Technical Support Document (TSD) for AERMOD/BLP Development and Testing

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Technical Support Document (TSD) for AERMOD/BLP Development and Testing

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Preface

This document provides information on the implementation and testing of the buoyant line source algorithms from the Buoyant Line and Point (BLP) model into AERMOD.

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1. Introduction

The proposed revisions to the U.S. Environmental Protection Agency's (EPA's) *Guideline on Air Quality Models*, published as Appendix W to 40 CFR Part 51, include the addition of a buoyant line source into AERMOD. The proposal is to include the algorithms from the Buoyant Line and Point (Schulman and Scire, 1980) dispersion model (BLP).

This document briefly describes the code changes that were made to AERMOD, changes to the BLP code to allow a comparison of concentration estimates from the two models without any missing data or calm winds, the processing of the meteorological data so the same meteorological conditions were used for both models, receptor and source configurations, model-to-model comparisons, and several results from input and output options in AERMOD that are not available in BLP.

2. Background

The BLP dispersion model was created to simulate the transport and diffusion of emissions from aluminum reduction plants in which some of the emissions are released through continuous ridge ventilators a few meters wide on multiple structures. The releases are buoyant and low-level (i.e., elevated, not ground level) in which the plumes from the individual lines likely interact. Since BLP was developed in the 1970's, it lacks the capabilities to process current day meteorological data archive formats and generate results compatible with current forms of ambient air quality (AAQ) standards, such as the 1-hour SO2 standard.

The current version available on EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website is version 99176, i.e., last updated in 1999. At that time BLP was changed 1) to read Industrial Source Complex Short Term (ISCST) type meteorological data in ASCII format and 2) a command line interface was added to the programs so that input and output filenames could be read from a MS-DOS prompt without having to use the "<" and ">" file redirection symbols.

3. Source Code Modifications

3.1 AERMOD

The algorithms that form the core of the BLP (version 99176) calculations were first implemented in AERMOD version 15181. For this phase of development, the buoyant line algorithms were ported unchanged from BLP to AERMOD. However, the BLP code structures were moved or changed to work within the AERMOD framework. Some of the key changes to the BLP algorithms incorporated into the AERMOD source code include:

- adding input control keywords specific to a processing a buoyant line source (additional keywords and parameters are described in the appendix),
- updating the processing of the input information (e.g., defining source and receptor data),
- updating many of the BLP algorithms to current Fortran coding structures,
- adding or changing variable names in BLP algorithms as needed to match AERMOD variable names,
- adding a new module to AERMOD to centralize the global variables associated with the buoyant line processing, and

- declaring real variables and constants in the module and routines as double precision.

One example of changes to coding structures in the BLP algorithms is BLP's ubiquitous use of GOTO statements and other obsolete branching structures to control conditional programming and looping. Most of those structures were replaced with IF..THEN..ELSE..ENDIF and SELECT..CASE structures. However, some of the GOTO statements were retained since deconstructing those structures would require a greater effort to maintain the correct flow of the algorithms. Another example of code updates is the use of named DO loop structures.

BLP version 99176 is very limited in the number of sources (up to 10 lines in a single buoyant line source and 51 point sources) and receptors (up to 100) that can be processed in a single model run. As part of the porting process, array size limitations imposed by BLP were changed to allocatable arrays in AERMOD.

BLP does not allow receptors defined as a grid network (i.e., starting/stopping coordinates, number of nodes, and node increment) to be located within the rectangle defined by the minimum and maximum extents of buoyant lines. This area will be referred to as the exclusion zone. Figure 1 shows an example of an original set of sources (the angled lines identified as OLine *n* in the legend), the translated and rotated lines[1] (the horizontal lines identified as RLine *n* in the legend), and the exclusion zone defined by the translated and rotated lines. This exclusion zone was implemented in AERMOD when the receptor networks are processed. Two important distinctions need to be made regarding the exclusion zone defined in BLP that are not carried over to AERMOD:

1. Receptors are excluded from the modeling for both buoyant line sources and point sources; AERMOD only excludes the receptors for buoyant lines.
2. An exclusion zone is only defined and applied for a gridded network of receptors; if discrete receptors are modeled, no exclusion zone is defined; in AERMOD, receptors are omitted independent of how receptors are defined (discrete, Cartesian grid, polar grid).

The following source code files were modified in the process of incorporating BLP into AERMOD: aermod.f, modules.f, setup.f, soset.f, reset.f, metext.f, inpsum.f, calc1.f, output.f, evset.f, evcalc.f, and evoutput.f.

[1] BLP translates the sources and receptors to the origin by first subtracting the (x,y) coordinate of the starting point of the first line of the buoyant line source followed by a rotation so the first line is parallel to the x-axis.

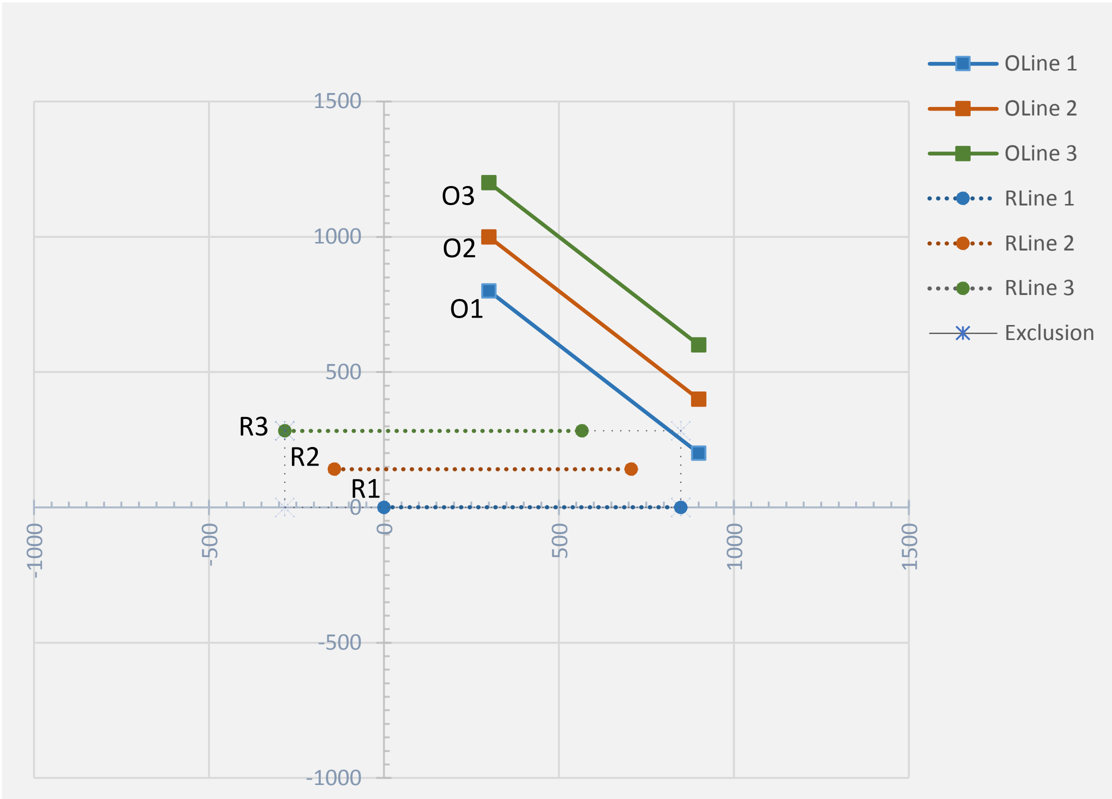

Figure 1. Definition of the Exclusion Zone for a Source Oriented 45 Degrees from Horizontal

3.2 BLP

Some modifications were made to BLP to compare concentration estimates from AERMOD and BLP. The version of BLP available from EPA's SCRAM website is limited to processing 100 receptors. For a more extensive comparison, the BLP code was changed to process 1000 receptors.

Hours with calm winds or missing data (as denoted by missing data indicators) invariably accompany meteorological data. If the missing data indicators are left in the meteorology, BLP will use them. If calm winds are present, BLP will use them and eventually stop due to a reaching a maximum number of iterations (i.e., not converging on a solution) too often. As a result, subsets of days were selected to model. However, using a subset of days introduced another problem with BLP - it will fail if the start day is any day other than January 1. The end date is not a problem. BLP was modified to allow the start date to match the date in the meteorological data files used in the model-to-model comparison. A discussion of the meteorology and how it was processed for this comparison can be found below.

4. Meteorology for Testing

Meteorology from the 1982/83 Baldwin evaluation database available from EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website was used to test the implementation of the buoyant line source into AERMOD. The Baldwin database contains a complete year of meteorology (8,760 hours) using both NWS and site-specific data. The output meteorology from AERMET has no missing or calm winds for the entire year. As a result, the AERMET surface file did not require modification to eliminate any troublesome hours.

4.1 Converting AERMET Data to PCRAMMET format for the BLP

A program was written to convert AERMET data (after persisting to eliminate problematic data) to the ASCII data format that BLP is able to process. The LTOPG subroutine in AERMOD was used to convert Monin-Obukov length (L) to a Pasquill-Gifford stability category for BLP. As required by BLP, wind directions from AERMET were converted to flow vectors. Finally, the maximum mixing height for the hour as estimated by AERMET (convective and mechanical for daytime hours ($L < 0$) and only mechanical for nighttime hours ($L > 0$)) was used for both rural and urban mixing heights for BLP.

5. Receptors

Local coordinates and Universal Transverse Mercator (UTM) coordinates were used in the various test scenarios. Since BLP cannot process local coordinates unless the lines are horizontal and the southwest corner of the set of buoyant lines is at (0, 0), UTM coordinates were created by adding an arbitrary easting and northing value to a system of local coordinates. This arbitrary addition of easting and northing values does not affect the results since the coordinate system is translated to (0, 0) and rotated such that the sources are parallel to the x-axis. All lines in the buoyant line source and receptors are referenced to this translated and rotated coordinate system when AERMOD and BLP are performing the calculations.

6. Sources

The coordinates used for the various line orientations are shown with each set of results. According to the BLP user's guide (Schulman and Scire, 1980), "[t]he plume rise formulation for multiple buoyant finite line sources … assumes the line sources are equally spaced, with identical heights, widths, buoyancy parameters, and line lengths. These assumptions allow evaluation of the plume rise enhancement effects of multiple line sources. For the plume rise calculations, therefore, a set of averaged line source characteristics must be input." For all simulations, the buoyant line parameters shown in Table 1 were used for this comparison.

Table 1. Buoyant Line Source Input Parameters

Building Length (m)	Building Height (m)	Building Width (m)	Line Width (m)	Building Separation (m)	Buoyancy Parameter (m^4/s^3)
848.0	20.0	100.0	2.0	37.5	300.0

7. Model-to-Model Results

For model-to-model comparisons, several source configurations were examined for flat terrain. The configuration of the receptor network, - 961 receptors in a 31 x 31 node arrangement - remained the same for all source configurations. The sources were located away from the receptor network such that the source did not overlap the receptor network. The results for each configuration are discussed below.

The results of the modeling are shown in the tables found in this section. The top 10 concentrations from BLP and AERMOD are shown for 1-hr, 3-hr, 8-hr, 24-hr, and period averages (summer - 61 days). Although there were three other periods of data, the summer period was the longest period. The percent (%) difference is shown in the tables and defined as

$$\% \text{ diff} = (X_{AERMOD} - X_{BLP})/X_{BLP} * 100$$

A negative value indicates that AERMOD's concentration estimate was less than the estimate from BLP.

7.1 Horizontal Source

For the horizontal source, a local coordinate system was defined such that the x-coordinate of the beginning of each of the lines was at 0 meters, the end of the lines was at 600 meters, and the lines were parallel to the x-axis. As noted above, this definition is a requirement of BLP when using local coordinates. Figure 2 shows the configuration for this source. For this configuration, the translated/ rotated lines are coincident with the original lines, thus are not visible in the figure. Table 2 shows the beginning and ending coordinates.

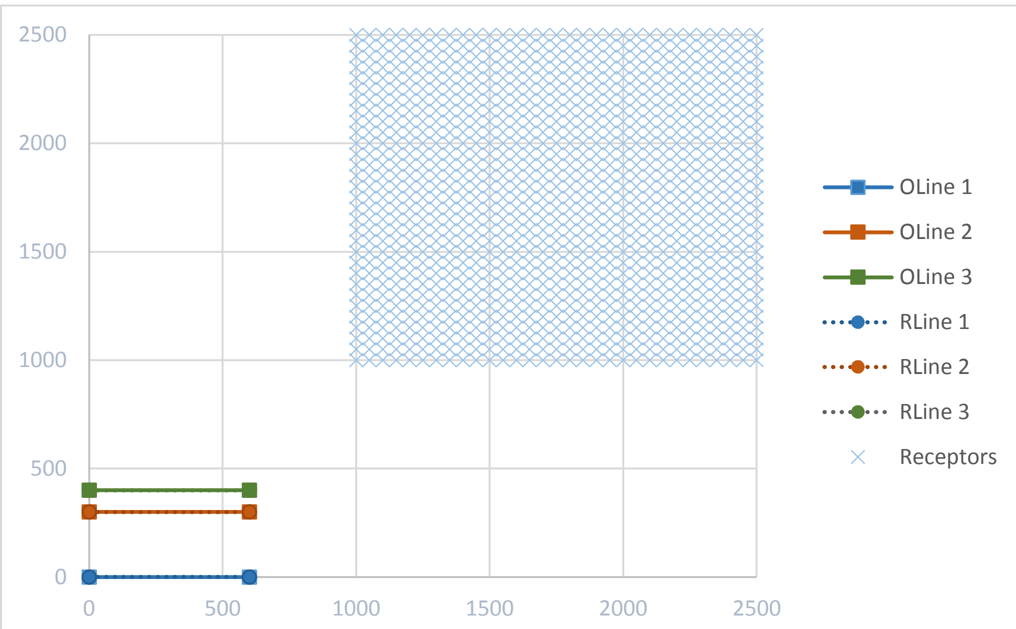

Figure 2. Source Oriented Horizontally.

Table 2. Start and End Points for Horizontal Source Buoyant Line Source

Source ID	$(X,Y)_{start}$	$(X,Y)_{end}$
LINE1	0, 0	600, 0
LINE2	0, 300	600, 300
LINE3	0, 400	600, 400

A gridded Cartesian receptor network was defined with the origin at (0, 0), 31 receptors in both the x- and y-directions, and 50 meter spacing between receptors, resulting in a network of 961 receptors.

The resulting receptor network is shown as light blue markers in Figure 2 with the sources to the upper right of the receptors.

The top 10 concentrations using the Baldwin meteorology is shown in Table 5. AERMOD and BLP are in agreement for all averaging times, ranks, and data sets.

Table 3. Top 10 Concentration Estimates for Buoyant Horizontally Oriented Line Source - Baldwin

Rank	1-hr			3-hr			8-hr		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	13071.5	13071.5	0.0%	5079.4	5079.4	0.0%	3189.4	3189.4	0.0%
2	13025.9	13025.9	0.0%	5070.9	5070.9	0.0%	3189.0	3189.1	0.0%
3	13018.1	13018.1	0.0%	5070.3	5070.4	0.0%	3177.9	3177.9	0.0%
4	13005.5	13005.5	0.0%	5064.2	5064.2	0.0%	3159.0	3159.1	0.0%
5	12913.4	12913.4	0.0%	5063.2	5063.3	0.0%	3151.1	3151.1	0.0%
6	12905.5	12905.6	0.0%	5051.8	5051.9	0.0%	3147.8	3147.8	0.0%
7	12900.0	12900.0	0.0%	5041.8	5041.9	0.0%	3126.9	3126.9	0.0%
8	12898.7	12898.7	0.0%	5037.9	5037.9	0.0%	3092.6	3092.6	0.0%
9	12831.1	12831.1	0.0%	5031.8	5031.8	0.0%	3088.2	3088.2	0.0%
10	12823.3	12823.3	0.0%	5024.4	5024.4	0.0%	3080.0	3080.0	0.0%

Rank	24-hr			Annual		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	1111.5	1111.5	0.0%	91.6	91.6	0.0%
2	1107.0	1107.0	0.0%	91.6	91.6	0.0%
3	1106.1	1106.1	0.0%	91.5	91.5	0.0%
4	1097.3	1097.3	0.0%	91.4	91.4	0.0%
5	1094.5	1094.5	0.0%	91.4	91.4	0.0%
6	1094.1	1094.1	0.0%	91.3	91.3	0.0%
7	1090.3	1090.3	0.0%	91.2	91.2	0.0%
8	1086.9	1086.9	0.0%	90.9	90.9	0.0%
9	1083.8	1083.8	0.0%	90.7	90.7	0.0%
10	1082.4	1082.4	0.0%	90.7	90.7	0.0%

7.2 Angled Source - ~10 degrees from Horizontal

For this source configuration, the start and end points were referenced to an arbitrary UTM coordinate system. The actual coordinate does not correspond to any particular point on the earth's surface, but the magnitudes of the coordinates are correct. Table 4 shows the UTM coordinates used in the modeling and Figure 3 shows the orientation of the three lines. To better visualize the relationship of the buoyant line source and the line source after it was translated and rotated, the two leading digits on the x-coordinate and three leading digits on the y-coordinate were omitted so both sets could be shown on a single graph with sufficient resolution to distinguish the lines. Parentheses in the coordinates in Table 5 indicate the digits that were removed. This convention will be used in subsequent coordinate tables as well.

The solid lines (labeled OLine *n*) are the original positions of the three lines and the dotted lines (labeled RLine *n*) are after the translation to the origin and rotation so the line is parallel to the x-axis. The exclusion zone is shown by the thin solid line bounding the translated/rotated lines. Although there are no receptors in the exclusion zone, it is important to note that the minimum and maximum extents of all the lines in a buoyant line source are used to define the exclusion zone and that the zone does not intersect the end points of each individual line.

Table 4. Start and End Points of Buoyant Line Source Angled 10 Degrees from Horizontal

Source ID	$(X,Y)_{start}$	$(X,Y)_{end}$
LINE1	(50)2300, (400)0800	(50)2900, (400)0700
LINE2	(50)2300, (400)1100	(50)2900, (400)1000
LINE3	(50)2300, (400)1200	(50)2900, (400)1100

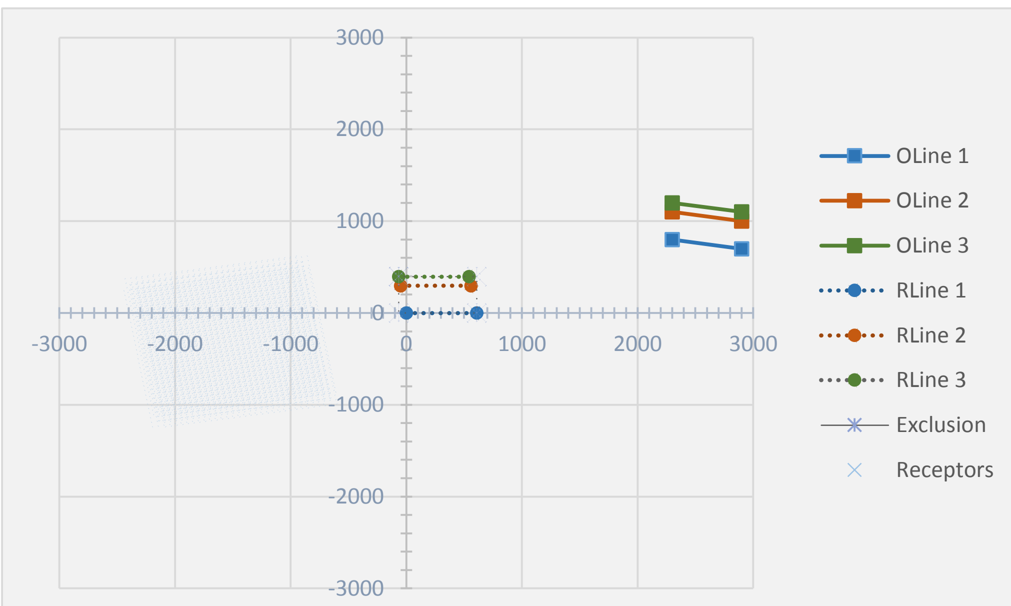

Figure 3. Source Oriented 10 Degrees from Horizontal

A gridded Cartesian receptor network was defined with the lower left corner at (500000, 4000000) and extending to (501500, 4001500). The spacing between grid points was 50 meters, resulting in a network of 961 receptors (31 receptors in the x- and y-directions). All 961 receptors were modeled since none of the receptors intersect the exclusion zone. The translated and rotated receptors are shown as light blue markers in Figure 3.

The top 10 concentrations using the Baldwin meteorology is shown in Table 5. The two models are in agreement.

Table 5. Top 10 Concentration Estimates for Buoyant Line Source Oriented 10 Degrees - Baldwin

Rank	1-hr			3-hr			8-hr		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	7256.8	7256.8	0.0%	5271.7	5271.7	0.0%	2548.1	2548.1	0.0%
2	7199.0	7199.0	0.0%	5179.9	5179.9	0.0%	2482.9	2482.9	0.0%
3	7049.7	7049.7	0.0%	5085.2	5085.3	0.0%	2472.4	2472.4	0.0%
4	7032.4	7032.4	0.0%	5058.5	5058.5	0.0%	2273.9	2273.9	0.0%
5	7003.1	7003.2	0.0%	4971.3	4971.3	0.0%	2254.1	2254.1	0.0%
6	6962.8	6962.8	0.0%	4947.1	4947.1	0.0%	2253.8	2253.8	0.0%
7	6898.4	6898.4	0.0%	4945.7	4945.8	0.0%	2251.8	2251.8	0.0%
8	6827.6	6827.6	0.0%	4933.9	4933.9	0.0%	2232.9	2232.9	0.0%
9	6818.5	6818.6	0.0%	4909.3	4909.3	0.0%	2221.8	2221.8	0.0%
10	6738.4	6738.4	0.0%	4847.7	4847.7	0.0%	2217.9	2217.9	0.0%

Rank	24-hr			Annual		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	1233.1	1233.1	0.0%	108.2	108.2	0.0%
2	1189.8	1189.8	0.0%	107.0	107.0	0.0%
3	1165.1	1165.1	0.0%	104.9	104.9	0.0%
4	1159.3	1159.3	0.0%	102.7	102.7	0.0%
5	1146.4	1146.4	0.0%	102.3	102.3	0.0%
6	1125.2	1125.2	0.0%	100.8	100.8	0.0%
7	1116.4	1116.4	0.0%	100.8	100.8	0.0%
8	1114.4	1114.4	0.0%	100.4	100.5	0.1%
9	1092.1	1092.0	0.0%	98.6	98.7	0.1%
10	1088.0	1088.0	0.0%	98.6	98.6	0.0%

7.3 Angled Source - ~45 degrees from Horizontal

This source configuration with the source embedded in the receptor network raised concern about the implementation of the buoyant line algorithms into AERMOD version 15181. A more complete discussion of this issue is presented later in this document. For this comparison, however, the sources were located away from the receptor network, just like in the other non-horizontal source configurations.

Table 6 shows the coordinates used for this scenario and Figure 4 shows the orientation of the three lines. The solid lines (OLine *n*) are the original positions (as shown in the table) and the dotted lines (RLine *n*) are after the translation to the origin and rotation so the line is parallel to the x-axis. To better visualize the relationship between the original and translated/rotate source, the leading digits of the UTM coordinate are not used in the figure. The exclusion zone is shown by the thin solid line bounding the translated/rotated lines.

Table 6. Start and End Points of Buoyant Line Source Angled 45 Degrees from Horizontal

Source ID	$(X,Y)_{start}$	$(X,Y)_{end}$
LINE1	(50)2300, (400)0800	(50)2900, (400)0200
LINE2	(50)2300, (400)1000	(50)2900, (400)0400
LINE3	(50)2300, (400)1200	(50)2900, (400)0600

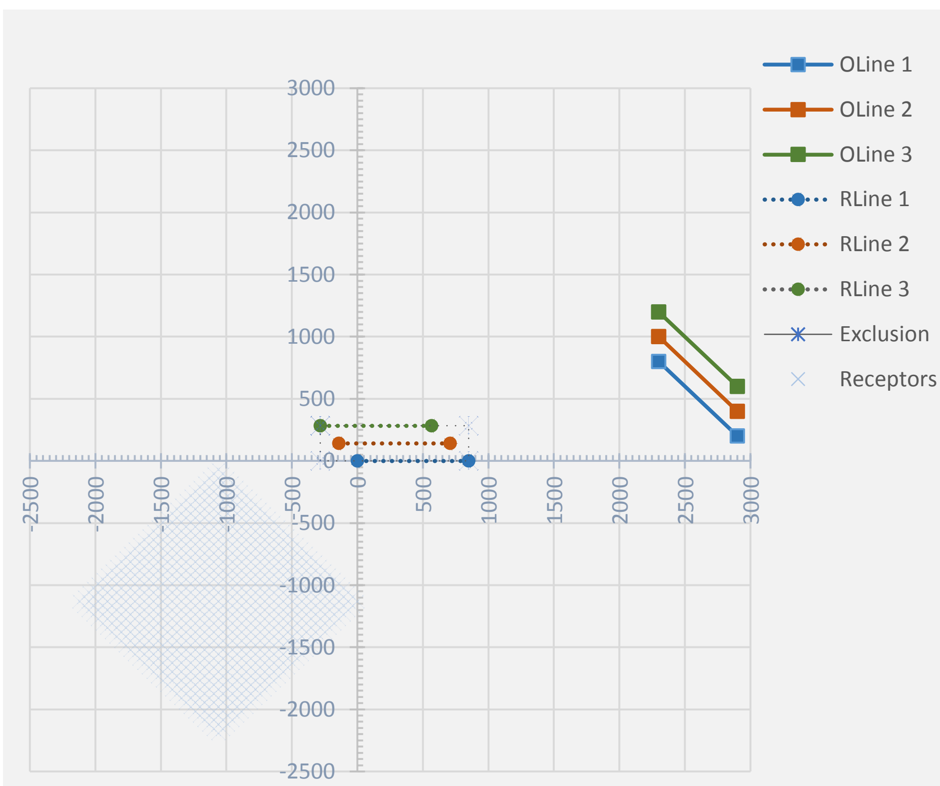

Figure 4. Source Oriented 45 Degrees from Horizontal

A gridded Cartesian receptor network was defined with the lower left corner at (500000, 4000000) and extending to (501500, 4001500). The spacing between grid points was 50 meters, resulting in a network of 961 receptors (31 receptors in the x- and y-directions). All 961 receptors were modeled since none of the receptors intersect the exclusion zone.

The top 10 concentrations using the Baldwin meteorology is shown in Table 7. The two models are in agreement.

Table 7. Top 10 Concentration Estimates for Buoyant Line Source Oriented 45 Degrees - Baldwin

Rank	1-hr			3-hr			8-hr		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	7646.7	7646.7	0.0%	5053.5	5053.5	0.0%	2468.9	2468.9	0.0%
2	7559.0	7559.0	0.0%	5043.9	5043.9	0.0%	2468.4	2468.5	0.0%
3	7518.5	7518.6	0.0%	5039.9	5039.9	0.0%	2464.9	2464.9	0.0%
4	7503.3	7503.3	0.0%	5039.5	5039.5	0.0%	2463.4	2463.4	0.0%
5	7420.6	7420.6	0.0%	5037.0	5037.1	0.0%	2463.2	2463.2	0.0%
6	7373.4	7373.5	0.0%	4989.2	4989.2	0.0%	2461.4	2461.4	0.0%
7	7358.4	7358.4	0.0%	4951.0	4951.0	0.0%	2460.5	2460.5	0.0%
8	7358.3	7358.4	0.0%	4928.4	4928.4	0.0%	2455.3	2455.4	0.0%
9	7356.1	7356.1	0.0%	4917.7	4917.7	0.0%	2455.0	2455.0	0.0%
10	7329.3	7329.3	0.0%	4913.6	4913.6	0.0%	2453.5	2453.5	0.0%

Rank	24-hr			Annual		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	1421.8	1421.9	0.0%	124.3	124.3	0.0%
2	1419.7	1419.8	0.0%	124.3	124.3	0.0%
3	1413.0	1413.0	0.0%	123.7	123.7	0.0%
4	1396.1	1396.1	0.0%	123.3	123.4	0.1%
5	1394.1	1394.2	0.0%	123.0	123.1	0.0%
6	1393.7	1393.7	0.0%	122.7	122.7	0.0%
7	1387.2	1387.2	0.0%	122.4	122.5	0.0%
8	1380.7	1380.7	0.0%	122.4	122.4	0.0%
9	1377.5	1377.5	0.0%	121.9	121.9	0.0%
10	1367.4	1367.4	0.0%	121.5	121.6	0.0%

7.4 Angled Source - ~85 degrees from Horizontal

For this source, a UTM coordinate system was defined. The actual coordinate does not necessarily correspond to any particular point on the earth's surface, but the magnitudes of the values are correct. Table 8 shows the UTM coordinates used in the modeling and Figure 5 shows the orientation of the three lines. To better visualize the relationship between the original and translated/rotate source, the leading digits of the UTM coordinate are not used in the figure. The solid lines (OLine *n*) are the original positions (as shown in the table) and the dotted lines (RLine *n*) are after the translation to the origin and rotation so the line is parallel to the x-axis. The exclusion zone is shown by the thin solid line bounding the translated/rotated lines.

Table 8. Start and End Points of Buoyant Line Source Angled 85 Degrees from Horizontal

Source ID	$(X,Y)_{start}$	$(X,Y)_{end}$
LINE1	(50)2300, (400)0200	(50)2400, (400)1300
LINE2	(50)2250, (400)0400	(50)2350, (400)1500
LINE3	(50)2200, (400)0600	(50)2300, (400)1700

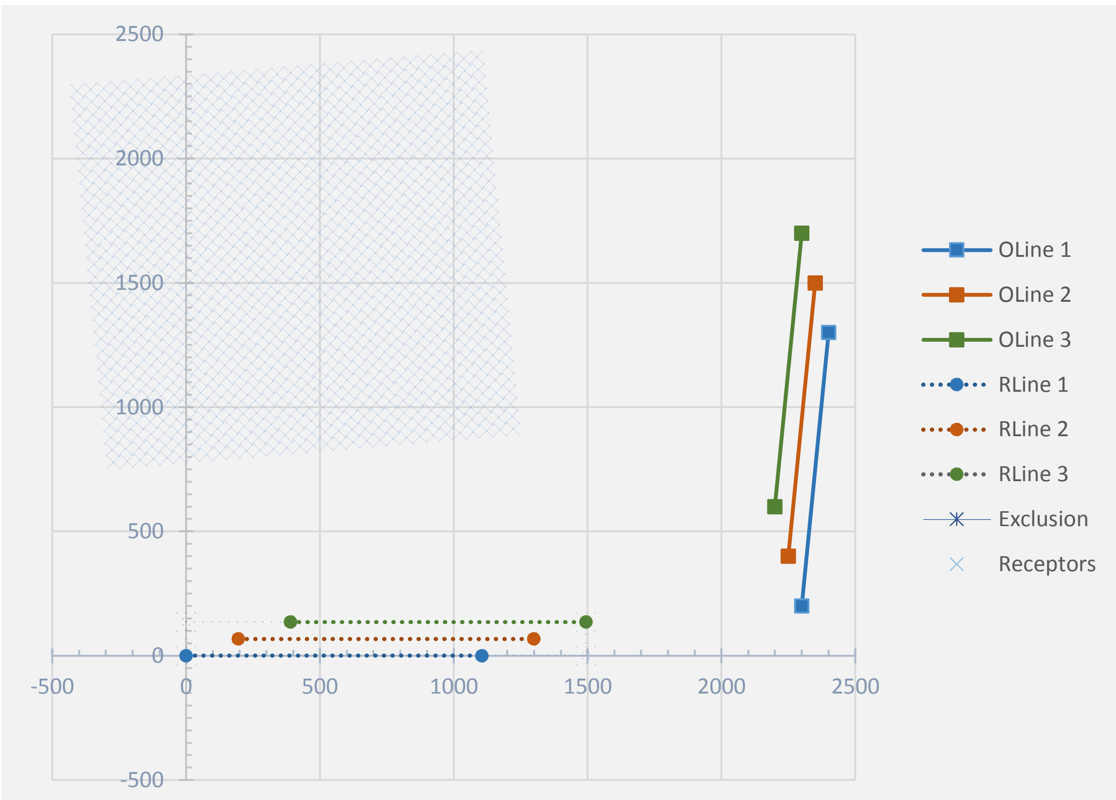

Figure 5. Source Oriented 85 Degrees from Horizontal

A gridded Cartesian receptor network was defined with the origin at (500000, 4000000) and 31 receptors on both the x- and y-axes. The spacing between grid points was 50 meters, resulting in a network of 961 receptors. All 961 receptors were modeled. The translated and rotated receptors are shown as light blue markers in Figure 5.

The top 10 concentrations using the Baldwin meteorology is shown in Table 9.   The two models are in agreement.

Table 9. Top 10 Concentration Estimates for Buoyant Line Source Oriented 85 Degrees - Baldwin

Rank	1-hr			3-hr			8-hr		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	6255.9	6255.9	0.0%	4886.8	4886.8	0.0%	3882.4	3882.4	0.0%
2	6145.9	6146.0	0.0%	4692.3	4692.3	0.0%	3758.6	3758.6	0.0%
3	6100.7	6100.7	0.0%	4533.6	4533.7	0.0%	3670.9	3670.9	0.0%
4	5985.7	5985.7	0.0%	4521.2	4521.2	0.0%	3643.4	3643.4	0.0%
5	5946.5	5946.5	0.0%	4508.0	4508.0	0.0%	3555.8	3555.8	0.0%
6	5832.2	5832.3	0.0%	4466.5	4466.5	0.0%	3532.1	3532.1	0.0%
7	5761.5	5761.6	0.0%	4399.8	4399.9	0.0%	3445.5	3445.5	0.0%
8	5722.9	5723.0	0.0%	4341.5	4341.6	0.0%	3442.9	3442.9	0.0%
9	5683.6	5683.6	0.0%	4334.8	4334.9	0.0%	3425.4	3425.4	0.0%
10	5655.8	5655.8	0.0%	4332.6	4332.7	0.0%	3338.2	3338.3	0.0%

Rank	24-hr			Annual		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	1463.6	1463.6	0.0%	264.8	264.9	0.0%
2	1424.8	1424.8	0.0%	258.5	258.5	0.0%
3	1410.1	1410.1	0.0%	251.6	251.7	0.0%
4	1379.9	1379.9	0.0%	250.1	250.2	0.0%
5	1373.1	1373.1	0.0%	244.5	244.5	0.0%
6	1372.3	1372.3	0.0%	244.3	244.3	0.0%
7	1362.3	1362.4	0.0%	237.7	237.7	0.0%
8	1360.4	1360.3	0.0%	237.3	237.4	0.0%
9	1359.4	1359.4	0.0%	237.2	237.2	0.0%
10	1354.7	1354.7	0.0%	231.5	231.5	0.0%

7.5 Vertical Source

For this scenario, a UTM coordinate system was defined. The actual coordinate does not necessarily correspond to any particular point on the earth's surface, but the magnitudes of the values are correct. Table 10 shows the UTM coordinates used in the modeling and Figure 6 shows the orientation of the three lines. To better visualize the relationship between the original and translated/rotate source, the leading digits of the UTM coordinate is not shown in the figure. The solid lines (OLine *n*) are the original positions (as shown in the table) and the dotted lines (RLine *n*) are after the translation to the origin and rotation so the line is parallel to the x-axis. The exclusion zone is shown by the thin solid line bounding the translated/rotated lines.

Table 10. Start and End Points of Buoyant Line Source Angled Vertically

Source ID	$(X,Y)_{start}$	$(X,Y)_{end}$
LINE1	(50)2500, (400)0000	(50)2500, (400)1000
LINE2	(50)2350, (400)0000	(50)2350, (400)1000
LINE3	(50)2200, (400)0000	(50)2200, (400)1000

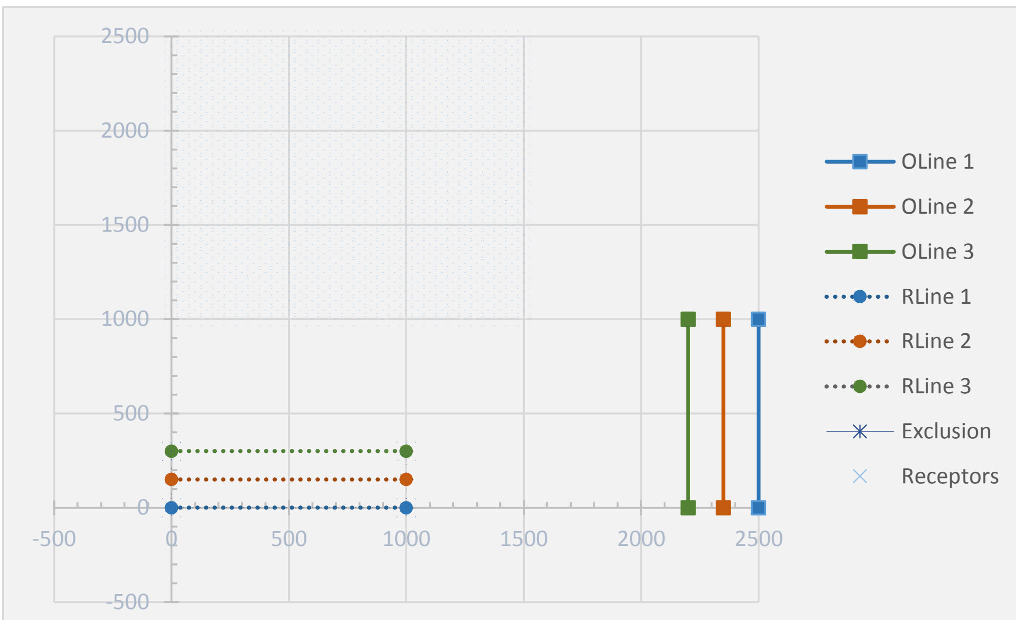

Figure 6. Source Oriented Vertically

A gridded Cartesian receptor network was defined with the origin at (500000, 4000000) and extending to (501500, 4001500). The spacing between grid points was 50 meters, resulting in a network of 961 receptors. All 961 receptors were modeled. The translated and rotated receptors are shown as light blue markers in Figure 6.

The top 10 concentrations using the Baldwin meteorology is shown in Table 11. The two models are in agreement.

Table 11. Top 10 Concentration Estimates for Vertically Oriented Buoyant Line Source - Baldwin

Rank	1-hr			3-hr			8-hr		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	13155.0	13155.0	0.0%	7769.0	7769.0	0.0%	5467.1	5467.1	0.0%
2	13044.0	13043.9	0.0%	7733.9	7734.0	0.0%	5459.0	5459.0	0.0%
3	12986.1	12986.1	0.0%	7719.5	7719.5	0.0%	5423.0	5423.0	0.0%
4	12780.9	12780.8	0.0%	7698.5	7698.5	0.0%	5420.0	5420.0	0.0%
5	12556.7	12556.6	0.0%	7648.4	7648.5	0.0%	5389.6	5389.5	0.0%
6	12301.5	12301.5	0.0%	7621.2	7621.2	0.0%	5372.6	5372.7	0.0%
7	12202.3	12202.3	0.0%	7529.9	7529.8	0.0%	5334.8	5334.7	0.0%
8	11925.3	11925.2	0.0%	7522.9	7522.9	0.0%	5310.9	5310.9	0.0%
9	11637.7	11637.6	0.0%	7437.3	7437.3	0.0%	5255.5	5255.5	0.0%
10	11501.2	11501.2	0.0%	7414.9	7414.9	0.0%	5243.8	5243.8	0.0%

Rank	24-hr			Annual		
	BLP	AERMOD	% diff	BLP	AERMOD	% diff
1	1846.9	1846.9	0.0%	268.3	268.4	0.0%
2	1844.1	1844.1	0.0%	267.5	267.6	0.0%
3	1826.1	1826.1	0.0%	266.9	266.9	0.0%
4	1824.2	1824.2	0.0%	264.6	264.7	0.0%
5	1813.8	1813.8	0.0%	263.4	263.5	0.0%
6	1807.1	1807.1	0.0%	261.0	261.0	0.0%
7	1793.0	1793.0	0.0%	259.6	259.7	0.0%
8	1775.3	1775.3	0.0%	257.9	257.9	0.0%
9	1772.5	1772.5	0.0%	255.7	255.7	0.0%
10	1771.6	1771.6	0.0%	255.6	255.7	0.0%

7.6 Contributions by Line

For each hour of meteorological data, the buoyant line calculations use the average values for all the lines (see Table 1) for the plume rise calculations. Once those calculations are completed, each individual line acts as a separate source. As a result, individual line contributions can be obtained using the appropriate control parameters in BLP and POSTBLP and the SRCGROUP keyword in AERMOD. In this section a test case is presented that compares source contributions from multiple lines.

The 85-degree source configuration for Baldwin described above is used for this comparison. In the following tables, all values are reported in µg/m^3; 'Line 1', 'Line 2', and 'Line 3' denote the individual line contributions. 'All Lines' represents the total concentration from all three lines.

The results for all averaging periods, shown in Table 12 through Table 15, shows no differences. The small differences in the tenths decimal position are due to rounding by BLP and truncation of AERMOD results when copied from the output file.

Table 12. Top 10 1-hour Concentration Estimates in µg/m^3 for Individual Lines and All Lines

Rank	Line 1		Line 2		Line 3		All Lines	
	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD
1	5847.5	5847.4	3352.8	3352.7	3515.6	3515.6	7256.8	7256.8
2	5801.8	5801.7	3351.7	3351.7	3371.9	3371.9	7199.0	7198.9
3	5795.6	5795.5	3327.3	3327.2	3350.6	3350.6	7049.7	7049.7
4	5746.7	5746.6	3304.8	3304.8	3224.4	3224.4	7032.4	7032.3
5	5715.2	5715.2	3221.7	3221.7	3060.8	3060.8	7003.1	7003.1
6	5646.3	5646.2	3177.1	3177.0	3009.1	3009.1	6962.8	6962.7
7	5637.0	5637.0	3141.2	3141.1	2990.5	2990.4	6898.4	6898.4
8	5540.9	5540.9	3140.7	3140.6	2962.5	2962.5	6827.6	6827.6
9	5484.4	5484.4	3115.5	3115.5	2955.3	2955.3	6818.5	6818.5
10	5378.4	5378.3	3084.7	3084.6	2930.5	2930.4	6738.4	6738.4

Table 13. Top 10 3-hour Concentration Estimates for Individual Lines and All Lines

Rank	Line 1		Line 2		Line 3		All Lines	
	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD
1	3551.0	3550.9	1986.7	1986.6	1952.9	1952.8	5271.7	5271.7
2	3542.0	3542.0	1969.6	1969.5	1766.3	1766.3	5179.9	5179.9
3	3527.3	3527.3	1967.1	1967.0	1727.4	1727.3	5085.2	5085.2
4	3522.4	3522.4	1962.3	1962.2	1721.9	1721.9	5058.5	5058.4
5	3486.9	3486.9	1959.0	1959.0	1718.2	1718.2	4971.3	4971.3
6	3434.4	3434.3	1958.6	1958.6	1716.8	1716.8	4947.1	4947.0
7	3425.6	3425.5	1957.7	1957.7	1708.6	1708.6	4945.7	4945.7
8	3300.7	3300.7	1955.7	1955.7	1700.4	1700.4	4933.9	4933.8
9	3277.0	3276.9	1942.8	1942.7	1696.5	1696.5	4909.3	4909.3
10	3271.9	3271.9	1941.8	1941.7	1693.1	1693.0	4847.7	4847.7

Table 14. Top 10 24-hour Concentration Estimates for Individual Lines and All Lines

Rank	Line 1		Line 2		Line 3		All Lines	
	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD
1	709.7	709.6	648.2	648.2	450.2	450.2	1233.1	1233.1
2	708.9	708.8	633.2	633.1	449.0	448.9	1189.8	1189.8
3	698.0	698.0	632.0	631.9	444.3	444.3	1165.1	1165.1
4	688.9	688.8	631.6	631.5	440.8	440.8	1159.3	1159.2
5	686.7	686.6	614.3	614.2	439.6	439.5	1146.4	1146.3
6	679.9	679.8	571.2	571.2	437.9	437.8	1125.2	1125.1
7	667.6	667.5	539.6	539.5	432.5	432.4	1116.4	1116.4
8	667.0	666.9	506.4	506.3	431.0	431.0	1114.4	1114.3
9	663.9	663.8	505.3	505.2	430.2	430.1	1092.1	1091.9
10	654.9	654.8	494.6	494.6	426.7	426.6	1088.0	1087.9

Table 15. Top 10 Period Concentration Estimates for Individual Lines and All Lines

Rank	Line 1		Line 2		Line 3		All Lines	
	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD
1	41.8	41.7	36.6	36.6	32.0	32.0	108.2	108.1
2	40.4	40.3	34.8	34.7	32.0	31.9	107.0	106.9
3	38.8	38.8	34.8	34.7	31.9	31.9	104.9	104.8
4	38.2	38.2	34.6	34.6	31.9	31.8	102.7	102.6
5	37.7	37.7	34.2	34.2	31.6	31.6	102.3	102.3
6	37.0	36.9	33.9	33.9	31.6	31.5	100.8	100.8
7	36.9	36.9	33.6	33.6	31.3	31.2	100.8	100.7
8	36.1	36.0	33.4	33.3	31.0	30.9	100.4	100.4
9	36.0	35.9	33.2	33.2	30.7	30.7	98.6	98.6
10	35.7	35.6	33.0	33.0	30.6	30.6	98.6	98.5

8. Complex Terrain

The testing to this point has used configurations in flat terrain. To see how the two models perform in complex terrain, four buoyant lines and 87 receptors were modeled. The terrain information (elevation and hill height scale) and control file were provided by EPA from an AERMOD model run. The terrain elevation of the four lines was just over 91-94 meters and the release heights were all about 16.75 meters. The terrain for the receptors ranged from 75 meters to 107 meters. The meteorological data used for the configurations above are used for this comparison.

Table 16 compares the H1H through the H4H concentrations for 1-, 3-, and 24-hour averages for the Baldwin meteorological data. AERMOD concentration estimates are identical to the BLP estimates for all ranks and averaging periods.

Table 16. Comparison of Ranked Concentrations for a Source in Complex Terrain

Rank	1-hr		3-hr		24-hr	
	BLP	AERMOD	BLP	AERMOD	BLP	AERMOD
H1H	7800.3	7800.3	3260.0	3260.0	452.1	452.0
H2H	5644.6	5644.5	2116.4	2116.3	343.1	343.1
H3H	4777.4	4777.4	1840.2	1840.1	326.7	326.6
H4H	3902.3	3902.2	1592.5	1592.4	312.1	312.1

Table 17 and Table 18 show the top ten values for 1-hr, 3-hr, and 24-hr show no differences. There is a small difference for a few of the annual averages. The reason is not clear at this time.

Table 17. Top 10 Concentration Estimates for Complex Terrain Case for 1-hr and 3-hr Averaging Periods.

Rank	1-hr			3-hr		
	BLP	AERMOD	% Difference	BLP	AERMOD	% Difference
1	7800.3	7800.3	0.0%	3260.0	3260.0	0.0%
2	7583.8	7583.7	0.0%	3172.6	3172.6	0.0%
3	6199.1	6199.1	0.0%	3063.3	3063.2	0.0%
4	5644.6	5644.5	0.0%	2671.0	2670.9	0.0%
5	5520.3	5520.3	0.0%	2392.8	2392.8	0.0%
6	5435.5	5435.5	0.0%	2209.8	2209.8	0.0%
7	5214.3	5214.3	0.0%	2147.0	2146.9	0.0%
8	5169.0	5169.0	0.0%	2116.4	2116.3	0.0%
9	4862.4	4862.3	0.0%	2066.4	2066.4	0.0%
10	4859.6	4859.5	0.0%	1923.1	1923.0	0.0%

Table 18. Top 10 Concentration Estimates for Complex Terrain Case for the 24-hr and Period Averaging Periods.

Rank	24-hr			Period		
	BLP	AERMOD	% Difference	BLP	AERMOD	% Difference
1	452.1	452.0	0.0%	30.6	30.6	0.0%
2	443.5	443.4	0.0%	27.8	27.8	0.1%
3	411.5	411.5	0.0%	24.3	24.3	-0.2%
4	407.5	407.5	0.0%	23.8	23.8	-0.1%
5	404.0	404.0	0.0%	22.4	22.4	-0.2%
6	396.6	396.5	0.0%	21.0	21.0	0.1%
7	394.4	394.4	0.0%	20.6	20.6	0.1%
8	363.9	363.8	0.0%	20.4	19.8	-3.1%
9	358.1	358.1	0.0%	19.8	19.6	-1.2%
10	345.6	345.5	0.0%	19.6	19.5	-0.7%

9. Sources within the Boundaries of the Buoyant Line Source

In AERMOD-BLP comparisons conducted with AERMOD version 15181, the single source configuration tested was embedded in the receptor network as shown in Figure 7. This configuration resulted in some very large concentrations generated by AERMOD that were not produced by BLP. In particular the maximum concentration from AERMOD was about 146,000 μg/m^3 whereas the maximum concentration from BLP was about 2,500 μg/m^3. This difference in magnitude occurred for only one hour for a one-year set of meteorological data[2]. While other differences were observed between the two models, the magnitude of the concentration estimates were the same.

It is important to note that in AERMOD version 15181, the exclusion zone had not been implemented so all receptors were modeled. Recall that BLP only defines an exclusion zone for a gridded receptor network. To make the model-to model comparison, discrete receptors were modeled.

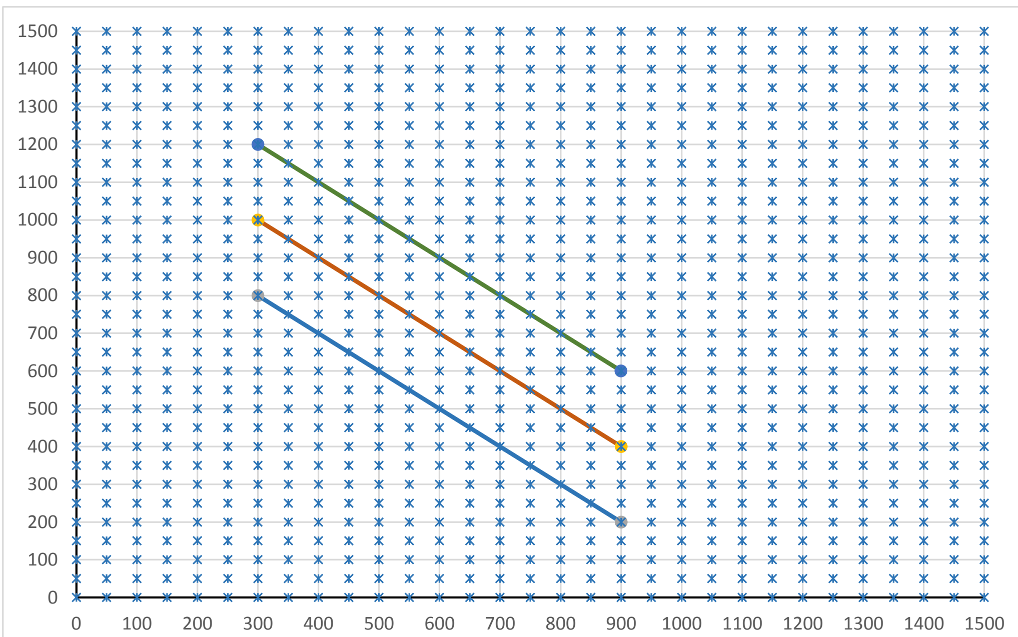

Figure 7. Discrete Receptors with Source inside Receptor Grid

A possible contributing factor to the large difference in magnitude in the concentration estimates between the two models is that AERMOD declares real-valued variables as double precision in the source code whereas BLP uses single precision real variables. With that in mind, BLP was recompiled with the Intel® compiler option real_size: 64 to define real variable declarations as DOUBLE PRECISION REAL*8. With this compiler option, the large concentrations were reproduced by BLP, suggesting that the discrepancies seen in the earlier comparison might be due, in part, to the precision of the real-valued variables.

[2] The meteorological data used in the initial testing was not the same data set used in the comparisons described in this document.

To see if the configuration of sources and receptors might contribute to this issue, a simple adjustment in the current comparison to the starting points of the three lines for the source oriented 45 degrees from horizontal was made. The x-coordinates of the starting point of all three lines were adjusted by 10 meters to the west, i.e., the starting point was at x = 290. The result was that BLP and AERMOD matched for the 1- and 3-hr results, and differed by up to about 5% for longer averaging periods for the 1464 summer hours. This result suggests that the configuration, possibly combined with the meteorology for that hour, played an important role in estimating the concentration.

With this version of AERMOD, with the exclusion zone defined, testing of the different source configurations embedded in the receptor network revealed that very large concentrations were occurring in AERMOD only when the lines were oriented northwest-southeast at a 45-degree angle relative to the receptor network as before, i.e., none of the other configurations exhibited this phenomenon.

Further investigation revealed that the receptor with the largest concentration was very close but just outside the exclusion zone. Figure 8 shows the rotated receptor network with the original (OLine *n*) and rotated source lines (RLine *n*). The receptor in question is highlighted by the red circle. The open space in the receptor network is the exclusion zone. Recall that the exclusion zone is defined by the minimum extent of all lines, so when the translation and rotation are performed, the left end point of OLine 3 is near X = -282.

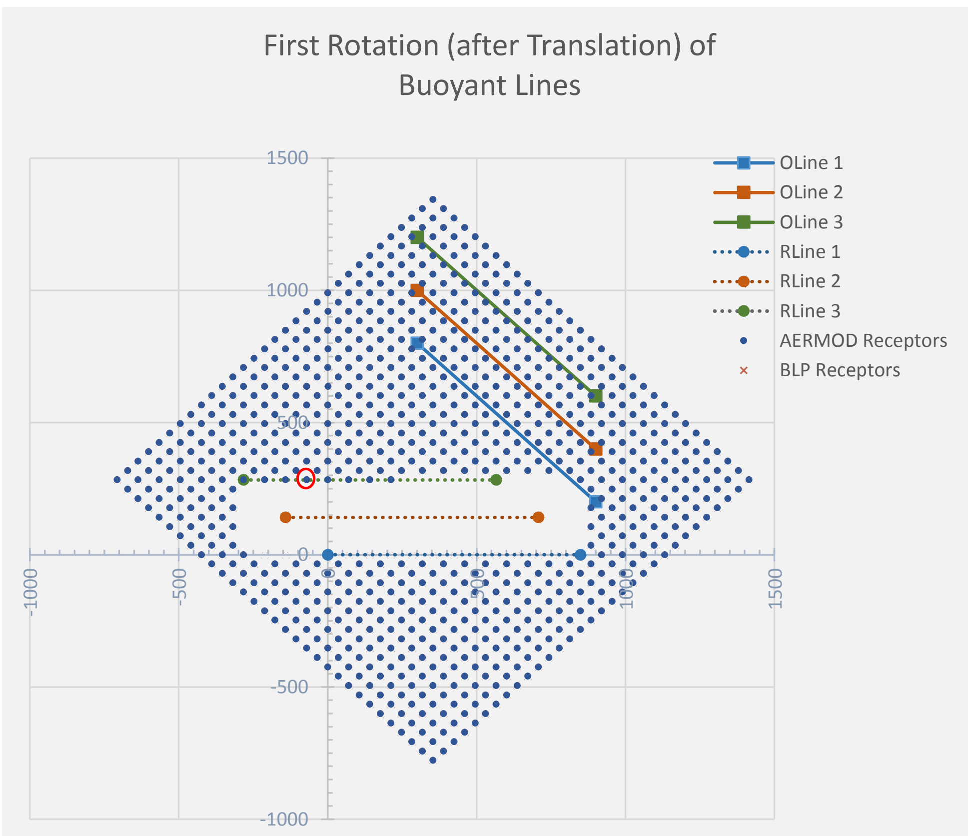

Figure 8. Receptors and Exclusion Zone for Source Angled 45 Degrees from Horizontal.

From Figure 8, given that the receptor has not been excluded by AERMOD, it is either outside or exactly on the boundary of the exclusion zone.

Looking at the modeled receptors more closely, BLP excluded about 8 receptors that AERMOD included in the calculations in this row. Note as well that for receptors on the x-axis (y = 0), BLP receptors are included but AERMOD receptors are excluded. This also suggests that the precision of the real valued variables may be playing a role in the comparison when a coordinate system is rotated, in other words, it is not possible to produce identical exclusion zones.

This source/receptor configuration and result appears to be unique to the lines angled 45 degrees from horizontal and the simple rectangular receptor network in which the receptors are at exactly integer values and the lines of the buoyant line source may intersect them exactly.

The unusually large concentration estimates that have been observed when the source is embedded in a receptor network are likely to be a rare occurrence for two reasons:

1) Source and receptor locations are rarely, if ever, exactly aligned in real-world applications as they are in this example, and

2) A facility's fence line defines the boundary for ambient air; receptors are modeled outside a facility's fence line (unless the public may have access) and sufficiently far from the sources so as to not be a problem.

To try to reduce the effect of this particular issue, a small value (an epsilon) was added to or subtracted from the extents defining the exclusion zone. A value of 1.0 meters was defined. Using this epsilon in determining whether a receptor is outside the exclusion zone eliminated the issue of a very large concentration estimate.

We also note that without the use of an epsilon, BLP and AERMOD can include and exclude different receptors at the exclusion zone boundary, as seen in Figure 8 and result in a different number of receptors being modeled.

As a test, BLP was modified to include the epsilon to see if BLP and AERMOD would model the same receptors and what the resulting concentrations would be. Table 19 through Table 22 compare BLP with and without use of epsilon to AERMOD with and without the use of epsilon. The number of receptors modeled is shown in parentheses below the model name. For 1-hr averages, AERMOD and BLP are in general agreement with the use of the epsilon in BLP. The same number of receptors are used by both models. If the epsilon is not used for AERMOD and BLP, there are a few minor differences between the two models except for the source angled at 45 degrees.

For the 45-degree orientation, both BLP and AERMOD were run without the use of epsilon and BLP was recompiled as a 64-bit executable as well. As noted above, the large values generated by AERMOD that had been seen in previous testing also appear here for BLP with the 64-bit executable, suggesting that the precision of the real variables plays a role in the concentration estimates.

Table 19. 1-hour Concentrations with and without Use of Epsilon for Horizontal Source

Rank	Epsilon		No Epsilon	
	BLP (844)	AERMOD (844)	BLP (844)	AERMOD (844)
1	15214.5	15214.4	15214.5	15214.4
2	15206.9	15206.9	15206.9	15206.9
3	15198.4	15198.3	15198.4	15198.3
4	15169.0	15169.0	15169.0	15169.0
5	15165.4	15165.4	15165.4	15165.4
6	15155.6	15155.5	15155.6	15155.5
7	15135.6	15135.5	15135.6	15135.5
8	15124.2	15124.1	15124.2	15124.1
9	15108.4	15108.4	15108.4	15108.4
10	15091.5	15091.4	15091.5	15091.4

Table 20. 1-hour Concentrations with and without Use of Epsilon for Source Oriented 10 Degrees from Horizontal

Rank	Epsilon		No Epsilon	
	BLP (850)	AERMOD (850)	BLP (853)	AERMOD (852)
1	15656.1	15656.1	15656.1	15656.1
2	15611.1	15611.1	15611.1	15611.1
3	15549.5	15549.5	15549.5	15549.5
4	15546.3	15546.3	15546.3	15546.3
5	15518.8	15518.7	15518.7	15518.7
6	15473.1	15473.1	15473.1	15473.1
7	15463.0	15463.0	15463.0	15463.0
8	15411.0	15410.9	15410.9	15410.9
9	15402.8	15402.7	15402.7	15402.7
10	15367.2	15367.2	15367.2	15367.2

Table 21. 1-hour Concentrations with and without Use of Epsilon for Source Oriented 45 Degrees from Horizontal

Rank	Epsilon		No Epsilon		
	BLP (812)	AERMOD (812)	BLP (829)	BLP 64-bit (832)	AERMOD (822)
1	39706.7	39706.7	46359.0	78729.9	73612.0
2	37438.4	37438.5	39707.6	66777.3	62537.6
3	37415.8	37415.8	37658.8	64655.2	60414.0
4	32954.1	32954.2	37438.6	61225.2	57228.5
5	31450.2	31450.2	37417.7	60808.0	57021.5
6	30934.5	30934.6	36573.1	46548.1	43859.5
7	30761.8	30761.7	34692.2	46360.3	41249.2
8	30757.4	30757.4	33008.8	43796.4	40548.0
9	30587.4	30587.4	32955.9	43660.0	40463.2
10	30450.5	30450.5	32348.2	43001.1	39707.6

Table 22. 1-hour Concentrations with and without Use of Epsilon for Source Oriented 85 Degrees from Horizontal

Rank	Epsilon		No Epsilon	
	BLP (886)	AERMOD (886)	BLP (888)	AERMOD (888)
1	64987.2	64986.6	64987.2	64986.6
2	64863.3	64863.3	64926.2	64926.2
3	64554.5	64553.4	64863.3	64863.3
4	64376.6	64376.7	64554.5	64553.4
5	64077.6	64076.8	64376.6	64376.7
6	63673.3	63673.3	64077.6	64076.8
7	62958.5	62958.5	63673.3	63673.3
8	61754.2	61752.4	62958.5	62958.5
9	61545.5	61545.0	61754.2	61752.4
10	60898.8	60898.4	61545.5	61545.0

10. Additional Testing with AERMOD

Several additional test were created to demonstrate some of the capabilities in AERMOD that are not available in BLP, as shown in Table 23. For these tests 1-year of meteorological data from the Lovett evaluation database were used. With this testing, the buoyant line source always consisted of three lines. In the tests that indicate two point sources, the sources were located slightly south of the center of the buoyant line source.

Table 23. Additional Testing - 1-year Scenarios

Test	Scenario
A	Buoyant line source, using an hourly emissions file: two scenarios - hourly emissions for a single line and hourly emissions for all three lines
B	Buoyant line source using HROFDY emission factors
C	Buoyant line source using three different emission factors for each of the lines (SEASON, HROFDY, MONTH)
D	Buoyant line source and two point sources modeling 24-hr PM2.5 and using MAXDCONT
E	Buoyant line source and two point sources modeling 1-hr SO2 and using MAXDCONT

Since most of these tests were to exercise AERMOD options and similar options are not available in BLP, model-to-model comparisons are not possible. Variations on input parameters were modeled to see if the results were as expected. For example, the emission rate in the hourly emission file was doubled or tripled to see if the resulting impacts doubled or tripled. All results were in line with what is expected.

10.1 Hourly Emissions File

In the first of the tests, an hourly emissions file was used in place of the constant emission rate entered through the control file. Table 24 represents hourly emissions for all three of the buoyant lines with an emission rate of 1.0 g/s, whereas Table 25 show the results when Line 3 is the only contributor to the estimates (emission rates for lines 1 and 2 were set to 0.0 g/s in the hourly emissions file).

One would expect that for emissions from a single line that the resulting 1-hr average concentration would be less than the estimates when all three lines are emitting. The range is about 1/3 for 1-hr averages to 1/6 for the annual averages.

Table 24. Top 5 Concentration Estimates (μg/m^3), Test A
(Hourly Emissions File with All Lines Contributing)

Rank	1-hour	3-hour	24-hour	Annual
1	103.9	63.1	19.7	1.56
2	102.6	62.1	18.6	1.41
3	101.9	60.6	17.6	1.41
4	101.7	59.6	16.5	1.30
5	100.6	56.7	16.0	1.29

Table 25. Concentration Estimates (µg/m^3), Test A (Hourly Emissions File with only Line 3 Contributing)

Rank	1-hour	3-hour	24-hour	Annual
1	23.8	13.2	4.4	0.276
2	23.8	13.1	4.3	0.258
3	23.8	13.1	4.3	0.256
4	23.5	12.9	4.3	0.255
5	23.4	12.6	4.2	0.253

10.2 HROFDY Emission Rate Flag

A second test using the HROFDY keyword to control the emissions was conducted. The following factors were used for the lines of a buoyant line source.

EMISFACT BLINE1 HROFDY 6*0.0 12*1.0 6*0.0
EMISFACT BLINE2 HROFDY 6*0.0 12*1.0 6*0.0
EMISFACT BLINE3 HROFDY 6*0.0 12*1.0 6*0.0

Table 26 shows the concentration estimates using this set of emission factors. Since the non-zero emission factors only applied to twelve hours, the resulting concentrations would be expected to be less than that seen in Test A in which all hours of the day were modeled. The concentration estimates were as expected. As a further test, the emission rate was doubled for the half day. The expected result is that the concentration estimates would double, and such was the case as well (Table 27).

Table 26. Concentration Estimates (µg/m^3) for Test B - Multiple Emission Factors

Rank	1-hour	3-hour	24-hour	Annual
1	90.9	32.7	4.2	0.1788
2	90.4	31.0	4.0	0.1787
3	89.9	30.9	4.0	0.1786
4	89.5	30.8	3.8	0.1780
5	89.4	30.8	3.8	0.1757

Table 27. Concentration Estimates (µg/m3) for Test B - Multiple Emission Factors Tripled

Rank	1-hour	3-hour	24-hour	Annual
1	181.9	65.4	8.5	0.3577
2	180.9	62.0	8.0	0.3574
3	179.8	61.8	8.0	0.3573
4	179.0	61.6	7.7	0.3560
5	178.9	61.6	7.7	0.3515

Instead of a single type of emission factor as above, a different emission rate flag was applied to each of the three lines. The following factors were used.

```
EMISFACT BLINE3 SEASON 1.0 1.0 1.0 0.0
EMISFACT BLINE2 HROFDY 5*0.0 1.0 18*0.0
EMISFACT BLINE1 MONTH 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
```

Table 28 shows the results when the three sets of factors are used. To ascertain that the factors were being applied correctly, all factors were tripled, with the expectation that the resulting concentrations would be tripled. Table 29 shows the results and are as expected. In addition to the total impact of the three lines, the contributions from each line were generated. Comparing the contributions from the emission factors above and the tripled emission factors, the results were as expected with each source's contribution tripled (results not shown).

Table 28. Concentration Estimates (µg/m3) for Test C

Rank	1-hour	3-hour	24-hour	Annual
1	763.2	390.3	86.7	13.9
2	755.2	378.2	77.7	13.2
3	710.8	349.1	77.0	12.2
4	683.5	326.7	65.0	10.9
5	676.9	302.5	64.4	10.3

Table 29. Concentration Estimates (µg/m3) for Test C with Emission Rates Tripled

Rank	1-hour	3-hour	24-hour	Annual
1	2289.6	1171.0	260.2	41.8
2	2265.7	1134.8	233.1	39.7
3	2132.4	1047.4	231.0	36.6
4	2050.7	980.1	195.1	32.8
5	2030.7	907.7	193.2	31.0

10.3 MAXDCONT

Several enhancements to support processing for the 1-hour NO_2 and SO_2 NAAQS have been implemented in AERMOD. The MAXDCONT option, applicable to 24-hour PM2.5, 1-hour NO_2 and 1-hour SO_2 standards, can be used to determine the contribution of each user-defined source group to the high ranked values for a target source group, paired in time and space. The MAXDCONT option was applied to a buoyant line source (with 3 lines) and two point sources.

Table 30 shows the results for the 24-hr PM2.5 impacts with the buoyant line and point sources for source groups ALL, STACKS (both stacks), and BLINES (three lines).

Table 30. 1st Highest Concentration Estimates (µg/m^3) for 24-hr PM2.5 (Test D)

Group	Rank	Average Concentration	Contribution ALL	Contribution STACKS	Contribution BLINES
ALL	1	2000.3	2000.3	21.8	1978.5
	2	1886.2	1886.2	21.9	1864.2
	3	1791.4	1791.4	21.8	1769.6

Group	Rank	Average Concentration	Contribution ALL	Contribution STACKS	Contribution BLINES
	4	1680.9	1680.9	22.1	1658.9
	5	1627.8	1627.8	21.9	1605.8
	6	1576.0	1576.0	21.7	1554.3
	7	1406.3	1406.3	22.1	1384.2
	8	1348.2	1348.2	22.0	1326.2
	9	1273.5	1273.5	21.8	1251.6
	10	1195.0	1195.0	21.6	1173.3
STACKS	1	75.1	104.8	75.1	29.7
	2	75.0	95.9	75.0	20.9
	3	74.7	118.6	74.7	43.9
	4	74.4	86.8	74.4	12.3
	5	74.4	88.8	74.4	14.4
	6	74.3	93.0	74.3	18.7
	7	74.1	80.3	74.1	6.2
	8	73.8	135.9	73.8	62.2
	9	73.7	100.0	73.7	26.3
	10	73.7	78.2	73.7	4.5
LINES	1	1978.5	2000.3	21.8	1978.5
	2	1864.2	1886.2	21.9	1864.2
	3	1769.6	1791.4	21.8	1769.7
	4	1658.9	1681.0	22.1	1658.9
	5	1605.8	1627.8	21.9	1605.9
	6	1554.3	1576.0	21.7	1554.3
	7	1384.2	1406.4	22.2	1384.2
	8	1326.2	1348.3	22.0	1326.2
	9	1251.6	1273.6	21.9	1251.7
	10	1173.3	1195.0	21.7	1173.3

Table 31 shows the results for the 1-hr SO2 impacts with the three buoyant lines and the two point sources modeled. The MAXDCONT output option was specified for source groups ALL, STACKS, and BLINES.

Table 31. 1st Highest Concentration Estimates ($\mu g/m^3$) 1-hr SO_2 (Test E)

Group	Rank	Average Concentration	Contribution ALL	Contribution STACKS	Contribution BLINES
ALL	1	10404.0	10404.0	9.0	10395.0
	2	10196.5	10196.5	0.0	10196.5
	3	10172.0	10172.0	0.0	10172.0
	4	10069.6	10069.6	0.0	10069.6
	5	10034.9	10034.9	0.0	10034.9
	6	9918.0	9918.0	0.0	9918.0
	7	9863.4	9863.5	0.0	9863.4
	8	9832.0	9832.1	0.0	9832.1
	9	9804.2	9804.3	0.0	9804.3
	10	9803.4	9803.4	0.0	9803.4

Group	Rank	Average Concentration	Contribution ALL	Contribution STACKS	Contribution BLINES
STACKS	1	1431.0	1431.1	1431.1	0.0
	2	1430.2	1430.3	1430.3	0.0
	3	1428.5	1428.5	1428.5	0.0
	4	1427.6	1427.7	1427.7	0.0
	5	1426.3	1426.4	1426.4	0.0
	6	1425.6	1425.7	1425.7	0.0
	7	1425.2	1425.2	1425.2	0.0
	8	1424.9	1424.9	1424.9	0.0
	9	1423.2	1423.3	1423.3	0.0
	10	1420.4	1420.4	1420.4	0.0
LINES	1	10394.9	10404.0	9.0	10395.0
	2	10196.5	10196.5	0.0	10196.5
	3	10172.0	10172.0	0.0	10172.0
	4	10069.6	10069.6	0.0	10069.6
	5	10034.9	10034.9	0.0	10034.9
	6	9918.0	9918.0	0.0	9918.0
	7	9863.4	9863.5	0.0	9863.4
	8	9832.0	9832.1	0.0	9832.1
	9	9804.2	9804.3	0.0	9804.3
	10	9803.4	9803.4	0.0	9803.4

Based on the results presented above, it appears that the buoyant line algorithms have been integrated successfully with several of the input and output options available in AERMOD.

11. Conclusions

The buoyant line source algorithms found in BLP version 99176 were implemented in AERMOD version 15181.

An exclusion zone in which any receptor within the minimum and maximum extents of the buoyant line source are excluded from the modeling, was added to AERMOD that mimics the exclusion zone in BLP. The only difference is that where BLP applied the exclusion zone to both buoyant line and point sources, AERMOD only applies it to a buoyant line source.

Several source configurations in flat terrain were tested, with the source and receptors separated by several hundred meters except for the horizontally oriented source using the 1-yr of meteorological data from the Baldwin evaluation database.

A rectangular array of 961 receptors spaced 50 meters apart with 31 nodes on the x-axis and 31 nodes on the y-axis was used. BLP had to be modified to accept this number of receptors since the version on SCRAM would allow up to 100 receptors.

AERMOD produced identical concentrations compared to the estimates from BLP for all source configurations, averaging periods, and ranks.

In addition, several tests were run that exercised several of the input and output options available in AERMOD that allow for varying the emission rates and to output results for the more recent probabilistic air quality standards. Since BLP does not have similar options, a comparison to BLP output is not possible. The results from AERMOD appear to be in line with what might reasonably be expected.

12. Additional information

Data for the analyses presented in this TSD can be obtained by contacting:

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Appendix A

AERMOD Keywords for Buoyant Line Sources

One LOCATION record for each line that comprises the buoyant line source.

SO **LOCATION** *sourceID* *BUOYLINE* *Xb* *Yb* *Xe* *Ye* *(Zs)*

Xb, Yb = coordinate of the beginning of the line source (m)
Xe, Ye = coordinate of the end of the line source (m)
Zs = line elevation (m) - optional; defaults to 0.0 if omitted

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One SRCPARAM record for each line that comprises the buoyant line source.

SO **SRCPARAM** *sourceID* *blemis* *relhgt*

Blemis = emission rate (g/s)
Relhgt = release height (m)

The BLPINPUT keyword defines the average values for the buoyant line (as a whole and not as the individual lines that comprise the buoyant line source). The order shown is the same as the input in BLP (in the namelist RISE), with the variable name used in BLP shown in parentheses. This keyword can only appear once.

SO **BLPINPUT** *blavgblen blavgbhgt blavgbwid blavglwid blavgbsep blavgfprm*

blavgblen (L) = average building length (m)
blavgbhgt (HB) = average building height (m)
blavgbwid (WB) = average building width (m)
blavglwid (WM) = average line source width (m) (of the individual lines)
blavgbsep (DX) = average building separation (m) (between the individual lines)
blavgfprm (FPRIME) = average buoyancy parameter (m^4/s^3)

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