>
<td>N Leg, E Side - 50 m</td>
<td>46.0</td>
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<td>N Leg, E Side-Midblk</td>
<td>46.0</td>
<td>636.0</td>
<td>5.9</td>
</tr>
<tr>
<td>N Leg, W Side-Corner</td>
<td>-46.0</td>
<td>46.0</td>
<td>5.9</td>
</tr>
<tr>
<td>N Leg, W Side - 25 m</td>
<td>-46.0</td>
<td>118.0</td>
<td>5.9</td>
</tr>
<tr>
<td>N Leg, W Side - 50 m</td>
<td>-46.0</td>
<td>200.0</td>
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<tr>
<td>N Leg, W Side-Midblk</td>
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<td>636.0</td>
<td>5.9</td>
</tr>
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<td>S Leg, E Side-Corner</td>
<td>46.0</td>
<td>-46.0</td>
<td>5.9</td>
</tr>
<tr>
<td>S Leg, E Side - 25 m</td>
<td>46.0</td>
<td>-118.0</td>
<td>5.9</td>
</tr>
<tr>
<td>S Leg, E Side - 50 m</td>
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<td>S Leg, W Side-Midblk</td>
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<td>-636.0</td>
<td>5.9</td>
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</tbody>
</table>
Links – Tier II Approach

Data Record View

Controls Provided for Navigating through Records
Links – Tier II Approach  (Data Grid View)

**STEP 3: Enter / Edit Links**

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<tr>
<th>Q</th>
<th>LNK</th>
<th>TYP</th>
<th>XL1</th>
<th>YL1</th>
<th>XL2</th>
<th>YL2</th>
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<td>-1200</td>
<td>18</td>
<td>0</td>
<td>55.7</td>
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</table>
Emissions – Tier II Approach
Meteorology  (View of CAL3QHCR Met Data File)
Model Results – Summary Table

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<tr>
<th>Rec</th>
<th>1-hr Avg Conc</th>
<th>1-hr Avg</th>
<th>8-hr Avg</th>
<th>8-hr Avg Conc</th>
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<td>3.3</td>
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<td>2.9</td>
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<td>4.5</td>
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<td>2.9</td>
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</tbody>
</table>

**CALQHC Results (ppm CO)**
Model Results – Chart

STEP 5: View Results Chart | CAL3i

Application Description
Job Title: Metro Transit Facility
Run Title: Westside Signalized Intersection

CAL3QHC Results (ppm CO)
1-hr Avg | 8-hr Avg

Receptor Number 1 to 28, with CO levels ranging from 0 to 9 ppm.
## Model Results – Output

![CALQHC Results](image)

**CALQHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 9/221**

**JOB: Metro Transit Facility**

**RUN: Westside Signalized Intersection**

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### SITE & METEOROLOGICAL VARIABLES

- **VS**: 0.0 CM/S
- **VD**: 0.0 CM/S
- **U**: 1.0 M/S
- **CLAS**: 4 (D)
- **Z0**: 10.8 CM
- **ATIM**: 60 MINUTES
- **MIXH**: 1000 M
- **AMH**: 0.0 PPM

### LINK VARIABLES

<table>
<thead>
<tr>
<th>LINK DESCRIPTION</th>
<th>X1</th>
<th>Y1</th>
<th>V1</th>
<th>X2</th>
<th>Y2</th>
<th>LENGTH (FT)</th>
<th>BRG TYPE</th>
<th>VPM</th>
<th>EF</th>
<th>M</th>
<th>W</th>
<th>V/C QUEUE</th>
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</thead>
<tbody>
<tr>
<td>1. N Leg App – FreeFlow</td>
<td>-18.0</td>
<td>0.0</td>
<td>-18.0</td>
<td>1200.0</td>
<td>*</td>
<td>1200.</td>
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<tr>
<td>3. S Leg App – FreeFlow</td>
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<td>*</td>
<td>1200.</td>
<td>360.</td>
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<td>-18.0</td>
<td>-18.0</td>
<td>1200.0</td>
<td>*</td>
<td>1200.</td>
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<td>7. E Leg App – FreeFlow</td>
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<td>-18.0</td>
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<td>*</td>
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<td>360.</td>
<td>AG</td>
<td>3111.</td>
<td>10.0</td>
<td>0.0</td>
<td>35.7</td>
</tr>
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</table>

**DATE**: 7/20/11

**TIME**: 5:59:26