United States
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Agency

COMPARISON OF REGULATORY DESIGN CONCENTRATIONS

AERMOD
vs
ISCST3, CTDMPLUS, ISC-PRIME

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Staff Report

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emissions Monitoring and Analysis Division
Research Triangle Park, North Carolina

Disclaimer

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[1] On assignment to the Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency.

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1. INTRODUCTION

1.1 Background information.

This report is a final version of an earlier consequence analysis[2], which was released to support the proposal of AERMOD (the **A**merican Meteorological Society/**E**nvironmental Protection Agency **R**egulatory Model Improvement Committee's Dispersion **Mod**el, version 99351) in a Federal Register notice[3] on April 21, 2000**.** At that time, the EPA also proposed an additional model, ISC-PRIME (**I**ndustrial **S**ource **C**omplex -Short Term Model[Version 3] - **P**lume **RI**se **M**odel **E**nhancements), designed to be used in cases where building downwash was significant; AERMOD was to be used for air pollution source scenarios where downwash was not an issue. To support the ISC-PRIME proposal, there was a separate but similar building-downwash-consequence analysis completed which compared ISC-PRIME to ISCST3[4] **(I**ndustrial **S**ource **C**omplex -**S**hort **T**erm Model--Version **3)**. Responding to the overwhelming reaction from the commenters on the proposal, the Agency decided to incorporate PRIME algorithms into AERMOD and thereby eliminate the use of the ISC-PRIME model. The final results in this report consider both downwash and non-downwash source scenarios since AERMOD now provides the state of the science for modeling both types of source scenarios. Thus, this report is designed to supercede the two earlier consequence analyses.

This analysis is based on the lastest version of AERMOD, version 02222[5], which includes the PRIME algorithms and the proposed version of AERMOD (99351). The ISC-PRIME results are based on version 99020; the ISCST3 results are based on version 96113 (for the downwash analysis) and version 97363 (for the point, area and volume sources) which are the same versions of the models used in the earlier consequence analyses.

The introduction includes the following additional sections: a description and purpose of a consequence analysis; a description of the 3 components to this study; and, a brief description of the air dispersion models of interest - AERMOD (including a list of AERMOD changes since the proposal), ISCST3, ISC-PRIME, and, CTDMPLUS (the **C**omplex **T**errain **D**ispersion **M**odel-**Plus**).

1.2 What is a consequence analysis?

The purpose of this report, often called a consequence analysis, is to give the user community a sense of how regulatory design concentrations from a new air dispersion model compare to those from an established model via a series of "representative" examples. After the release of a new model for regulatory applications, the user community will want to know: "What does this mean to my modeling projects?". This analysis is designed to answer that question by

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[2] Peters,W.D. et al, "Comparison of Regulatory Design Concentrations: AERMOD versus ISCST3 and CTDMPlus", draft document, April 1999, available on the EPA website: www.epa.gov/scram001.

[3] Federal Register notice, 65FR21506, April 21, 2000.

[4] Paine, R.J. and Lew, F., "Consequence Analysis for Adoption of PRIME: an Advanced Building Downwash Model", August 24, 1998, available on the EPA website: www.epa.gov/scram001.

[5] Available on the EPA website: www.epa.gov/scram001.

showing the effects of the new model as compared to the existing regulatory model which it replaces. For this study, the new model is AERMOD with the PRIME algorithms. The existing regulatory models used in this report are ISCST3, ISC-PRIME, and CTDMPLUS. This consequence analysis does not substitute for detailed comparative evaluations or sensitivity analyses, but rather, provides to the modeler some simple comparisons of regulatory design concentration estimates from these air quality models for an extensive number of typical source scenarios.

1.3 The three components of this study.

There are three parts to this study: the flat and simple terrain component; the building downwash component; and, the complex terrain component. The building downwash component has been added to the original report since AERMOD now contains the PRIME building downwash feature and will be used for sources near buildings. All of the study components use source scenarios and meteorological data sets which remain unchanged from the earlier consequence analyses.

The flat and simple terrain consequence analysis is based on comparative runs made using a composite of standard data sets. These data sets include a range of point sources with varying stack parameters, area and volume sources, and two point sources in simple terrain[6]. All source scenarios are evaluated with two meteorological data sets representing different climatic regimes in the U.S. For building downwash, a series of point sources with varying stack heights and different building configurations are included in the data sets. Only one of the meteorological data sets used in the previous description is used in this part of the analysis. For the complex terrain, the study includes a number of stack heights, buoyancy regimes, distances from source to hill, and hill types along with its own meteorological data base (one site).

After applying the model to all of the above source scenarios, the consequence analysis is summarized by tabulating the important regulatory (design) concentrations for the new model against those predicted by the existing regulatory models. Often, the concentrations of regulatory interest are the high and the high-second-highest concentrations for 1-hour, 3-hour, 24-hour, and annual averages, and they are used in this study. The choice of averaging times is based on the earlier consequence analyses, although this choice is not consistent across all three components of this study.

1.4 A Brief Description of AERMOD[7].

A committee, AERMIC (the **A**merican Meteorological Society/**E**nvironmental Protection Agency **R**egulatory **M**odel **I**mprovement **C**ommittee), was formed to introduce state-of-the-art modeling concepts into the EPA’s local-scale air quality models. AERMIC's focus was on a new platform for regulatory steady-state plume modeling; this platform would include air dispersion

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[6] Simple terrain includes receptors with elevations below the top of the stack and at elevations above or below the stack base. Intermediate terrain includes receptors with elevations above stack top and below the plume centerline. Complex terrain includes receptors with elevations above the top of the stack.

[7] User’s Guide for the AMS/EPA Regulatory Model - AERMOD, US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, Report No EPA-454/B-03-001, July 2003. Available on the EPA website: www.epa.gov/scram001.

fundamentally based on planetary boundary layer turbulence structure, scaling and concepts. AERMOD is designed to treat both surface and elevated sources in simple and complex terrain.

Special features of AERMOD include its ability to treat the vertical inhomogeneity of the planetary boundary layer, special treatment of surface releases, irregularly-shaped area sources, a three-plume model for the convective boundary layer, and limitation of vertical mixing in the stable boundary layer. A treatment of dispersion in the presence of intermediate and complex terrain is used that improves on that treatment currently in use in ISCST3 and other models, yet without the complexity of a model such as CTDMPLUS.

AERMOD incorporates, with a new simple approach, current concepts about flow and dispersion in complex terrain. Where appropriate, the plume is modeled as either impacting and/or following the terrain. This approach is designed to be physically realistic and simple to implement while avoiding the need to distinguish among simple, intermediate and complex terrain, as is required by present regulatory models. As a result, AERMOD removes the need for defining complex terrain regimes; all terrain is handled in a consistent and continuous manner that is simple while still considering the dividing streamline concept in stably-stratified conditions.

AERMOD is actually a modeling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor), and AERMET (AERMOD Meteorological Preprocessor).

AERMET is the meteorological preprocessor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmosheric parameters.

AERMAP is a terrain preprocessor designed to simplify and standardize the input of terrain data for AERMOD. Input data include receptor terrain elevation data. The terrain data may be in the form of digital terrain data that is available from the U.S. Geological Survey. For each receptor, the output includes a location and height scale, which is an elevation used for the computation of air flow around hills.

Additional information about AERMOD can be found in other documents. The model evaluation paper[8] compares both AERMOD (proposed and current versions), CTDMPLUS, ISCST3's and ISC-PRIME's model predictions against measured ambient concentrations. The Model Formulation Document[9] provides a detailed explanation of the science behind the model.

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[8] USEPA, "AERMOD: Latest features and Evaluation Results." Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA Report No. EPA-454/R-03-003. July 2003. Available on the EPA website: www.epa.gov/scram001.

[9] USEPA, " AERMOD: Description of Model Formulation (Version 02222) ", Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA Report No. EPA-454/R-03-004, October 2002. Available on the EPA website: www.epa.gov/scram001.

The AERMOD, AERMET and AERMAP User's Guides[7,10,11] inform the user community about the various options and features of the model and its preprocessors.

1.5 Changes made to AERMOD since the proposal

A summary of the changes made to the AERMOD in response to comments include the following:

* adding the PRIME algorithms to the model (response to public comments);
* modifying the complex terrain algorithms to make AERMOD less sensitive to the selection of the domain of the study area (response to public comments);
* modifying the urban dispersion for low-level emission sources, such as area sources, to produce a more realistic urban dispersion and, as a part of this change, changing the minimum layer depth used to calculate the effective dispersion parameters for all dispersion settings (scientific formulation correction which was requested by beta testers); and making an adjustment to the friction velocity and the Monin-Obukhov length for urban stable cases (improved scientific formulation);
* upgrading AERMOD to include all the newest features that exist in the latest version of ISC such as FORTRAN 90 compliance and allocatable arrays, EVENTS processing and the TOXICS option (response to public comments).

In doing the follow-up quality control checking of the model and the source code, the need for additional changes were identified and the following changes have been made:

* adding meander to: 1) the stable and unstable urban and 2) the rural unstable dispersion settings (only the rural, stable dispersion setting considered meander in the earlier version of AERMOD - this change provides a consistent treatment of air dispersion in all dispersion settings);
* making some changes to the basic meander algorithms (improved scientific formulation);
* making a correction to avoid elevated concentrations for terrain below stack base from the virtual image source (response to public comments about spurious results in complex terrain); and,
* repairing miscellaneous coding errors.

A more detailed list of corrections are given in the model evaluation paper[8] **.**

1.6 Overview of ISCST3[12].

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[10] USEPA, "User's Guide for the AERMOD Meteorological Preprocessor (AERMET)", US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA Report No EPA-454/B-03-002, July 2003. Available on the EPA website: www.epa.gov/scram001.

[11] USEPA, "User's Guide for the AERMOD Terrain Preprocessor (AERMAP), US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, EPA Report No EPA-454/B-03-003, August 2002. Available on the EPA website: www.epa.gov/scram001.

[12] USEPA,"User's Guide for the Industrial Source Complex (ISC3) Dispersion Models", Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, Report No. EPA-454/B-95-003a, September 1995. Available on the EPA website: www.epa.gov/scram001.

ISCST3 is especially designed to support the EPA's regulatory modeling programs. This model is a steady-state Gaussian dispersion model with a number of options available to the user. These options include the use of stack-tip downwash, buoyancy-induced dispersion, final plume rise (except for sources with building downwash), a routine for processing averages when calm winds occur, and default values for wind profile exponents and for the vertical potential temperature gradients. The Short Term model also incorporates COMPLEX1 screening model dispersion algorithms for receptors in complex terrain. The user may select either rural or urban dispersion parameters, depending on the characteristics of the source location. A more detailed side-by-side explanation and comparison of features between ISCST3 and AERMOD is given in Appendix A.

1.7 Overview of PRIME.

PRIME was developed by the Electric Power Research Institute to provide new and improved plume rise and building downwash algorithms. The PRIME set of algorithms was incorporated into ISCST3 and the new model was called ISC-PRIME. The improved algorithms provided the following new features:

. consideration of the location of the stack in relationship to the building;
. consideration of the streamline deflection over the building;
. inclusion of plume rise affected by the velocity deficit in the wake or vertical wind speed shear;
. a linkage between plume material captured by the near wake and far wake concentrations;
. elimination of discontinuities at the interface between the two downwash algorithms;
. provision of wind direction effects for squat buildings;
. elimination of the large concentrations predicted by ISCST3 during light wind speed, stable conditions that are not supported by observations.

A further, more detailed, description of the model[13] and the evaluation results [14]are available.

1.8 A Brief Description of CTDMPLUS[15].

CTDMPLUS is a refined Gaussian plume dispersion model designed to estimate hourly concentrations of plume material from elevated point sources at receptors on or near isolated terrain features. This model can assess stable and neutral atmospheric conditions as well as daytime, unstable conditions. Its use of meteorological data and terrain information is different from other regulatory models in that considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPLUS.

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[13] L.L. Schulman, D.G. Strimaitis, J.S. Scire, “Development and Evaluation of the PRIME Plume Rise and Building Downwash Model”, Jounrnal of Air and Waste Management Association, 50: 378-390, March 2000.

[14] R.J. Paine, F. Lew, “Results of of the Independent Evaluation of ISCST3 and ISC-PRIME”, Electric Research Institute, EPRI TR-2460026, November 1997. Available at www.epa.gov/scram001.

[15] User’s Guide to the Complex Terrain Dispersion Model Plus Algorithm for Unstable Situations, US EPA, Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC 27711, Report No. EPA/600/8-89/041, March 1989. Available on the EPA website: www.epa.gov/scram001.

In modeling stable to neutral conditions, a central feature of CTDMPLUS is its use of a critical dividing-streamline height to separate the flow in the vicinity of a hill into two separate layers. Flow in the upper layer has sufficient kinetic energy to pass over the top of the hill, while the streamlines in the lower layer are constrained to flow in a horizontal plane around the hill. In modeling unstable or convective conditions, the model relies on a probability density function (PDF) description of the vertical velocities to estimate the vertical distribution of pollutants.

Hourly profiles of wind and temperature measurements are used by CTDMPLUS to compute plume rise, plume penetration, convective scaling parameters. In stable/neutral conditions, the profiles of turbulence data are used to compute dispersion parameter values at plume height.

The model calculates on an hourly basis how the plume trajectory is deformed by each hill. The computed concentration at each receptor is then derived from the receptor position on the hill and the resultant plume position and shape.

2. METEOROLOGICAL DATA BASES

2.1 Flat and Simple Terrain.

One year of hourly data for two sites were retrieved and processed. The two sites selected for this study are Pittsburgh, PA (**WBAN** [**W**eather **B**ureau-**A**ir Force-**N**avy] station No. 94823), representative of an urban eastern site; and Oklahoma City, OK (WBAN station No. 13967), representative of a southwestern plains site. The 1964 data are used at the Pittsburgh site and 1984 data are used at the Oklahoma City site. ISCST3 meteorological data were preprocessed by PCRAMMET and AERMOD meteorological data were preprocessed by AERMET.

2.1.1 AERMET Overview. AERMET [10] provides a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by AERMOD. National Weather Service (NWS) hourly surface observations and twice-daily upper air soundings, plus site-specific data from a meteorological measurement program can be processed in AERMET. There are three stages to processing the data. The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks. The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file. The third stage reads the merged meteorological data and estimates the necessary parameters for use by AERMOD. Two files are written for AERMOD: 1) a file of hourly boundary layer parameter estimates; and, 2) a file of multiple-level observations (profiles) of wind speed and direction, temperature, and standard deviation of the fluctuating horizontal and vertical components of the wind.

Input data used in this part of the study include: 1) hourly specification of wind speed; 2) hourly specification of wind direction; 3) hourly ambient temperature; 4) hourly solar radiation[16]; 5) hourly cloud cover values; 6) a quantification of surface characteristics (surface roughness, albedo, Bowen ratio); and 7) twice-daily upper air soundings[17]. Output includes hourly values for mixing heights and Monin-Obukhov lengths, surface friction velocity, convective velocity scale, and profiles of wind speed and direction, temperature and turbulence. Table 2-1 lists the albedo, Bowen ratio, and surface roughness that are assumed for this analysis. Table 2-1 lists only the rural settings for the meteorological data. The urban analysis is accomplished by setting the urban mode and urban source option in AERMOD and using the rural meteorological data for the model inputs.

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[16] Solar and Meteorological Surface Observation Network 1961-1990, Version 1.0, US Department of Commerce, National Climatic Data Center, Asheville, NC / US Department of Energy, National Renewable Energy Laboratory, Golden CO, September 1993.

[17] Radiosonde Data of North America 1946-1992, Version 1.0, Forecast Systems Laboratory, Boulder, CO and National Climatic Data Center, Asheville, NC, August 1993.

Table 2-1. Albedo, Bowen Ratio, and Surface Roughness length assumed for AERMET preprocessor.				
Site	Option	Albedo	Bowen Ratio	Surface roughness (meters)
Pittsburgh	Rural	0.25	0.75	0.15
Oklahoma City	Rural	0.25	0.75	0.15

2.1.2 PCRAMMET Overview. The PCRAMMET [18]model requires the twice-daily mixing heights and NWS surface observations. Prior to being made available, the data were checked for blank fields (missing data) and filled by accepted procedures. A modification was made to the data sets by setting the minimum mixing heights to 10 meters. This change was made to avoid spuriously high or low concentrations for the short stacks. Only the meteorological data used for the ISCST3 analysis was affected.

For ISCST3, the minimum input data requirements to the PCRAMMET are the twice-daily mixing heights and hourly surface observations of wind speed, wind direction, dry bulb temperature, opaque cloud cover and ceiling height. The operations performed by the PCRAMMET include: 1) calculation of hourly values for atmospheric stability from meteorological surface observations; and, 2) interpolation of twice-daily-mixing heights to hourly values. A brief description of the meteorological data for the two sites is given in Table 2-2.

Table 2-2. Missing soundings and calm wind conditions by site and year.

Site	Year	Anemometer height (feet)	Hours/ year	Missing Soundings		Calm wind conditions
				0000 GMT[19]	1200 GMT	
Pittsburgh	1964	20	8784	0	0	858
Oklahoma City	1984	20	8784	0	0	181

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[18] PCRAMMET User's Guide, US EPA, Office of Air Quality Planning and Standards, RTP, NC 27711, EPA-454/B-96-001, October 1996. Available from EPA's world-wide-web site at www.epa.gov/scram001.

[19] GMT = Greenwich Mean Time

2.2 Building Downwash.

Only the meteorological data from Pittsburgh (1964), as described in the preceding section, is used in the building downwash scenarios. No modifications were made to the data because there are no short stacks, (i.e. less than 20 meters) in this part of the analysis.

2.3 Complex Terrain.

The meteorological data base used in the complex terrain portion of this study is taken from a project where site-specific data were collected[20]. A 100-m tower, instrumented at 10, 50, and 100 meters and sodar equipment were used to gather the meteorological data. The sodar data was collected at 50-meter intervals, and the 150 - 400 meter sodar data were used with the tower data to construct the meteorological profiles. The use of sodar turbulence data is limited to vertical turbulence values only. All of the tower and sodar levels are used in AERMOD and CTDMPLUS runs. Only the 100-m tower data (wind speed and wind direction) are used in ISCST3 runs (see Figure 2-1 for the 100 meter wind rose). The atmospheric turbulence and dispersion for ISCST3 are addressed by applying atmospheric stability classifications which are estimated by the solar radiation/delta-T (SRDT) stability scheme[21].

To confine the differences between CTDMPLUS and AERMOD to differences in the dispersion algorithms, the METPRO[22] output used for CTDMPLUS (including the boundary layer parameters) is reformatted in a mode compatible with AERMOD meteorological data requirements. However, the predicted concentrations are not sensitive to these boundary layer values because profiled meteorological data are available at several levels straddling the stack release heights.

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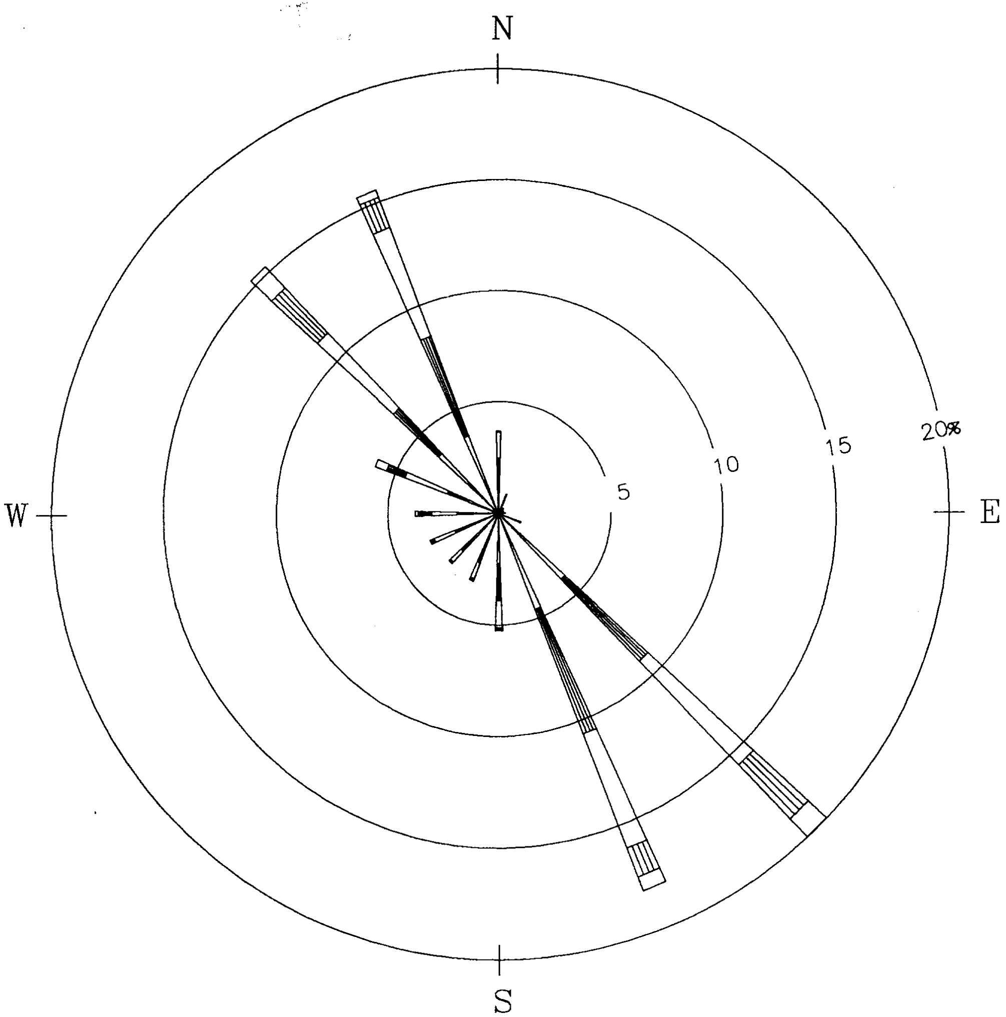
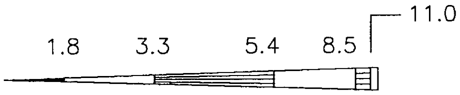
[20] The data came from an unnamed source.

[21] “An Evaluation of A Solar Radiation/Delta-T Method for EstimatingPasquill-Gifford (P-G) Stability Categories", EPA-454/R-93-055, October 1993.

[22] “User’s Guide to the CTDM Meteorological Preprocessor Program”, EPA-600/8-88-004, 1988. Available on the EPA website: www.epa.gov/scram001.

Wind Rose for 100-m Tower Winds





WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

WINDROSE

FIGURE 2-1.

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 3.7 PERCENT OF THE TIME.

3. MODEL OPTIONS AND SOURCE DEFINITIONS

3.1 Modeling Options for Flat, Simple and Complex Terrain.

The regulatory dispersion model used in this study for the flat and simple terrain is the ISCST3 model. The model was run in the "regulatory mode" which uses the option settings as described in Table 3-1. Table 3-1 also shows the parallel settings or options used for AERMOD setup.

Table 3-1. Model Options Used in Consequence Analysis.

ISCST3	AERMOD
* Use stack tip downwash	* Use stack tip downwash
* Use buoyancy-induced dispersion	* Use buoyancy-induced dispersion (not an option)
* Do not use gradual plume rise (gradual plume rise is used in complex terrain)	* Use gradual plume rise (not an option)
* Use the calms-processing routines	* Use the calms-processing routines(not an option)
* Use default wind profile exponents	* Calculate wind profiles (not an option)
* Use default vertical potential temperature gradients	* Calculate vertical potential temperature gradients (not an option)

The results reported in these 2 components of the study are the high and the highest second-high concentrations averaged over 1-hr, 3-hr and 24-hr short term averages and the high annual average.

3.2 Source Characteristics for Flat, Simple Terrain.

Ten source types are processed for the flat terrain part of this study: seven point sources, one area source and two volume sources. Source characteristics for each source type are presented in Table 3-2. The very buoyant 35 meter stack source and the 200 meter stack source in Table 3-2 are used in the simple terrain part of this study. All these sources are evaluated using: 1) both the rural and urban settings; and 2) both sets of meteorological data. Thus, there are 48 scenarios [(10 flat terrain sources + 2 simple terrain sources) x 2 land use settings (rural, urban) x 2 meteorological sites] and 7 different maximum concentration values for a total of 336 cases .

Table 3-2. Source characteristics for flat and simple terrain.

Point sources					
Stack height (m)	X,Y location & base elevation (m)	Emission rate (gs^{-1})	Exit velocity (ms^{-1})	Stack diameter (m)	Temperature (K)
5	0, 0, 0	100	0	2.4	Ambient
10	0, 0, 0	100	0	2.4	Ambient
20	0, 0, 0	100	0	2.4	Ambient
35 (moderately buoyant)	0, 0, 0	100	11.7	2.4	293
35 (very buoyant)[23]*	0, 0, 0	100	11.7	2.4	432
100	0, 0, 0	100	18.8	4.6	416
200*	0, 0, 0	100	26.5	5.6	425

Area source			
Area (m^2)	Length of side (m)	Emission rate ($gs^{-1}m^{-2}$)	Height of emission release (m)
1,000,000	1000	0.0001	0.0

Volume sources			
Emission rate (gs^{-1})	Height of emision release (m)	Length of side divided by 4.3 (m)	Vertical dimension divided by 4.3 (m)
100	10	14.	16.
100	35	14.	16.

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[23]* These sources are also used for the simple terrain part of the consequence analysis.

3.3 Source Characteristics for Complex Terrain.

The complex terrain analysis examines a combination of four hills, two stack heights, two buoyancies, and two source-hill distances. The four hills are: 1) Piedmont, a hill near Keyser, WV; 2) Montour Ridge - Crosswind, near Sunbury, PA; 3) Montour Ridge - Alongwind; and 4) Cinder Cone Butte, located near Boise, ID. Except for "Montour Crosswind", the sources are located to the west of the hill centers, at distances of about 1 kilometer for the "close-in" case and about 10 kilometers for the "far-out" case (See Appendix B for the figures describing the hills) . For "Montour Crosswind", the sources are located to the north of the east-west oriented ridge. The meteorological data base used in this study features a high percentage of winds from the northwest quadrant (see Figure 2-1). Therefore, the modeling results reflect a large number of cases of plume transport from the hypothetical sources to these hills. The source parameters for the complex terrain analysis are provided in Table 3-3. Although there are 32 possible combinations of hill/source/source-hill distances (4 hills x 2 stack heights x 2 buoyancies x 2 source hill distances), the plume never significantly impacts the Cinder Cone Butte hill in 4 of the cases and are not included in the analysis. Thus, the results are reported for a total of 28 complex terrain cases.

3.4 Source Characteristics for Building Downwash.

A series of hypothetical scenarios involving single point sources and rectangularly shaped buildings were chosen in an earlier work and these configurations are retained for this study. ISCST3, ISC-PRIME and AERMOD are applied to each scenario. The test cases include the following situations:

* a stack adjacent to a building structure, and also four building heights away from the northeast corner of the building;

* stack height to building height ratios of 1.0 and 2.0;

* squat, supersquat, and tall building shapes; and,

* urban and rural settings.

A no-building set of cases is also used for "control" runs. Not counting the no-building cases, there are 20 source/building scenarios and three averaging times to provide a total of 60 cases in this component of the study. The selection of this set of source configurations and averaging times matches that of the earlier consequence analysis.

The stack parameters are listed in Table 3.4.

One year of meteorological data (Pittsburgh, 1964) is employed in this analysis. The results for the highest second-highest 3-hour and 24-hour concentrations, as well as the highest annual concentration are tabulated for each run. The analysis also includes the model predictions for the highest 1 hour cavity concentration.

Table 3-3. Complex Terrain Source Configurations.

Stack height - Buoyancy	Emission rate (g/s)	Stack Height (m)	Stack Gas Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)
Low/Low	1.0	30.	400.	10.	2.0
Low/High	1.0	30.	500.	30.	6.
High/Low	1.0	150.	400.	10.	2.0
High/High	1.0	150.	500.	30.	6.

Table 3-4. Source characteristics for building downwash analysis - point sources.

Stack height (m)	Emission rate (gs^{-1})	Exit velocity (ms^{-1})	Stack diameter (m)	Temperature (K)
35	100	11.7	2.4	432
100	100	18.8	4.6	416

3.5 Receptor Configuration for Flat and Simple Terrain

A gridded polar array of receptors is used in the flat terrain portion of the analysis. For the point sources, there are 36 radials (beginning at 10 degrees from north and spaced every 10 degrees). The distance of the concentric rings are: 125m, 250m, 400m, 800m, 2000m, 4000m, 8000m, and 16000m. The volume and the area source polar grid is also set up for 10 degree radials but uses concentric ring distances of 125m, 250m, 400m, 800m, and 2000m.

A gridded polar array of receptors is used for the point sources in simple terrain settings. There are 36 radials (beginning at 10 degrees from north and spaced every 10 degrees). The distance of the concentric rings were: 800m, 2000m, 4000m, 7000m, and 15000m. The elevations for the receptors are plotted (with isopleths) in Figures 3-1 (35 meter stack) and 3-2 (200 meter stack).

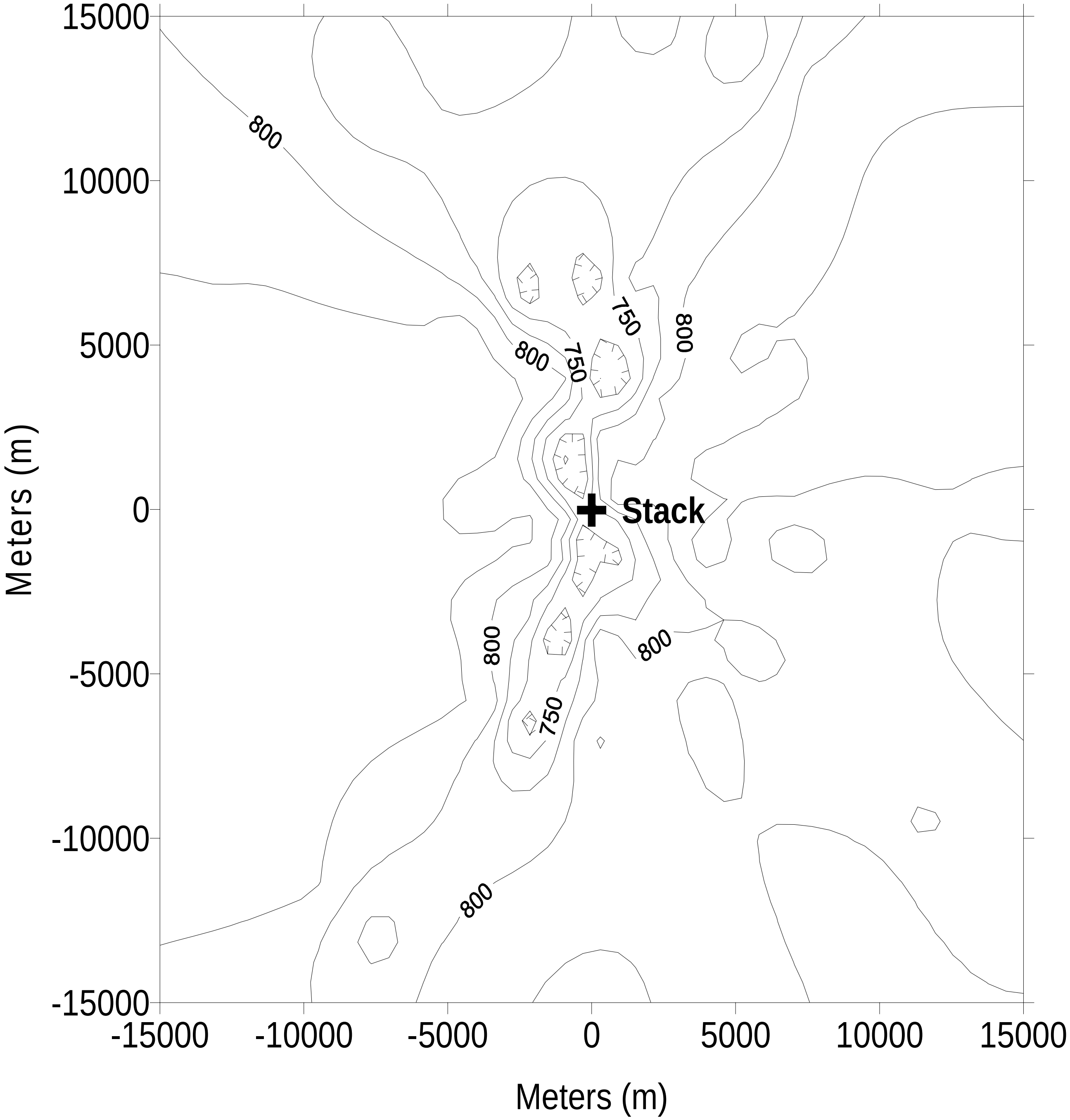
3.6 Receptor Configuration for Building Downwash.

A cartesian receptor grid extending out to 10 kilometers is used in the building downwash analysis. The receptor density varies, with 50-m spacing for the first 500 meters, 100 m spacing out to 1000 m, 200 m spacing out to 2000 m and 1000 m spacing out to 10000 m. This spacing matches that used in the original ISC-PRIME consequence analysis.

3.7 The Complex Terrain Receptor Locations.

The Figures in Appendix B show the contours of the hills used in the analysis. AERMOD, ISCST3, and CTDMPLUS are run with the full year of data described above for 28 combinations of sources, and source-hill distances (1 and 10 kilometers). The CCB and Montour longwind/crosswind setting includes a total of 140 receptors; the Piedmont Hill setting uses a total of 144 receptors; and, the Cinder Cone Butte setting uses 140 receptors. Appendix C contains the input files used to run AERMOD and provides the location and elevations of all the receptor locations for all runs. In all cases, each model estimates concentrations on single hills downwind from the source.

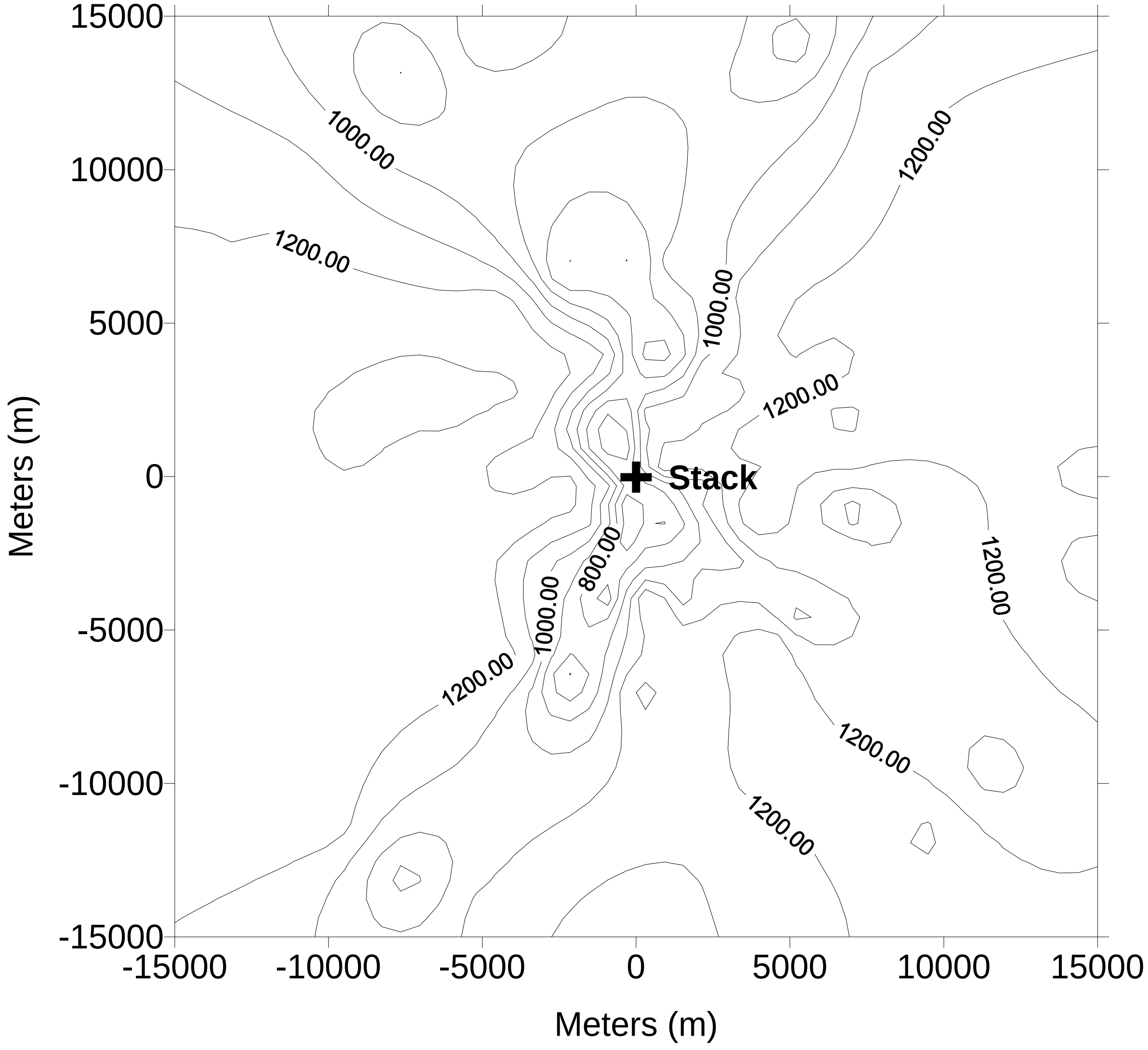
Figure 3-1
Elevation in Feet Around the 35 Meter Stack



Note: 25 ft. contours

Stack base = 797 feet, stack top = 911 feet

Figure 3-2
Elevation in Feet Around the 200 Meter Stack



Note: 100 ft. contours

Stack base = 797 feet, stack top = 1453 feet.

4. MODELING RESULTS

The results from the three components of the study are given in this section. The three components are for the flat and simple terrain, the building downwash and the complex terrain scenarios. The results compare the new (AERMOD version 02222) versus the old model's (ISCST3 or ISC-PRIME) predicted maximum concentrations. The relationship between the current version of AERMOD versus the old model is the focal point of this study. Generally, the modeling community is not concerned about the magnitude of the concentration predictions, but is interested in those situations where the new model predicts higher or lower concentrations than the old model. Thus, the parameter of choice to present the consequences of the new model is the concentration ratio. The concentration ratio can be calculated by dividing the current version of AERMOD's maximum predicted concentration by the old model's corresponding maximum concentration. The concentration ratio parameter is convenient because a ratio greater than 1 occurs when the new model predicts maximum concentrations higher than the old model and, conversely, concentration ratios less than 1 occur when the new model predicts lower maximum concentrations.

As additional information for those who are interested in the model changes since the proposal, the results include concentration ratios which are based on the earlier consequence analyses[2]. That is, the concentration ratios between the current version of the AERMOD versus the proposed version of AERMOD (version 99351) are provided. Often, this second set of concentration ratios is redundant, but they directly help readers who are familiar with the original consequence analysis and who want to study the changes to the consequences subsequent to the Federal Register proposal[3].

4.1 The Flat and Simple Terrain Results.

The results for the flat and simple terrain part of this study are found in Appendix D. The high and the highest second high (H2H) concentrations for the 1, 3, 24 hour and annual averaging times are provided for the ISCST3 model (column 2) and, in parallel, the concentration ratios are provided for the proposed and the current version of AERMOD (columns 3 and 4). The third column reproduces information presented in the earlier consequence analysis, that is, the ratio of maximum concentrations comparing the proposed version of AERMOD to ISCST3. The last column of numbers presents the ratio of the air quality concentrations as predicted by the current versus the proposed version of AERMOD. Although redundant, this last column helps the reader to quickly determine the changes in the consequence analysis since the April 1999 report. Each modeling scenario is defined by a code and the code key is provided at the bottom of each page for convenience.

Because of the amount of data and complexity of the tables in Appendix D, a series of tables are presented to summarize the statistics of the relationship between the predicted concentrations from AERMOD and ISCST3. Tables 4-1, 4-2 and 4-3 have identical structures. There are 4 columns of numbers providing a distribution of concentration ratios. The second column provides a distribution, an average and the maximum and minimum value of the concentration ratios, for the proposed version of AERMOD versus ISCST3, as reported in Appendix D. Again, this is a reference point back to the earlier consequence analysis. The third column shows the new concentration ratios based on the current version of AERMOD (02222) and ISCST3. The last column is redundant but directly supplies information about the magnitude of the changes between the earlier and the current version of the new air dispersion model since those ratios compare the new version of AERMOD to the proposed version of AERMOD. Table 4-1 provides the results for all the modeling scenarios, while Tables 4-2 and Tables 4-3 break out the results by the rural and urban settings.

For example, to further explain the summary tables, refer to the third column in Table 4-1. According to the number in the second row, there are 5 cases where the current version of AERMOD predicts a maximum concentration that is a factor of 3 greater than ISCST's prediction. The third row, column 3 indicates that there are 25 cases where AERMOD's predictions are a factor of 2 greater than ISCST3's. The fifth row indicates the total number of cases (336) in this component of the study. The fourth row and the sixth row values are the most significant. These entries provide the number of cases where the AERMOD (version 02222) maximum concentrations are higher than ISCST3's (116) or lower than ISCST3's maximum concentrations (220). In the seventh row, there are 46 cases where AERMOD concentrations are less than ½ of the ISCST3 's maximum concentrations. The average concentration ratio in row 10, the highest ratio in row 11 and the lowest ratio are based on all 336 cases.

Table 4-1. Summary statistics based on the ratio of AERMOD predicted concentration to ISCST3 predicted concentrations for flat and simple terrain (see Appendix D) over all averaging times and all source types and both rural and urban settings.

	99351AER/ ISC	02222AER/ ISC	02222AER/ 99351AER
no. of ratios > 4	1	0	0
no. of ratios > 3	12	5	0
no. of ratios > 2	43	25	0
no. of ratios > 1	157	116	82
Total No.	336	336	336
no. of ratios < 1.0	179	220	254
no. of ratios < 0.5	44	46	24
no. of ratios <0.33	11	14	7
no. of ratios < 0.25	2	3	1
average	1.14	0.96	0.90
high	4.25	3.82	1.73
low	0.22	0.20	0.22

Table 4-2. Summary statistics based on the ratio of AERMOD predicted concentration to ISCST3 predicted concentrations for flat and simple terrain (see Appendix D) over all averaging times and all source types - FOR THE RURAL SETTING ONLY.

	RURAL RESULTS		
	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
number of ratios >4	0	0	0
>3	8	5	0
>2	27	25	0
>1	91	85	48
total	168	168	168
<1.0	77	83	120
<0.5	16	6	0
<0.33	0	0	0
<0.25	0	0	0
max	3.89	3.83	1.73
min	0.35	0.41	0.73
average	1.25	1.21	1.00

Table 4-3. Summary statistics based on the ratio of AERMOD predicted concentration to ISCST3 predicted concentrations for flat and simple terrain (see Appendix D) over all averaging times and all source types - FOR THE URBAN SETTING ONLY.

	URBAN RESULTS		
	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
number of ratios >4	1	0	0
>3	4	0	0
>2	16	0	0
>1	66	31	34
total	168	168	168
<1.0	102	137	134
<0.5	28	40	24
<0.33	11	14	7
<0.25	2	3	1
max	4.25	1.49	1.61
min	0.22	0.20	0.22
average	1.02	0.71	0.80

4.2 The Building Downwash Results.

As mentioned in the introduction, this section was not in the April 1999 AERMOD consequence analysis since AERMOD was not proposed as the model of choice for building downwash analyses. Because PRIME has now been incorporated into AERMOD, the AERMOD consequence analysis now contains comparisons of the building downwash models. The results, which are patterned after the earlier ISC-PRIME consequence analysis[4], are given in Table 4-4.

Table 4-4 has four sets of columns. The first set of three columns are the scenario descriptions. The second set of 4 columns include: the maximum annual concentrations from ISCST3; the ISC-PRIME to ISCST3 annual concentration ratios (which were reported in the earlier ISC-PRIME consequence analysis); the AERMOD (with PRIME) to ISCST3 annual concentration ratios; and the AERMOD to ISC-PRIME annual concentration ratios (which are redundant). The third set of four columns are for the high-second-high 24 hour concentration rations, using the column structure as for the annual results. The fourth set of four columns are for the high-second-high 3 hour concentration ratios. Table 4-5 presents the summary statistics for the building downwash analysis, that is, the maximum, minimum and average concentration ratios for each of the three averaging times and over all the averaging times.

Table 4-4 makes note of those source/building scenarios where building downwash is significant. This criterion is based on cavity concentrations. Many source scenarios do not produce an estimated cavity concentration (e.g. the 100 meter stack separated from the tall building in a rural setting); but, those that do are marked as significant downwash sources (e.g. the 35 meter stack next to the squat building in a rural setting). There are two examples where both models generate a cavity concentration output, but the estimated cavity concentrations are very small (the 100 meter stack next to the squat building in the urban and rural settings). Table 4-6 presents the summary statistics of the maximum concentration ratios only for those cases where there is significant building downwash.

In addition to the downwind concentrations, cavity concentrations are calculated and Table 4-7 presents the results for each source/building scenario. The maximum cavity concentrations from ISC-PRIME and AERMOD (with PRIME) are given respectively in columns 4 and 5 and the concentration ratios are seen in column 6. ISCST3 does not contain an algorithm to estimate the cavity concentration and could not be included in this table. The summary statistics for the maximum 1 hour cavity concentration ratios are given in Table 4-8.

Table 4-4. Building downwash results.

						ANNUAL RATIOS				24 H2H RATIOS				3 H2H RATIOS
Case	Dispersion	Stack (M)	ISC	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISC	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISC	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP
No building (reference)	**Urban**	**35**	**27.1**	**1.00**	**0.65**	**0.65**	**198.8**	**1.00**	**0.63**	**0.63**	**362.4**	**1.00**	**0.85**	**0.85**
No building (reference)	**Rural**	**35**	**5.8**	**1.00**	**3.36**	**3.36**	**56.1**	**1.00**	**2.78**	**2.78**	**174.7**	**1.00**	**2.06**	**2.06**
No building (reference)	**Urban**	**100**	**3.3**	**1.00**	**0.46**	**0.46**	**22.4**	**1.00**	**0.53**	**0.53**	**58.6**	**1.00**	**0.60**	**0.60**
No building (reference)	**Rural**	**100**	**0.4**	**1.00**	**3.76**	**3.76**	**5.1**	**1.00**	**2.34**	**2.34**	**22.6**	**1.00**	**1.56**	**1.56**
Squat Building -Stack adjacent to NE of building|												|		
Hb=34; 60x120m *	**Urban**	**35**	**232.6**	**1.23**	**1.23**	**1.00**	**1439.8**	**1.48**	**1.38**	**0.93**	**3442.4**	**0.85**	**0.79**	**0.93**
Hb=34; 60x120m *	**Rural**	**35**	**236.6**	**0.87**	**1.11**	**1.29**	**1574.7**	**1.03**	**1.16**	**1.13**	**5662.6**	**0.39**	**0.45**	**1.17**
Hb=50; 60x120m	**Urban**	**100**	**4.1**	**2.15**	**0.77**	**0.36**	**30.0**	**2.07**	**0.87**	**0.42**	**62.4**	**1.93**	**1.29**	**0.66**
Hb=50; 60x120m	**Rural**	**100**	**1.5**	**1.61**	**2.79**	**1.74**	**21.9**	**1.80**	**1.91**	**1.06**	**59.2**	**1.62**	**1.41**	**0.87**
Squat Building -Stack at distance 4*Hb to NE of building|												|		
Hb=34; 60x120m	**Urban**	**35**	**180.4**	**0.22**	**0.09**	**0.42**	**1097.4**	**0.25**	**0.11**	**0.47**	**3007.7**	**0.18**	**0.12**	**0.66**
Hb=34; 60x120m	**Rural**	**35**	**180.7**	**0.05**	**0.12**	**2.46**	**1556.5**	**0.11**	**0.12**	**1.16**	**4292.8**	**0.11**	**0.10**	**0.87**
Hb=50; 60x120m	**Urban**	**100**	**3.9**	**1.09**	**0.44**	**0.40**	**26.0**	**1.17**	**0.47**	**0.40**	**58.6**	**1.38**	**0.65**	**0.47**
Hb=50; 60x120m	**Rural**	**100**	**1.4**	**0.38**	**1.22**	**3.19**	**17.3**	**0.32**	**0.71**	**2.19**	**59.2**	**0.41**	**0.64**	**1.57**
Tall Building -Stack adjacent to NE of building|												|		
Hb=34; 30x30m *	**Urban**	**35**	**243.9**	**1.72**	**1.35**	**0.79**	**1508.3**	**2.24**	**1.87**	**0.84**	**3442.4**	**1.29**	**1.20**	**0.93**
Hb=34; 30x30m *	**Rural**	**35**	**242.5**	**1.32**	**1.32**	**0.99**	**1751.9**	**1.36**	**1.55**	**1.14**	**5662.6**	**0.64**	**0.71**	**1.11**
Hb=50; 30x30m	**Urban**	**100**	**3.4**	**1.63**	**0.45**	**0.28**	**23.4**	**1.60**	**0.51**	**0.32**	**58.6**	**1.58**	**0.60**	**0.38**
Hb=50; 30x30m	**Rural**	**100**	**0.4**	**1.21**	**3.66**	**3.03**	**7.5**	**0.76**	**1.57**	**2.07**	**31.3**	**0.99**	**1.12**	**1.13**
Tall Building -Stack at distance 4*Hb to NE of building|												|		
Hb=34; 30x30m	**Urban**	**35**	**150.8**	**0.26**	**0.12**	**0.45**	**1023.5**	**0.28**	**0.12**	**0.43**	**2780.6**	**0.23**	**0.11**	**0.47**
Hb=34; 30x30m	**Rural**	**35**	**181.5**	**0.04**	**0.11**	**2.59**	**1556.1**	**0.05**	**0.10**	**2.18**	**4206.6**	**0.07**	**0.09**	**1.25**
Hb=50; 30x30m	**Urban**	**100**	**3.4**	**1.32**	**0.45**	**0.34**	**22.7**	**1.42**	**0.52**	**0.37**	**58.6**	**1.45**	**0.60**	**0.41**
Hb=50; 30x30m	**Rural**	**100**	**0.4**	**1.06**	**3.67**	**3.46**	**7.3**	**0.69**	**1.62**	**2.34**	**31.3**	**0.76**	**1.12**	**1.48**
Super Squat Building -Stack adjacent to NE of building|												|		
Hb=34; 180x180m *	**Urban**	**35**	**244.2**	**0.75**	**0.74**	**0.99**	**1508.3**	**0.90**	**0.86**	**0.96**	**3017.8**	**0.74**	**0.76**	**1.02**
Hb=34; 180x180m *	**Rural**	**35**	**243.2**	**0.57**	**0.69**	**1.23**	**1761.8**	**0.66**	**0.69**	**1.06**	**5614.5**	**0.34**	**0.38**	**1.12**
Super Squat Building -Stack at distance 4*Hb to NE of building|												|		
Hb=34; 180x180m	**Urban**	**35**	**226.2**	**0.17**	**0.08**	**0.45**	**1154.4**	**0.20**	**0.14**	**0.70**	**3007.7**	**0.16**	**0.14**	**0.85**
Hb=34; 180x180m	**Rural**	**35**	**240.6**	**0.05**	**0.10**	**2.08**	**1556.5**	**0.14**	**0.15**	**1.04**	**4292.8**	**0.12**	**0.12**	**0.98**

* Significant downwash source

Table 4-5. Summary of the building downwash analysis.

	ANNUAL RATIOS			24 H2H RATIOS			3 H2H RATIOS			ALL AVERAGING TIMES		
	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP
ave	**0.88**	**1.03**	**1.38**	**0.93**	**0.82**	**1.06**	**0.76**	**0.62**	**0.92**	**0.86**	**0.82**	**1.12**
max	**2.15**	**3.67**	**3.46**	**2.24**	**1.91**	**2.34**	**1.93**	**1.41**	**1.57**	**2.24**	**3.67**	**3.46**
min	**0.04**	**0.08**	**0.28**	**0.05**	**0.10**	**0.32**	**0.07**	**0.09**	**0.38**	**0.04**	**0.08**	**0.28**
No cases	**20**			**20**			**20**			**60**		

Table 4-6. Summary of results for those sources with significant downwash.

	ANNUAL RATIOS			24 H2H RATIOS			3 H2H RATIOS			ALL AVERAGING TIMES		
	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP	ISCP/ ISC3	AERMOD/ ISC3	AERMOD/ ISCP
ave	**1.08**	**1.08**	**1.05**	**1.28**	**1.25**	**1.01**	**0.71**	**0.71**	**1.05**	**1.02**	**1.01**	**1.03**
max	**1.72**	**1.35**	**1.29**	**2.24**	**1.87**	**1.14**	**1.29**	**1.20**	**1.17**	**2.24**	**1.87**	**1.29**
min	**0.57**	**0.69**	**0.79**	**0.66**	**0.69**	**0.84**	**0.34**	**0.38**	**0.93**	**0.34**	**0.38**	**0.79**
No cases	**6**			**6**			**6**			**18**		

Table 4-7. Results of the PRIME cavity max hourly concentrations (ug/m3) in ISC-PRIME and AERMOD (version 02222). Summary statistics of the AERMOD to ISC-PRIME ratios are included.

			MAX 1 HR CAVITY CONC		
Case	Dispersion	Stack (M)	ISCP	AERMOD	AERMOD/ ISCP
No building	**Urban**	**35**			
No building	**Rural**	**35**			
No building	**Urban**	**100**			
No building	**Rural**	**100**			
Squat Building -Stack adjacent to NE of building					
Hb=34; 60x120m	**Urban**	**35**	**3202**	**3180**	**0.99**
Hb=34; 60x120m	**Rural**	**35**	**2341**	**3180**	**1.36**
Hb=50; 60x120m	**Urban**	**100**	**10***	**0.08***	**N/A**
Hb=50; 60x120m	**Rural**	**100**	**0***	**0.08***	**N/A**
Squat Building -Stack at distance 4*Hb to NE of building					
Hb=34; 60x120m	**Urban**	**35**			
Hb=34; 60x120m	**Rural**	**35**			
Hb=50; 60x120m	**Urban**	**100**			
Hb=50; 60x120m	**Rural**	**100**			
Tall Building -Stack adjacent to NE of building					
Hb=34; 30x30m	**Urban**	**35**	**5034**	**4388**	**0.87**
Hb=34; 30x30m	**Rural**	**35**	**3963**	**4388**	**1.11**
Hb=50; 30x30m	**Urban**	**100**			
Hb=50; 30x30m	**Rural**	**100**			
Tall Building -Stack at distance 4*Hb to NE of building					
Hb=34; 30x30m	**Urban**	**35**			
Hb=34; 30x30m	**Rural**	**35**			
Hb=50; 30x30m	**Urban**	**100**			
Hb=50; 30x30m	**Rural**	**100**			
Super Squat Building -Stack adjacent to NE of building					
Hb=34; 180x180m	**Urban**	**35**	**2524**	**2498**	**0.99**
Hb=34; 180x180m	**Rural**	**35**	**2321**	**3276**	**1.41**
Super Squat Building -Stack at distance 4*Hb to NE of building					
Hb=34; 180x180m	**Urban**	**35**			
Hb=34; 180x180m	**Rural**	**35**			

* considered insignificant

Table 4-8. Summary of the building downwash 1 hour cavity concentration ratios.

	AERMOD/ ISCP
ave	1.12
max	1.41
min	0.87
No cases	6

4.3 The Complex Terrain Results.

The complex terrain results which compare AERMOD to ISCST3[24] and to CTDMPLUS, are presented in Appendix E. The Appendix E table includes the highest second high ratios along with the highest annual concentrations. A summary of the complex terrain results are provided below in Table 4-9. Table 4-9 provides a distribution of AERMOD to other model concentration ratios. There were no cases where AERMOD predicted higher concentrations than either ISC or CTDMPLUS. As seen before, the last column in Table 4-9 provides data, presented in the earlier consequence analysis, as a convenient reference for the reader.

Table 4-9. Summary statistics based on the ratio of AERMOD predicted regulatory design concentration to ISCST3(COMPLEX1) and CTDMPlus predicted-regulatory-design concentrations for complex terrain (see Appendix E).

	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
NO OF RATIOS>4	0	0	0
NO OF RATIOS>3	0	0	0
NO OF RATIOS>2	0	2	1
NO OF RATIOS>1	0	40	74
TOTAL NO	196	196	196
NO OF RATIOS<1.0	196	152	77
NO OF RATIOS<0.5	189	58	0
NO OF RATIOS<0.33	163	28	0
NO OF RATIOS<0.25	119	15	0
AVERAGE	0.24	0.75	1.01
MAX	0.79	2.13	2.67
MIN	0.07	0.14	0.61

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[24] In complex terrain, the COMPLEX1 portion of the ISCST3 model is playing a significant role. For receptors with elevations above the plume height, the COMPLEX1 concentration estimates are used. In intermediate terrain, the highest estimates from the "ISCST3" simple terrain model and the COMPLEX1 model are used.

5. DISCUSSION OF RESULTS

5.1 Discussion of Flat and Simple Terrain Results.

5.1.1. The current version of AERMOD (02222). With all the flat and simple terrain results viewed as a whole, the current version of AERMOD produces maximum concentrations that are similar to ISCST3's predicted concentrations. The reported average of 0.96 (Table 4-1, row 10 column 3) indicates that AERMOD predicts concentrations only about 4% lower than ISCST3. This average is taken over all source types, stack heights, settings and concentration averaging times. However, as expected when a new model is developed, there are differences between the old and the new air dispersion model predictions. Although about 80% of the AERMOD concentrations are within a factor of 2 (high or low) from the ISCST3 concentrations Table 4-1, column 3 also indicates that, for certain situations, the proposed AERMOD predictions are higher or lower than ISCST3 predictions by a factor of 3 or more. Upon studying column 4 in the detailed Appendix D listing, one can find that the most significant differences between the 2 models are found in the following scenarios:

1. in the rural, low level stacks (AERMOD is lower);

2. in the long-term concentrations for the rural, taller stacks (AERMOD is higher);

3. in the short-term, urban short stacks and urban area sources (AERMOD is lower); and,

4. in all of the regulatory concentrations for urban very tall stacks in simple terrain (AERMOD is lower).

These results are consistent across the 2 meteorological data bases. Because the 2 air dispersion models are significantly different from one another (see Appendix A for side-by-side comparison), such variation in the model differences is expected.

5.1.2. Impacts of the changes to AERMOD. Changes made to AERMOD produced changes to the consequence analysis. Column 2 in Table 4-1 shows that, over all source types, settings, and averaging times, the proposed version of AERMOD predicts an average concentration ratio of 1.14 or about 14% higher than ISCST3 (compared to 0.96 or about 4% lower based on the current version of AERMOD). Thus, there is about a 16% [25]reduction in the overall average of concentration ratios. Table 4-1 column 3 also indicates that the differences in the AERMOD predictions are not as extreme as seen in the earlier consequence analysis. The number of cases where the AERMOD to ISCST3 ratios are greater than a factor of 2 drops from 43 out of a total of 336 (proposed version) to 25 (current version). The number of cases where the concentration ratios are greater than 3 drops from 12 to 5. On the other side of the distribution where AERMOD predictions are less than ISCST3's predictions, the distribution of cases where the AERMOD to

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[25] The 16% = (1.14-0.96) / 1.14 x 100.

ISCST3 concentration ratios are less than one-half, less than one-third and less than one-fourth remains almost the same as those from the April 1999 analysis.

Reviewing the urban and rural breakout tables (Tables 4-2, 4-3), one sees that the largest changes occur in the urban setting while the rural distribution and averages do not change significantly. In the urban setting results in Appendix D, the most significant changes are found in the following scenarios:

1. in the short-term concentrations for area sources (a decrease in concentrations due to the proper urbanization of the dispersions parameters);

2. in the short-term concentrations for low stacks (a decrease in concentrations due to the addition of meander for both stable and unstable settings); and,

3. in the overall urban category when comparing the averages in Table 4-3, row 11, columns 3 and 4 (a decrease due to the addition of stable and unstable urban meander).

In the rural setting, less significant changes are seen and those changes are found:

1. in the short-term concentration for low stacks (an increase due to the changing of the minimum layer depth used to calculate the effective dispersion parameters- a secondary effect from fixing the urban dispersion problem); and,

2. in the overall results (a slight overall reduction in concentration predictions due to the addition of meander in the rural, stable setting).

5.1.3. Model Evaluation Study support. Differences between models leads to the next topic for discussion - how do these models perform when compared to measured data? Do the differences represent an improvement in model predictions? The model evaluation study (MES)[8] provides AERMOD's (including the proposed version and the current version) and ISCST3's predictions and compares them to ambient air quality data. Of the 5 available flat terrain data bases in the MES, there is one MES site with a low-level release in a flat rural setting. In this scenario, the current version of AERMOD's (version 02222) short-term concentration predictions (the Robust Highest Concentrations[26] [RHCs]) are about ½ of the ISCST3 estimates, with the AERMOD estimates more closely matching the observed values. The MES also includes 3 rural, tall stack scenarios in flat or simple terrain locations which shows AERMOD predicting long-term concentrations (RHCs that are almost twice as high as the ISCST3 predictions. In all 3 cases, AERMOD predictions are closer to the measured values. The MES does not have any data bases which are representative of the shorter stacks in urban settings. The one urban data set (tall stack) in the MES is based on a limited monitoring study. The urban one-hour RHC for AERMOD is about 20% lower than the ISCST3 with AERMOD predictions closer to the measured concentrations. The MES supports the

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[26] W.M. Cox, J.A. Tikvart, "A Statistical Procedure for Determining the Best Performing Air Quality Simulation Model", Atmospheric Environment, Vol.24A, No 9, pp 2387-2395, 1990

AERMOD concentration predictions over those provided by the ISCST3 model, i.e., AERMOD's performance is better than ISCST3's performance when compared to monitored concentrations.

Also, the MES indicates a slight performance improvement when comparing the current version of AERMOD (version 02222) to the proposed version of AERMOD. The most notable differences are in the short term concentrations with a tall stack in the urban area and with a tall stack in moderate hilly terrain in a rural area. In both settings, the current version of AERMOD predicts lower RHCs than the proposed version (which is consistent with this study) and predicts concentrations that are closer to the measured values.

5.2 Discussion of Building Downwash Results.

The discussion in this section does not include the proposed version of AERMOD. The proposed version of AERMOD (99351) does not include the PRIME algorithms and does not play a role in the building downwash analysis. For this component of the consequence analysis, the current version of AERMOD (02222) is the new model, ISC-PRIME is the proposed model, and ISCST3 is the currently approved model.

5.2.1 AERMOD versus ISCST3. Table 4-4 presents the results of the downwash analysis and Table 4-5 presents a summary of the results. The summary table indicates that AERMOD (with PRIME) produces somewhat lower maximum concentration estimates, on average, than ISCST3. The AERMOD to ISCST3 ratios in column 12 displays an average concentration ratio of 0.82; that is, on average over all 60 cases (10 source types, 2 settings and 3 averaging times), AERMOD predicts concentrations that are about 18% lower than ISCST3's predictions. However, the range of the concentration ratios is more significant; AERMOD predicted concentrations that are up to a factor of 4 higher and up to a factor of 10 lower than ISCST3.

The situation where AERMOD's predicts maximum concentrations much lower than the ISCST concentrations is found in several cases. For example, the 35 meter stack separated from the building for all averaging times in urban and rural settings for all 3 building types (total of 18 cases in Table 4-4) indicate lower AERMOD predictions. Because the downwash algorithms in ISCST3 ignore the separation between stacks and buildings and is designed to be environmentally conservative[27], relatively smaller AERMOD concentrations are expected for the shorter stacks. This scenario with stack/building separation was chosen originally to highlight the differences in the ISCST3 and PRIME models, thus, significant differences are expected. The vast majority of the remaining cases have AERMOD concentrations that are within a factor of 2 of the ISCST3 concentrations.

There are situations where AERMOD is higher than ISCST3. For example, in the annual concentration estimates for the rural setting, tall and squat building with a 100 meter stack (both adjacent to the building and separated from the building), the AERMOD maximum concentrations are larger than the ISCST3 estimates. In these cases, building downwash is not important to the

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[27] ISCST3 assumes that the stack is located in the center of the building which maximizes the impacts of the building wake on the plume dispersion. Generally, this assumption will predict the highest concentrations.

calculation of maximum annual concentration estimates, so the difference between AERMOD and ISCST3 concentration estimates are attributable only to the differences in the dispersion algorithms within the two models. The insignificance of building downwash for these cases is seen: 1) by the lack of a calculated cavity concentration (Table 4-7); and, by comparing the ISCST3 maximum concentrations to the matching non-downwash case for 100 meter stack in the rural setting (Table 4-4). The maximum annual concentrations and the concentration ratios for the downwash cases remains basically unchanged from the corresponding “No building” case.

There is a second set of statistics prepared for those sources where cavity concentrations are calculated, that is, building downwash is a known significant factor in the dispersion of the plume (Table 4-6). These sources are marked in Table 4-4. The summary results in column 12, Table 4-6, show that the AERMOD maximum concentration predictions are, on average, about the same as those produced by ISCST3 (average concentration ratio of 1.01). The concentration ratios range from a maximum of 1.87 to a minimum of 0.38. In all these significant downwash cases in Table 4-4, the stack is close to the building and the discrepancies between the 2 models are due only to the differences in the downwash algorithms.

5.2.2 AERMOD versus ISC-PRIME. Table 4-5 provides the summary information about the comparison between AERMOD and ISC-PRIME. Because PRIME is in both models, the expectation is that the 2 models should be in reasonable agreement. On average over the 60 cases, the ratio of AERMOD to ISC-PRIME maximum concentration predictions was 1.12 (AERMOD predictions are about 12% higher than ISC-PRIME predictions), which is rather good agreement. However, the maximum concentration ratio (3.46) and the minimum concentration ratio (0.28) are of initial concern. When studying the concentration values in Table 4-4 for those cases with the highest differences (rural case with 100 meter stack separated from a tall building) and lowest differences (urban case with 100 meter stack near a tall building), one can see that there are similar differences between the two models in the no-building scenario (rows 3 and 4). Thus, these extreme cases, which are not significant downwash cases, are mostly explained by the differences in the dispersion algorithms.

For those cases where building downwash was more important, the two models should be in closer agreement, because the PRIME algorithms are in both models and should be dominating the dispersion calculations. Although there are differences in the way that PRIME interacts with the two dispersion models (the numerical plume rise, the plume capture criteria and blending of the disturbed plume with the surrounding undisturbed atmosphere), there are a number of tests to check AERMOD with the PRIME insertion.

The first test involves the cavity concentrations which should be similar between the two models. Tables 4-7 and 4-8 indicate that this is so. In Table 4-8, for the 6 cases with significant maximum 1 hour cavity concentrations estimates, the average AERMOD/ISC-PRIME concentration ratio is 1.12 with the concentration ratio ranging from a maximum of 1.41 to a minimum of 0.87. These cavity concentration differences are attributable to the differences in the plume rise equations. There are two cases where a very small cavity concentration is calculated by both models, but these results not included in the previously mentioned statistics. These two cases include the 100 meter stack with a squat building in the rural and urban setting.

The second related test reviews the AERMOD versus ISC-PRIME maximum concentration results for all averaging times for those cases with significant downwash (Table 4-6). The average AERMOD/ISC-PRIME concentration ratio is 1.03 with a maximum value of 1.29 and a minimum value of 0.79 (column 13). As expected in these cases with a definite cavity, the two models agree very closely (plus or minus 30%).

The third test of model consistently compares those cases where building downwash is not significant enough to produce concentrations different from the reference ("No-building") case (the first 4 rows in Table 4-4). In this test, both models should predict maximum concentrations that are essentially the same as those predicted by the model in the corresponding "No building" scenario. Table 4-4 indicates there are three source scenarios (all averaging times) where the building has little or no effects on the ISC-PRIME maximum concentrations: rural, urban 100 meter stacks separated from a squat building; and rural, urban 100 meter stacks near and separated from a tall building. In all these cases, AERMOD produces a matching result in that the building had almost no effect on the estimated maximum concentrations.

Conversely, there are cases where AERMOD shows no change from the no-building to the with building scenario and ISC-PRIME modeling results predict some impact from the building. Examples of this result are seen in the 3 hour averaging columns: the urban and rural 100 meter stack near and separated from a tall building; the urban and rural 35 meter stack separated from the tall building; and, the urban 100 meter stack separated from the tall building. This difference in the two models is expected because of the critical angle of plume rise used for calculating the amount of pollution that is caught in the wake of the building. AERMOD development work suggested a change in this area and a different critical angle was implemented in the AERMOD.

5.2.3. Model Evaluation Study support. The original model evaluation reports [13,14], in general, support the addition of PRIME to the ISCST3 model. The reports conclude that the PRIME had a statistically better performance result for each data base in the independent evaluation. Although these results support the implementation of PRIME into the regulatory models, none of the evaluation databases have examples of stacks significantly separated from the building. So the model differences cannot be confirmed for this scenario.

Although the AERMOD and ISC-PRIME maximum concentration estimates are in general agreement, there are differences. Some variations are expected because of the way that PRIME is integrated into AERMOD. When reviewing the model evaluation results[8], one finds that the AERMOD performance is slightly better than ISC-PRIME. There are four cases of slight degradation of performance, four cases of similar performance and, five cases with improved performance. Of the five cases with improved performance, there is one case with a rather dramatic performance improvement.

5.3 Discussion of Complex Terrain Results.

5.3.1 The current version of AERMOD (02222). The current version of AERMOD (02222) consistently produced lower or significantly lower regulatory design concentrations estimates than those generated from the ISCST3 (Table 4-9). This result was expected since that portion of the ISCST3 model that deals with complex terrain,COMPLEX1, is used for screening purposes and has been designed to be conservative[28]. The average AERMOD/ISCST3 concentration ratio, overall scenarios and averaging times, is 0.24 (column 2, row 10). Thus, AERMOD produced maximum concentrations that were, over all all cases, a factor of 4 lower than the ISCST3 predictions. The concentration ratios ranged from 0.07 to 0.79. In well over half of the cases (119 of the 196 cases), AERMOD produced maximum concentrations that were a factor of 4 lower than the ISCST3 estimates. There were no cases where AERMOD predicted maximum concentrations higher than ISCST3. When examining Appendix E, the differences between the 2 models tended to increase with averaging time, i.e. the largest differences were seen in the maximum annual averages.

Also, Table 4-9 and Appendix E contain the results for the AERMOD/CTDMPLUS comparison. As expected, the models agreed more closely, since CTDMPLUS, which is not a screening model like COMPLEX1, is a more refined, site-specific complex terrain model. Table 4-9 indicates that the average AERMOD/CTDMPLUS ratio over all cases was 0.75 with a range of 0.14 (lowest value) to 2.13 (highest value). Table 4-9 indicates that AERMOD predicted maximum concentrations that were larger than CTDMPLUS in about 20% of cases (40 out of 196).

5.3.2. Impacts of the changes to AERMOD. In the complex terrain scenarios, changes to the complex terrain algorithms do not produce much of a change to the consequence analysis. Some minor changes were made to the algorithm to make the model's concentration predictions less sensitive to the domain selection. The critical value of hill height scale was not changed in the input files. Thus, significant changes from the earlier consequence analysis are not expected. Table 4-9 column 4 summarizes the numerical changes to the concentration ratios of the current version of AERMOD to the proposed version of AERMOD. The average concentration ratio over all 196 cases is 1.01 which implies that the changes did not bias the model towards higher or lower concentration estimates. The range of concentration ratios of new versus the old version of AERMOD was 0.61 to 2.67. The one high value of 2.67 was due to changes in the meander algorithm and was not a repercussion of the complex terrain changes. Although not shown in the summary table, about 94 % of the concentration ratios were within a factor of plus or minus 30%.

5.3.3. Model evaluation study support. As mentioned above, the differences between AERMOD and ISCST3 tend to increase with averaging time, i.e. the largest differences are seen in the maximum annual averages. These results are confirmed by the complex terrain model evaluation results. AERMOD consistently predicts lower maximum concentrations than ISCST3

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[28] That is, the model is designed to overestimate or produce concentration estimates which are larger than concentrations that one would measure.

with the largest variations occurring in the annual averages. AERMOD provides much better performance in the complex terrain data bases.

AERMOD does not consistently predict lower maximum concentrations than CTDMPLUS's estimates, as is seen in the comparisons. There are cases where AERMOD is higher and lower than the site-specific complex terrain model. These results are consistent with the model evaluation results as AERMOD produces RHCs higher and lower than CTDMPLUS. However, in all but one of the 10 evaluation cases, AERMOD outperforms CTDMPLUS.

The model evaluation results indicate that the current version of the model performs slightly better than the proposed version. In all of the 10 complex terrain database cases, the change to the performance is no greater than 9%.

6. GENERAL CONCLUSIONS

The following general conclusions are made.

1) For non-downwash settings in flat and simple terrain, the current version of AERMOD (version 02222): a) on average, tends to predict maximum concentrations that are similar to ISCST3; b) , on average, tends to predict concentrations closer to ISCST3 than the proposed version of AERMOD; and, c) predicts maximum concentrations which are not as extreme in their differences from ISCST3 as those seen when applying the proposed version of AERMOD; and, on average, tends to predict urban maximum concentrations that are lower than the proposed version of AERMOD.

2) Where building downwash is a significant factor in the air dispersion analysis, the current version of AERMOD predicts maximum concentrations and maximum cavity concentrations that are very similar to ISC-PRIME.

3) In general, the consequences from using the current version of AERMOD instead of ISCST3 in complex terrain are significant, the current version of AERMOD produces much lower maximum concentrations than the screening technique in ISCST3. Also, the current version of AERMOD produced results that are essentially unchanged from the results reported using the proposed version of AERMOD. When compared to CTDMPLUS, AERMOD tends to predict somewhat lower maximum concentrations with examples of AERMOD predictions being higher and lower than the CTDMPLUS predictions.

4) Where data are available, the model evaluation results support the differences identified in this report when comparing the proposed version of AERMOD to ISCST3 and when comparing the current version of AERMOD to the proposed version of AERMOD. . The model evaluation report indicates that the current version of AERMOD outperforms all the other four models (ISCST3, ISC-PRIME, CDTMPLUS and the proposed version of AERMOD).

5) Because of the stability of AERMOD model throughout the consequence analysis and because the model evaluation study supports AERMOD (02222) when significant differences occur between the current version of AERMOD and ISCST3 or the earlier version of AERMOD, it is appropriate for the Agency to adopt the current version of AERMOD (02222) as a regulatory model and is a suitable replacement for ISCST3 for many regulatory applications.

7. COMPUTER RUN TIMES

As an additional feature to the consequence analysis, ISCST3 and AERMOD models were compiled and run on a typical personal computer**.** The purpose of this exercise was to provide the user community with a sense of the potential changes in the amount of time to run typical source configurations on their computer systems. The results are tabulated below in Table 7-1. The computer used to complete this table was a Pentium 2.4 Gigahertz computer with 256 megabytes of random access memory. Each source run evaluated 180 receptors in a polar grid (36 radials with 5 ring distances). One full year (8784 hours) of meteorological data was used for each run.

Table 7-1. Computer Run Times for Typical Source Configurations.

Source Type	**AERMOD**	**ISCST3**	**AER/ISC RATIO**
Point source	**20.1 seconds**	**2.34 seconds**	**8.5**
Point source w/ downwash	**179**	**42**	**4.1**
Volume source	**12.8**	**2.03**	**6.3**
Area source	**2190**	**515**	**4.3**

APPENDIX A

SIDE BY SIDE COMPARISON

AERMOD VERSUS ISCST3

Feature	ISCST3	AERMOD (version 02222)	Comments
Types of sources modeled	Point, area, and volume sources	Same as ISCST3	Models are comparable
Plume Rise	Uses Briggs equations with stack-top wind speed and vertical temperature gradient	In stable conditions, uses Briggs equations with winds and temperature gradient at stack top and half-way to final plume rise; in convective conditions, plume rise is superposed on the displacements by random convective velocities	AERMOD is better because in stable conditions it factors in wind and temperature changes above stack top, and in unstable conditions it accounts for convective updrafts and downdrafts
Meteorological Data Input	One level of data accepted	An arbitrarily large number of data levels can be accommodated	AERMOD can adapt multiple levels of data to various stack and plume height
Profiling Meteorological Data	Only wind speed is profiled	AERMOD creates profiles of wind, temperature, and turbulence, using all available measurement levels	AERMOD is much improved over ISCST3 in this area
Use of Meteorological Data in Plume Dispersion	Stack-top variables for all downwind distances	Variables measured throughout the plume depth (averaged from plume centerline to 2.15 sigma-z below centerline; changes with downwind distance)	AERMOD treatment is far more advanced than that of ISCST3; accounts for meteorological data throughout the plume depth
Plume Dispersion: General Treatment	Gaussian treatment in horizontal and vertical	Gaussian treatment in horizontal and in vertical for stable conditions; non-Gaussian probability density function in vertical for unstable conditions	AERMOD’s unstable treatment of vertical dispersion is a more accurate portrayal of actual conditions

Feature	ISCST3	AERMOD (version 02222)	Comments
Urban Treatment	**Urban option either on or off; no other specification available; all sources must be modeled either rural or urban**	**Population is specified, so treatment can consider a variety of urban conditions; sources can individually be modeled rural or urban**	**AERMOD provides variable urban treatment as a function of city population, and can selectively model sources as rural or urban**
Characterization of Modeling Domain Surface Characteristics	**Choice of rural or urban**	**Selection by direction and month of roughness length, albedo, and Bowen ratio, providing user flexibility to vary surface characteristics**	**AERMOD provides the user with considerably more options in the selection of the surface characteristics**
Boundary Layer Parameters	**Wind speed, mixing height, and stability class**	**Friction velocity, Monin-Obukhov length, convective velocity scale, mechanical and convective mixing height, sensible heat flux**	**AERMOD provides parameters required for use with up-to-date planetary boundary layer (PBL) parameterizations; ISCST3 does not**
Mixed Layer Height	**Holzworth scheme; uses interpolation based upon maximum afternoon mixing height**	**Has convective and mechanical mixed layer height; convective height based upon hourly accumulation of sensible heat flux**	**AERMOD's formulation is significantly more advanced than that of ISCST3, includes a mechanical component, and in using hourly input data, provides a more realistic sequence of the diurnal mixing height changes**

Feature	ISCST3	AERMOD (version 02222)	Comments
Terrain Depiction	Elevation at each receptor point	Controlling hill elevation and point elevation at each receptor, obtained from special terrain pre-processor (AERMAP) that uses digital elevation model (DEM) data	AERMOD’s terrain pre-processor provides information for advanced critical dividing streamline height algorithms and uses digital data to obtain receptor elevations
Plume Dispersion: Plume Growth Rates	Based upon 6 discrete stability classes only; dispersion curves (Pasquill-Gifford) are based upon surface release experiments (e.g., Prairie Grass)	Uses profiles of vertical and horizontal turbulence (from measurements and/or PBL theory); variable with height; uses continuous growth functions rather than a discrete (stability-based) formulation	Use of turbulence-based plume growth with height dependence rather than that based upon stability class provides AERMOD with a substantial advancement over the ISCST3 treatment
Plume Interaction with Mixing Lid: convective conditions	If plume centerline is above lid, a zero ground-level concentration is assumed	Three plume components are considered: a “direct” plume that is advected to the ground in a downdraft, an “indirect” plume caught in an updraft that reaches the lid and eventually is brought to the ground, and a plume that penetrates the mixing lid and disperses more slowly in the stable layer aloft (and which can re-enter	The AERMOD treatment avoids potential underpredictions suffered by ISCST3 due to its “all or nothing” treatment of the plume; AERMOD’s use of convective updrafts and downdrafts in a probability density function approach is a significant advancement over ISCST3

Feature	ISCST3	AERMOD (version 02222)	Comments
		the mixed layer and disperse to the ground)	
Plume Interaction with Mixing Lid: stable conditions	The mixing lid is ignored (assumed to be infinitely high)	A mechanically mixed layer near the ground is considered. Plume reflection from an elevated lid is considered.	AERMOD's use of a mechanically mixed layer is an advancement over the very simplistic ISCST3 approach
Building Downwash	Combination of Huber-Snyder and Scire-Schulman algorithms; many discontinuities	New PRIME downwash algorithm installed	AERMOD benefits from the technological advances offered by the PRIME model

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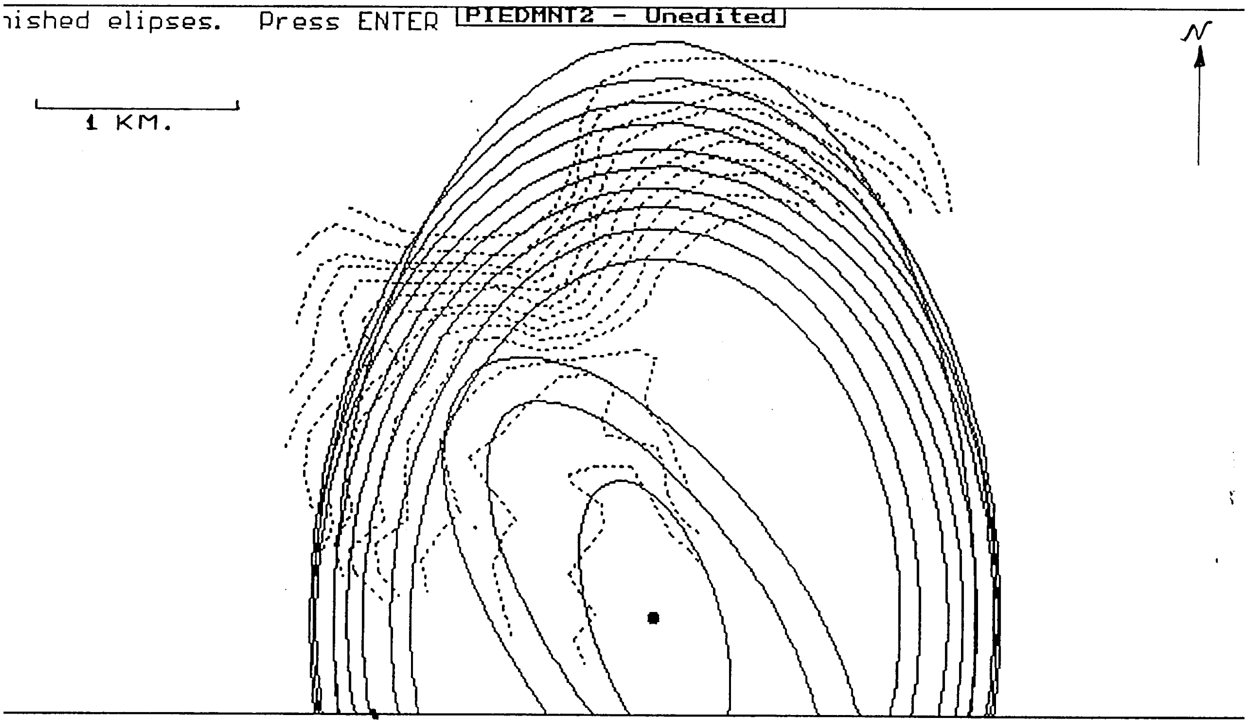
APPENDIX B

FIGURES FOR DESCRIBING COMPLEX TERRAIN


ished elipses. Press ENTER

PIEDMNT2 - Unedited

Figure B-1. Plot of Piedmont Hill Contours.*

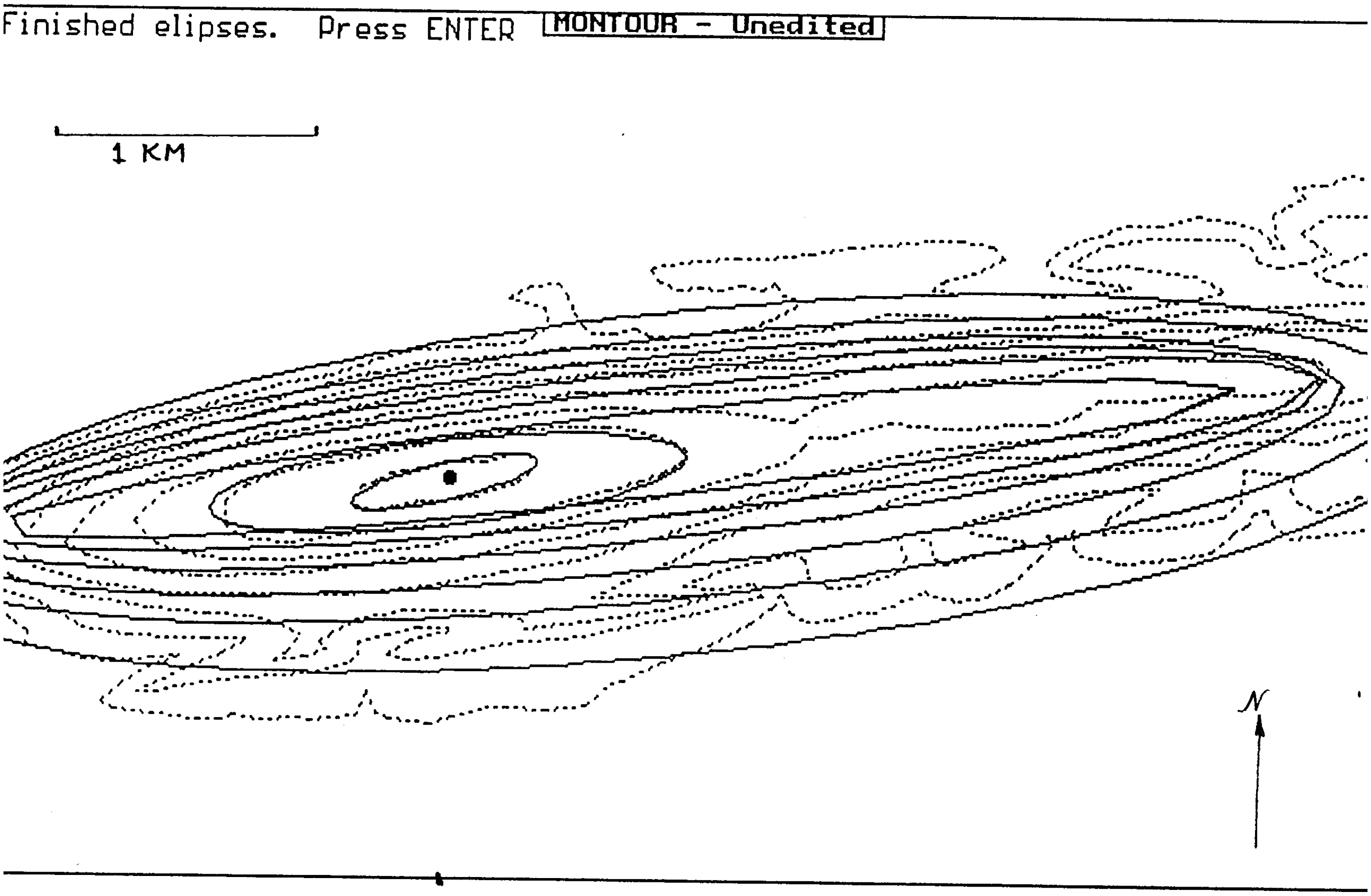
* TERRAIN INFORMATION

HILL NAMED PIEDMONT HILL TOP: 2240.0 feet

Figure B-1 displays both actual and transformed contours for the Piedmont hill. The transformed contours were used in the modeling analysis. There are 2 sets of 13 contours; the dotted lines are the actual contours and the solid lines are the transformed or modeled contours. The elevations for the 13 contours are listed below:

1000.0 feet
1100.0
1200.0
1300.0
1400.0
1500.0
1600.0
1700.0
1800.0
1900.0
2000.0
2100.0

The actual receptor locations are listed in the AERMOD control files which are listed in Appendix C.



Finished elipses. Press ENTER [MONTOUR - Unedited]

Figure B-2. Plot of Montour Ridge Contours.*

* TERRAIN INFORMATION

HILL NAMED MONTOUR HILL TOP: 1429.0 meters

Figure B-2 displays both actual and transformed contours for the Montour Ridge. The transformed contours were used in the modeling analysis. There are 2 sets of 8 contours; the dotted lines are the actual contours and the solid lines are the transformed or modeled contours. The elevations for the 8 contours are listed below:

700.0 meters

800.0

900.0

1000.0

1100.0

1200.0

1300.0

1400.0

The actual receptor locations are listed in the AERMOD control files which are listed in Appendix C.

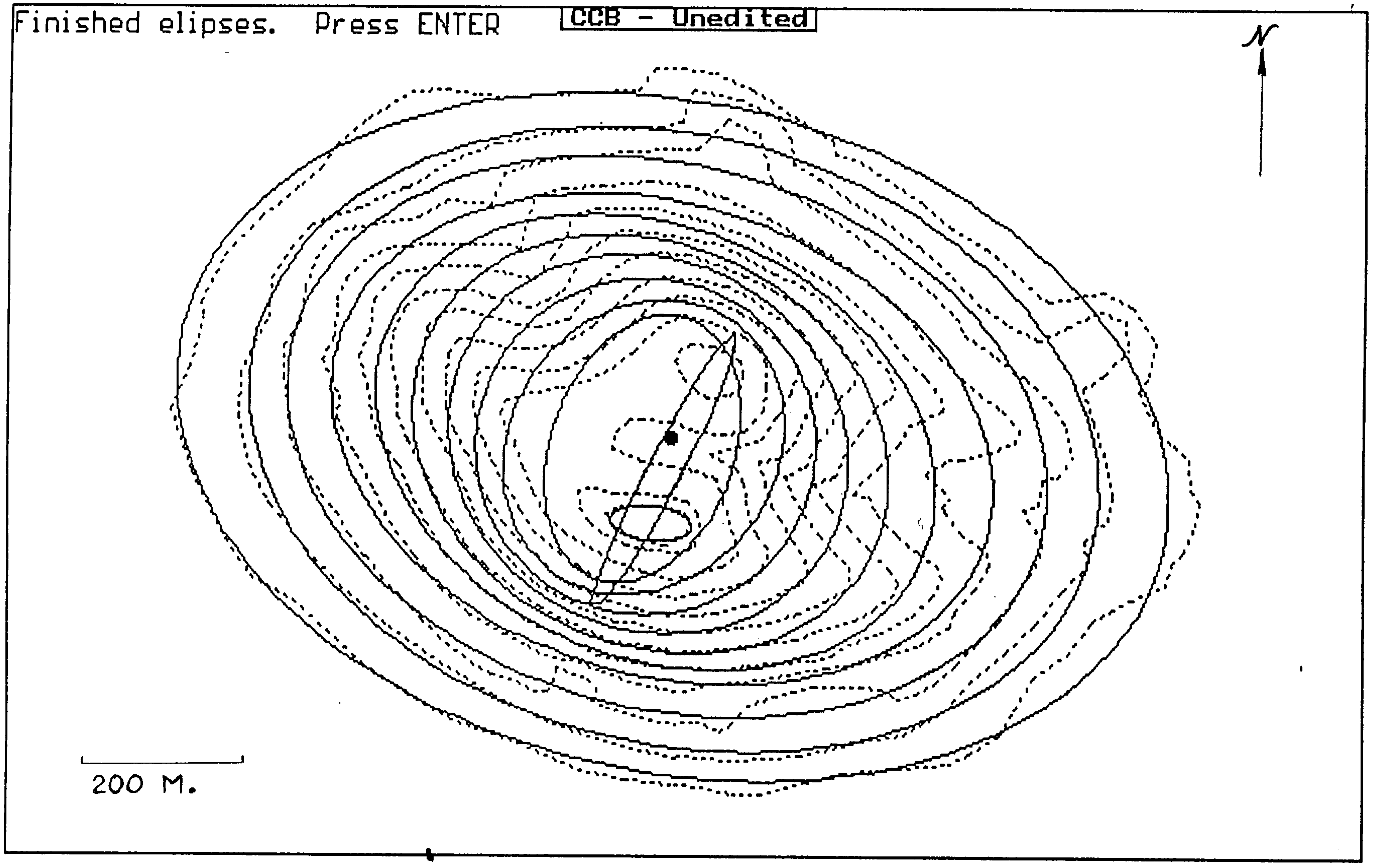


Figure 8-3. Plot of Cinder Cone Butte Contours.*

TERRAIN INFORMATION

HILL NAMED CINDER CONE BUTTE (CCB) HILL TOP: 100.0 meters

Figure B-3 displays both actual and transformed contours for CCB. The transformed contours were used in the modeling analysis. There are 2 sets of 11 contours; the dotted lines are the actual contours and the solid lines are the transformed or modeled contours. The elevations for the 11 contours are listed below:

0.0 meters
5.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0

The actual receptor locations are listed in the AERMOD control files which are listed in Appendix C.

APPENDIX C

LOCATION OF SOURCE AND RECEPTORS FOR THE COMPLEX TERRAIN ANALYSIS

**** Cinder Cone Butte**
**** Low Stack Height: 30 meters**
**** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
** Cinder Cone Butte
** Low Stack Height: 30 meters
** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar
**
CO STARTING
   TITLEONE  Cinder Cone Butte: Source 1 km away
   TITLETWO  30-m Stack Height; High Buoyancy Case
   MODELOPT  CONC             MSGPRO
   AVERTIME  1 3 24 Period
   POLLUTID  SO2
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
   TERRHGTS  ELEV
CO FINISHED

SO STARTING
   ELEVUNIT  FEET
   LOCATION  STACK1  POINT  0.0  1500.0   3100.0
** Point Source       QS    HS    TS    VS   DS
** Parameters:       ----  ----  ----  ----  ---
   SRCPARAM  STACK1    1.   30.  500.  30.0  6.0

   SRCGROUP  ALL
SO FINISHED

RE STARTING
RE ELEVUNIT    FEET
**         X (meters) y(meters)  z (feet)
RE DISCCART      2.00   -302.00   3198.42    3395.27
RE DISCCART    -88.98   -269.90   3198.42    3395.27
RE DISCCART   -164.25   -208.74   3198.42    3395.27
RE DISCCART   -222.04   -130.75   3198.42    3395.27
RE DISCCART   -258.22    -40.01   3198.42    3395.27
RE DISCCART   -288.26     51.90   3198.42    3395.27
RE DISCCART   -287.25    147.62   3198.42    3395.27
```

```
** Cinder Cone Butte
** Low Stack Height: 30 meters
** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

RE DISCCART   -241.83    223.90   3198.42    3395.27
RE DISCCART   -146.77    217.43   3198.42    3395.27
RE DISCCART    -98.96    288.04   3198.42    3395.27
RE DISCCART    -11.03    302.58   3198.42    3395.27
RE DISCCART     78.05    263.18   3198.42    3395.27
RE DISCCART    154.00    201.72   3198.42    3395.27
RE DISCCART    211.91    123.27   3198.42    3395.27
RE DISCCART    256.99     38.11   3198.42    3395.27
RE DISCCART    196.67    -33.00   3198.42    3395.27
RE DISCCART    202.01   -107.64   3198.42    3395.27
RE DISCCART    253.73   -185.45   3198.42    3395.27
RE DISCCART    190.44   -256.50   3198.42    3395.27
RE DISCCART    103.16   -295.08   3198.42    3395.27
RE DISCCART      2.00   -278.00   3231.23    3395.27
RE DISCCART    -79.33   -250.67   3231.23    3395.27
RE DISCCART   -146.86   -196.29   3231.23    3395.27
RE DISCCART   -198.80   -127.07   3231.23    3395.27
RE DISCCART   -232.68    -47.04   3231.23    3395.27
RE DISCCART   -261.87     34.64   3231.23    3395.27
RE DISCCART   -267.17    121.16   3231.23    3395.27
RE DISCCART   -230.33    194.77   3231.23    3395.27
RE DISCCART   -146.35    179.65   3231.23    3395.27
RE DISCCART    -91.21    229.83   3231.23    3395.27
RE DISCCART    -26.62    275.52   3231.23    3395.27
RE DISCCART     55.30    248.31   3231.23    3395.27
RE DISCCART    126.01    197.64   3231.23    3395.27
RE DISCCART    179.34    129.32   3231.23    3395.27
RE DISCCART    202.47     52.18   3231.23    3395.27
RE DISCCART    162.42    -23.57   3231.23    3395.27
RE DISCCART    151.72    -91.57   3231.23    3395.27
RE DISCCART    201.61   -163.01   3231.23    3395.27
RE DISCCART    176.30   -232.57   3231.23    3395.27
RE DISCCART     97.36   -267.36   3231.23    3395.27
RE DISCCART      2.00   -251.00   3264.04    3395.27
RE DISCCART    -71.09   -230.09   3264.04    3395.27
RE DISCCART   -131.43   -182.39   3264.04    3395.27
RE DISCCART   -178.05   -120.85   3264.04    3395.27
```

** Cinder Cone Butte
** Low Stack Height: 30 meters
** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

```
RE DISCCART   -201.61    -47.29   3264.04    3395.27
RE DISCCART   -230.06     24.39   3264.04    3395.27
RE DISCCART   -237.00    100.64   3264.04    3395.27
RE DISCCART   -214.19    169.15   3264.04    3395.27
RE DISCCART   -140.21    150.71   3264.04    3395.27
RE DISCCART    -81.40    187.62   3264.04    3395.27
RE DISCCART    -31.28    243.37   3264.04    3395.27
RE DISCCART     41.60    231.33   3264.04    3395.27
RE DISCCART    105.42    187.96   3264.04    3395.27
RE DISCCART    155.35    129.97   3264.04    3395.27
RE DISCCART    163.34     61.63   3264.04    3395.27
RE DISCCART    135.40     -9.50   3264.04    3395.27
RE DISCCART    113.60    -71.80   3264.04    3395.27
RE DISCCART    149.22   -140.06   3264.04    3395.27
RE DISCCART    151.97   -204.88   3264.04    3395.27
RE DISCCART     84.02   -240.37   3264.04    3395.27
RE DISCCART      2.00   -231.00   3296.85    3395.27
RE DISCCART    -61.01   -208.49   3296.85    3395.27
RE DISCCART   -114.04   -168.94   3296.85    3395.27
RE DISCCART   -153.87   -115.63   3296.85    3395.27
RE DISCCART   -180.97    -54.34   3296.85    3395.27
RE DISCCART   -206.06      7.87   3296.85    3395.27
RE DISCCART   -215.00     73.91   3296.85    3395.27
RE DISCCART   -195.31    130.00   3296.85    3395.27
RE DISCCART   -129.76    120.63   3296.85    3395.27
RE DISCCART    -74.20    152.79   3296.85    3395.27
RE DISCCART    -32.19    204.87   3296.85    3395.27
RE DISCCART     31.93    209.23   3296.85    3395.27
RE DISCCART     86.72    172.28   3296.85    3395.27
RE DISCCART    130.34    123.48   3296.85    3395.27
RE DISCCART    136.25     61.17   3296.85    3395.27
RE DISCCART    114.98     -2.29   3296.85    3395.27
RE DISCCART     85.47    -49.87   3296.85    3395.27
RE DISCCART    106.04   -113.29   3296.85    3395.27
RE DISCCART    125.03   -175.86   3296.85    3395.27
RE DISCCART     73.77   -215.85   3296.85    3395.27
RE DISCCART      3.00   -206.00   3329.66    3395.27
```

** Cinder Cone Butte
** Low Stack Height: 30 meters
** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

```
RE DISCCART    -53.07   -188.80   3329.66    3395.27
RE DISCCART    -99.24   -153.39   3329.66    3395.27
RE DISCCART   -134.94   -107.29   3329.66    3395.27
RE DISCCART   -159.94    -54.13   3329.66    3395.27
RE DISCCART   -179.33      1.32   3329.66    3395.27
RE DISCCART   -187.72     58.87   3329.66    3395.27
RE DISCCART   -156.80     93.46   3329.66    3395.27
RE DISCCART    -99.24     95.55   3329.66    3395.27
RE DISCCART    -55.52    134.37   3329.66    3395.27
RE DISCCART    -17.95    179.52   3329.66    3395.27
RE DISCCART     36.11    181.51   3329.66    3395.27
RE DISCCART     83.25    147.75   3329.66    3395.27
RE DISCCART    114.87     99.51   3329.66    3395.27
RE DISCCART    104.12     42.87   3329.66    3395.27
RE DISCCART     72.48     -4.28   3329.66    3395.27
RE DISCCART     50.78    -31.31   3329.66    3395.27
RE DISCCART     69.73    -83.64   3329.66    3395.27
RE DISCCART     88.06   -138.92   3329.66    3395.27
RE DISCCART     65.18   -187.19   3329.66    3395.27
RE DISCCART      2.00   -181.00   3362.46    3395.27
RE DISCCART    -51.36   -161.23   3362.46    3395.27
RE DISCCART    -94.97   -124.59   3362.46    3395.27
RE DISCCART   -127.05    -78.21   3362.46    3395.27
RE DISCCART   -143.69    -23.72   3362.46    3395.27
RE DISCCART   -161.36     30.37   3362.46    3395.27
RE DISCCART   -125.43     62.70   3362.46    3395.27
RE DISCCART    -72.68     83.20   3362.46    3395.27
RE DISCCART    -32.04    122.40   3362.46    3395.27
RE DISCCART      7.68    162.36   3362.46    3395.27
RE DISCCART     59.05    141.43   3362.46    3395.27
RE DISCCART     87.00     94.58   3362.46    3395.27
RE DISCCART     83.26     38.04   3362.46    3395.27
RE DISCCART     41.54      8.84   3362.46    3395.27
RE DISCCART    -12.50     25.13   3362.46    3395.27
RE DISCCART    -54.22      2.65   3362.46    3395.27
RE DISCCART    -17.83    -30.31   3362.46    3395.27
RE DISCCART     36.25    -48.00   3362.46    3395.27
```

```
** Cinder Cone Butte
** Low Stack Height: 30 meters
** High Buoyancy Case: 6-m diameter, 30 m/s Exit Vel, 500 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

RE DISCCART     52.65   -100.60   3362.46    3395.27
RE DISCCART     57.52   -155.07   3362.46    3395.27
RE DISCCART      4.00   -146.00   3395.27    3395.27
RE DISCCART    -22.33   -143.15   3395.27    3395.27
RE DISCCART    -46.82   -133.11   3395.27    3395.27
RE DISCCART    -67.86   -117.36   3395.27    3395.27
RE DISCCART    -82.70    -95.60   3395.27    3395.27
RE DISCCART    -88.59    -70.00   3395.27    3395.27
RE DISCCART    -66.55    -64.01   3395.27    3395.27
RE DISCCART    -40.90    -69.61   3395.27    3395.27
RE DISCCART    -14.47    -72.14   3395.27    3395.27
RE DISCCART     10.97    -79.29   3395.27    3395.27
RE DISCCART     23.83   -101.15   3395.27    3395.27
RE DISCCART     23.86   -127.28   3395.27    3395.27
RE DISCCART      7.13   -144.96   3395.27    3395.27
RE DISCCART     15.65     73.30   3395.27    3395.27
RE DISCCART      3.80     96.84   3395.27    3395.27
RE DISCCART      9.99    119.90   3395.27    3395.27
RE DISCCART     34.87    124.11   3395.27    3395.27
RE DISCCART     55.86    108.49   3395.27    3395.27
RE DISCCART     65.52     85.47   3395.27    3395.27
RE DISCCART     57.11     61.70   3395.27    3395.27

RE FINISHED

ME STARTING
   SURFFILE  SURFACE  FREE
   PROFFILE  PROFILE  FREE
   SURFDATA  99999  1994  Tower/Sodar
   UAIRDATA  99999  1994  Tower/Sodar
   SITEDATA  00000  1994  Tower/Sodar
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
OU FINISHED
```

**** Montour Alongwind Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
** Montour Alongwind Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar
**
CO STARTING
   TITLEONE  Montour Alongwind Hill: Source 1 km away
   TITLETWO  150-m Stack Height; Low Buoyancy Case
   MODELOPT  CONC             MSGPRO
   AVERTIME  1 3 24 Period
   POLLUTID  SO2
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
**   TERRHGTS  ELEV
CO FINISHED

SO STARTING
   ELEVUNIT  FEET
   LOCATION  STACK1  POINT  -3500.0   0.0   700.0
** Point Source       QS    HS    TS    VS   DS
** Parameters:       ----  ----  ----  ----  ---
   SRCPARAM  STACK1    1.  150.  400.  10.0  2.0

   SRCGROUP  ALL
SO FINISHED

RE STARTING
RE ELEVUNIT    FEET
RE DISCCART    1655.00    146.00   1200.00    1400.
RE DISCCART    1075.54    -98.85   1200.00    1400.
RE DISCCART     481.15   -308.48   1200.00    1400.
RE DISCCART    -125.99   -475.98   1200.00    1400.
RE DISCCART    -747.97   -576.12   1200.00    1400.
RE DISCCART   -1367.68   -518.96   1200.00    1400.
RE DISCCART   -1332.89    -67.94   1200.00    1400.
RE DISCCART    -761.22    195.56   1200.00    1400.
```

```
** Montour Alongwind Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

RE DISCCART    -149.69    347.21   1200.00    1400.
RE DISCCART     465.45    485.10   1200.00    1400.
RE DISCCART    1093.57    506.82   1200.00    1400.
RE DISCCART    1712.61    443.97   1200.00    1400.
RE DISCCART    2281.57    691.14   1200.00    1400.
RE DISCCART    2905.52    783.48   1200.00    1400.
RE DISCCART    3514.58    925.91   1200.00    1400.
RE DISCCART    4142.81    947.59   1200.00    1400.
RE DISCCART    4040.15    665.33   1200.00    1400.
RE DISCCART    3413.23    607.18   1200.00    1400.
RE DISCCART    2851.31    427.99   1200.00    1400.
RE DISCCART    2224.11    416.49   1200.00    1400.
RE DISCCART     141.00   -299.00   1300.00    1400.
RE DISCCART    -108.32   -341.14   1300.00    1400.
RE DISCCART    -358.91   -376.51   1300.00    1400.
RE DISCCART    -607.97   -421.69   1300.00    1400.
RE DISCCART    -857.60   -453.09   1300.00    1400.
RE DISCCART   -1083.05   -366.88   1300.00    1400.
RE DISCCART   -1074.53   -137.83   1300.00    1400.
RE DISCCART    -875.96     10.86   1300.00    1400.
RE DISCCART    -637.92     95.96   1300.00    1400.
RE DISCCART    -395.29    168.10   1300.00    1400.
RE DISCCART    -152.75    240.59   1300.00    1400.
RE DISCCART      92.72    301.83   1300.00    1400.
RE DISCCART     342.50    342.65   1300.00    1400.
RE DISCCART     592.42    378.00   1300.00    1400.
RE DISCCART     843.23    366.02   1300.00    1400.
RE DISCCART    1081.96    287.07   1300.00    1400.
RE DISCCART    1102.55     95.11   1300.00    1400.
RE DISCCART     886.71    -29.07   1300.00    1400.
RE DISCCART     649.92   -118.37   1300.00    1400.
RE DISCCART     420.08   -223.10   1300.00    1400.
RE DISCCART    -373.00    -31.00   1400.00    1400.
RE DISCCART    -287.24     27.50   1400.00    1400.
RE DISCCART    -188.10     58.73   1400.00    1400.
RE DISCCART     -89.24     90.31   1400.00    1400.
RE DISCCART       9.09    119.15   1400.00    1400.
```

**** Montour Alongwind Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
RE DISCCART     113.04    125.22   1400.00    1400.
RE DISCCART     214.03    144.82   1400.00    1400.
RE DISCCART     311.84    177.82   1400.00    1400.
RE DISCCART     410.80    157.11   1400.00    1400.
RE DISCCART     405.63     69.59   1400.00    1400.
RE DISCCART     337.71     -8.29   1400.00    1400.
RE DISCCART     244.77    -55.12   1400.00    1400.
RE DISCCART     152.08   -102.54   1400.00    1400.
RE DISCCART      53.15   -132.88   1400.00    1400.
RE DISCCART     -48.48   -155.28   1400.00    1400.
RE DISCCART    -151.63   -169.15   1400.00    1400.
RE DISCCART    -253.71   -189.72   1400.00    1400.
RE DISCCART    -354.07   -217.34   1400.00    1400.
RE DISCCART    -450.53   -194.01   1400.00    1400.
RE DISCCART    -460.63   -106.35   1400.00    1400.

RE FINISHED

ME STARTING
   SURFFILE  SURFACE  FREE
   PROFFILE  PROFILE  FREE
   SURFDATA  99999  1994  Tower/Sodar
   UAIRDATA  99999  1994  Tower/Sodar
   SITEDATA  00000  1994  Tower/Sodar
   PROFBASE 0
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
OU FINISHED
```

**** Montour Crosswind Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
** Montour Crosswind Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar
**
CO STARTING
   TITLEONE  Montour Crosswind Hill: Source 1 km away
   TITLETWO  150-m Stack Height; Low Buoyancy Case
   MODELOPT  CONC             MSGPRO
   AVERTIME  1 3 24 Period
   POLLUTID  SO2
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
**   TERRHGTS  ELEV
CO FINISHED

SO STARTING
   ELEVUNIT  FEET
   LOCATION  STACK1  POINT  0.0   2000.0   700.0
** Point Source       QS    HS    TS    VS   DS
** Parameters:       ----  ----  ----  ----  ---
   SRCPARAM  STACK1    1.  150.  400.  10.0  2.0

   SRCGROUP  ALL
SO FINISHED

RE STARTING
RE ELEVUNIT    FEET
RE DISCCART    1655.00    146.00   1200.00    1400.
RE DISCCART    1075.54    -98.85   1200.00    1400.
RE DISCCART     481.15   -308.48   1200.00    1400.
RE DISCCART    -125.99   -475.98   1200.00    1400.
RE DISCCART    -747.97   -576.12   1200.00    1400.
RE DISCCART   -1367.68   -518.96   1200.00    1400.
RE DISCCART   -1332.89    -67.94   1200.00    1400.
RE DISCCART    -761.22    195.56   1200.00    1400.
```

```
** Montour Crosswind Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

RE DISCCART    -149.69    347.21   1200.00    1400.
RE DISCCART     465.45    485.10   1200.00    1400.
RE DISCCART    1093.57    506.82   1200.00    1400.
RE DISCCART    1712.61    443.97   1200.00    1400.
RE DISCCART    2281.57    691.14   1200.00    1400.
RE DISCCART    2905.52    783.48   1200.00    1400.
RE DISCCART    3514.58    925.91   1200.00    1400.
RE DISCCART    4142.81    947.59   1200.00    1400.
RE DISCCART    4040.15    665.33   1200.00    1400.
RE DISCCART    3413.23    607.18   1200.00    1400.
RE DISCCART    2851.31    427.99   1200.00    1400.
RE DISCCART    2224.11    416.49   1200.00    1400.
RE DISCCART     141.00   -299.00   1300.00    1400.
RE DISCCART    -108.32   -341.14   1300.00    1400.
RE DISCCART    -358.91   -376.51   1300.00    1400.
RE DISCCART    -607.97   -421.69   1300.00    1400.
RE DISCCART    -857.60   -453.09   1300.00    1400.
RE DISCCART   -1083.05   -366.88   1300.00    1400.
RE DISCCART   -1074.53   -137.83   1300.00    1400.
RE DISCCART    -875.96     10.86   1300.00    1400.
RE DISCCART    -637.92     95.96   1300.00    1400.
RE DISCCART    -395.29    168.10   1300.00    1400.
RE DISCCART    -152.75    240.59   1300.00    1400.
RE DISCCART      92.72    301.83   1300.00    1400.
RE DISCCART     342.50    342.65   1300.00    1400.
RE DISCCART     592.42    378.00   1300.00    1400.
RE DISCCART     843.23    366.02   1300.00    1400.
RE DISCCART    1081.96    287.07   1300.00    1400.
RE DISCCART    1102.55     95.11   1300.00    1400.
RE DISCCART     886.71    -29.07   1300.00    1400.
RE DISCCART     649.92   -118.37   1300.00    1400.
RE DISCCART     420.08   -223.10   1300.00    1400.
RE DISCCART    -373.00    -31.00   1400.00    1400.
RE DISCCART    -287.24     27.50   1400.00    1400.
RE DISCCART    -188.10     58.73   1400.00    1400.
RE DISCCART     -89.24     90.31   1400.00    1400.
RE DISCCART       9.09    119.15   1400.00    1400.
```

**** Montour Crosswind Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
RE DISCCART     113.04    125.22   1400.00    1400.
RE DISCCART     214.03    144.82   1400.00    1400.
RE DISCCART     311.84    177.82   1400.00    1400.
RE DISCCART     410.80    157.11   1400.00    1400.
RE DISCCART     405.63     69.59   1400.00    1400.
RE DISCCART     337.71     -8.29   1400.00    1400.
RE DISCCART     244.77    -55.12   1400.00    1400.
RE DISCCART     152.08   -102.54   1400.00    1400.
RE DISCCART      53.15   -132.88   1400.00    1400.
RE DISCCART     -48.48   -155.28   1400.00    1400.
RE DISCCART    -151.63   -169.15   1400.00    1400.
RE DISCCART    -253.71   -189.72   1400.00    1400.
RE DISCCART    -354.07   -217.34   1400.00    1400.
RE DISCCART    -450.53   -194.01   1400.00    1400.
RE DISCCART    -460.63   -106.35   1400.00    1400.

RE FINISHED

ME STARTING
   SURFFILE  SURFACE  FREE
   PROFFILE  PROFILE  FREE
   SURFDATA  99999  1994  Tower/Sodar
   UAIRDATA  99999  1994  Tower/Sodar
   SITEDATA  00000  1994  Tower/Sodar
   PROFBASE 0
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
OU FINISHED
```

**** Piedmont Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
** Piedmont Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar
**
CO STARTING
   TITLEONE  Piedmont Hill: Source 1 km away
   TITLETWO  150-m Stack Height; Low Buoyancy Case
   MODELOPT  CONC             MSGPRO
   AVERTIME  1 3 24 Period
   POLLUTID  SO2
   RUNORNOT  RUN
   ERRORFIL  ERRORS.OUT
**   TERRHGTS  ELEV
CO FINISHED

SO STARTING
   ELEVUNIT  FEET
   LOCATION  STACK1  POINT  0.0   1000.0   1000.0
** Point Source       QS    HS    TS    VS   DS
** Parameters:       ----  ----  ----  ----  ---
   SRCPARAM  STACK1    1.  150.  400.  10.0  2.0

   SRCGROUP  ALL
SO FINISHED

RE STARTING
RE ELEVUNIT    FEET
RE DISCCART   -612.40  -1792.00   1500.00    2200.00
RE DISCCART   -632.69  -1395.44   1500.00    2200.00
RE DISCCART   -495.55  -1025.07   1500.00    2200.00
RE DISCCART   -433.60   -668.18   1500.00    2200.00
RE DISCCART   -106.68   -522.37   1500.00    2200.00
RE DISCCART    245.80   -585.23   1500.00    2200.00
RE DISCCART    413.78   -230.98   1500.00    2200.00
RE DISCCART    553.12    138.16   1500.00    2200.00
```

**** Piedmont Hill**
**** High Stack Height: 150 meters**
**** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K**
**** Close to Hill: 1 km away**
**** Meteorology from 100-m Tower and Sodar**

```
RE DISCCART    882.78    337.97   1500.00    2200.00
RE DISCCART   1211.30    132.16   1500.00    2200.00
RE DISCCART   1277.72   -198.82   1500.00    2200.00
RE DISCCART   1032.05   -511.55   1500.00    2200.00
RE DISCCART   -582.60  -2015.00   1600.00    2200.00
RE DISCCART   -561.02  -1616.37   1600.00    2200.00
RE DISCCART   -479.65  -1223.82   1600.00    2200.00
RE DISCCART   -341.53   -863.47   1600.00    2200.00
RE DISCCART   -133.80   -612.84   1600.00    2200.00
RE DISCCART    242.75   -647.07   1600.00    2200.00
RE DISCCART    448.16   -311.09   1600.00    2200.00
RE DISCCART    592.43     59.94   1600.00    2200.00
RE DISCCART    918.60    238.86   1600.00    2200.00
RE DISCCART   1228.23      4.15   1600.00    2200.00
RE DISCCART   1088.95   -350.46   1600.00    2200.00
RE DISCCART    885.35   -698.68   1600.00    2200.00
RE DISCCART   -505.50  -2155.00   1700.00    2200.00
RE DISCCART   -480.41  -1760.47   1700.00    2200.00
RE DISCCART   -465.41  -1358.34   1700.00    2200.00
RE DISCCART   -310.06   -987.10   1700.00    2200.00
RE DISCCART   -138.32   -654.32   1700.00    2200.00
RE DISCCART    231.42   -710.58   1700.00    2200.00
RE DISCCART    469.14   -408.24   1700.00    2200.00
RE DISCCART    618.92    -32.23   1700.00    2200.00
RE DISCCART    944.57    168.79   1700.00    2200.00
RE DISCCART   1164.28   -117.76   1700.00    2200.00
RE DISCCART    962.35   -467.47   1700.00    2200.00
RE DISCCART    783.63   -831.20   1700.00    2200.00
RE DISCCART   -357.70  -2305.00   1800.00    2200.00
RE DISCCART   -437.57  -1945.98   1800.00    2200.00
RE DISCCART   -369.41  -1566.25   1800.00    2200.00
RE DISCCART   -285.45  -1172.66   1800.00    2200.00
RE DISCCART   -166.77   -788.53   1800.00    2200.00
RE DISCCART    192.72   -801.51   1800.00    2200.00
RE DISCCART    486.38   -562.30   1800.00    2200.00
RE DISCCART    638.29   -189.10   1800.00    2200.00
RE DISCCART    945.65     31.54   1800.00    2200.00
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** Piedmont Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

```
RE DISCCART   1040.60   -246.59   1800.00    2200.00
RE DISCCART    845.76   -601.19   1800.00    2200.00
RE DISCCART    700.78   -978.55   1800.00    2200.00
RE DISCCART   -312.10  -2275.00   1900.00    2200.00
RE DISCCART   -352.85  -1926.16   1900.00    2200.00
RE DISCCART   -284.39  -1572.42   1900.00    2200.00
RE DISCCART   -219.41  -1204.49   1900.00    2200.00
RE DISCCART   -103.65   -845.19   1900.00    2200.00
RE DISCCART    231.54   -848.17   1900.00    2200.00
RE DISCCART    526.84   -634.35   1900.00    2200.00
RE DISCCART    675.48   -292.95   1900.00    2200.00
RE DISCCART    957.97    -77.44   1900.00    2200.00
RE DISCCART    856.22   -432.11   1900.00    2200.00
RE DISCCART    728.44   -787.98   1900.00    2200.00
RE DISCCART    646.54  -1155.69   1900.00    2200.00
RE DISCCART   -211.00  -2248.00   2000.00    2200.00
RE DISCCART   -208.98  -2019.81   2000.00    2200.00
RE DISCCART   -103.15  -1812.17   2000.00    2200.00
RE DISCCART   -133.27  -1588.07   2000.00    2200.00
RE DISCCART   -159.02  -1357.53   2000.00    2200.00
RE DISCCART    -71.30  -1142.46   2000.00    2200.00
RE DISCCART     67.68   -957.10   2000.00    2200.00
RE DISCCART    296.79   -912.52   2000.00    2200.00
RE DISCCART    524.56   -859.69   2000.00    2200.00
RE DISCCART    573.38  -1049.63   2000.00    2200.00
RE DISCCART    607.64  -1272.62   2000.00    2200.00
RE DISCCART    677.99  -1493.23   2000.00    2200.00
RE DISCCART     99.85  -2515.00   2100.00    2200.00
RE DISCCART     52.53  -2279.43   2100.00    2200.00
RE DISCCART     34.82  -2043.20   2100.00    2200.00
RE DISCCART     93.40  -1816.61   2100.00    2200.00
RE DISCCART     -9.02  -1599.99   2100.00    2200.00
RE DISCCART      2.67  -1394.18   2100.00    2200.00
RE DISCCART    127.68  -1190.55   2100.00    2200.00
RE DISCCART    276.83  -1010.06   2100.00    2200.00
RE DISCCART    443.05  -1102.06   2100.00    2200.00
RE DISCCART    421.80  -1337.79   2100.00    2200.00
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** Piedmont Hill
** High Stack Height: 150 meters
** Low Buoyancy Case: 2-m diameter, 10 m/s Exit Vel, 400 K
** Close to Hill: 1 km away
** Meteorology from 100-m Tower and Sodar

```
RE DISCCART    613.92  -1451.98   2100.00    2200.00
RE DISCCART    643.13  -1689.91   2100.00    2200.00
RE DISCCART    348.70  -2665.00   2200.00    2200.00
RE DISCCART    323.75  -2501.71   2200.00    2200.00
RE DISCCART    375.69  -2350.23   2200.00    2200.00
RE DISCCART    308.07  -2194.93   2200.00    2200.00
RE DISCCART    340.42  -2038.55   2200.00    2200.00
RE DISCCART    409.93  -1883.47   2200.00    2200.00
RE DISCCART    387.04  -1722.33   2200.00    2200.00
RE DISCCART    296.38  -1584.62   2200.00    2200.00
RE DISCCART    440.59  -1521.57   2200.00    2200.00
RE DISCCART    552.40  -1613.29   2200.00    2200.00
RE DISCCART    606.70  -1773.86   2200.00    2200.00
RE DISCCART    666.27  -1932.25   2200.00    2200.00

RE FINISHED
ME STARTING
   SURFFILE  SURFACE  FREE
   PROFFILE  PROFILE  FREE
   SURFDATA  99999  1994  Tower/Sodar
   UAIRDATA  99999  1994  Tower/Sodar
   SITEDATA  00000  1994  Tower/Sodar
   PROFBASE 0
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
OU FINISHED
```

APPENDIX D

FLAT AND SIMPLE TERRAIN MODELING RESULTS --

LISTING OF REGULATORY DESIGN CONCENTRATIONS

Appendix D. Results of the flat and simple terrain analysis. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

R05NDNBO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.477E+06	0.434	0.673	1.550
1 Hour H2H	1.477E+06	0.432	0.668	1.546
3 Hour H1H	9.403E+05	0.454	0.688	1.516
3 Hour H2H	6.626E+05	0.461	0.574	1.244
24 Hour H1H	1.678E+05	0.539	0.596	1.106
24 Hour H2H	1.355E+05	0.591	0.730	1.235
Annual	1.537E+04	0.388	0.434	1.119

R05NDNBP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.215E+06	0.357	0.619	1.734
1 Hour H2H	1.477E+06	0.433	0.671	1.548
3 Hour H1H	8.294E+05	0.608	0.783	1.288
3 Hour H2H	6.729E+05	0.427	0.629	1.473
24 Hour H1H	3.350E+05	0.347	0.510	1.470
24 Hour H2H	1.503E+05	0.472	0.687	1.455
Annual	9.266E+03	0.500	0.593	1.185

R10NDNBO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	8.679E+05	0.442	0.504	1.139
1 Hour H2H	8.679E+05	0.440	0.502	1.140
3 Hour H1H	5.524E+05	0.484	0.541	1.118
3 Hour H2H	3.918E+05	0.574	0.591	1.030
24 Hour H1H	1.018E+05	0.694	0.592	0.852
24 Hour H2H	8.792E+04	0.645	0.605	0.937
Annual	1.147E+04	0.515	0.529	1.027

R10NDNBP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.283E+06	0.355	0.410	1.155
1 Hour H2H	8.679E+05	0.441	0.503	1.140
3 Hour H1H	4.871E+05	0.706	0.764	1.082
3 Hour H2H	3.966E+05	0.542	0.546	1.009
24 Hour H1H	2.044E+05	0.399	0.438	1.098
24 Hour H2H	9.117E+04	0.550	0.613	1.115
Annual	7.044E+03	0.615	0.661	1.075

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Appendix D. Results of the flat and simple terrain analysis. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

R20NDNBO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.518E+04	0.510	0.480	0.941
1 Hour H2H	5.041E+04	0.551	0.602	1.092
3 Hour H1H	3.027E+04	0.735	0.621	0.846
3 Hour H2H	1.975E+04	0.875	0.850	0.971
24 Hour H1H	8.005E+03	1.076	1.052	0.978
24 Hour H2H	5.218E+03	1.496	1.417	0.947
Annual	8.692E+02	2.277	2.269	0.996

R20NDNBP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.595E+04	0.524	0.508	0.970
1 Hour H2H	4.889E+04	0.709	0.618	0.873
3 Hour H1H	3.242E+04	0.745	0.682	0.916
3 Hour H2H	2.192E+04	0.835	0.767	0.918
24 Hour H1H	7.737E+03	1.207	1.166	0.966
24 Hour H2H	6.170E+03	1.254	1.242	0.990
Annual	6.952E+02	1.926	1.931	1.002

R35MFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.394E+03	1.093	1.652	1.511
1 Hour H2H	1.257E+03	1.103	1.192	1.081
3 Hour H1H	1.091E+03	0.971	0.989	1.019
3 Hour H2H	9.733E+02	0.932	0.932	1.000
24 Hour H1H	3.291E+02	1.624	1.581	0.974
24 Hour H2H	3.022E+02	1.723	1.689	0.980
Annual	4.046E+01	2.005	2.002	0.998

R35MFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.394E+03	1.215	1.823	1.500
1 Hour H2H	1.267E+03	1.193	1.326	1.111
3 Hour H1H	9.518E+02	1.207	1.154	0.956
3 Hour H2H	7.229E+02	1.181	1.087	0.920
24 Hour H1H	3.393E+02	1.206	1.262	1.046
24 Hour H2H	2.322E+02	1.295	1.260	0.97
Annual	2.781E+01	1.835	1.815	0.989

The first letter indicates urban (U) or rural (R) settings: the number indicates the stack height (meters): the next set of letters - VOL, volume source; ARE, area source; ND, no downwash; NB, no building; M, moderately buoyant; B, bouyant plume; F, flat terrain; T, simple terrain: the last letter indicates the met data site - O, Oklahoma City; P, Pittsburgh

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R35BFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.651E+02	1.589	1.589	1.000
1 Hour H2H	2.551E+02	1.623	1.622	1.000
3 Hour H1H	1.832E+02	2.142	2.142	1.000
3 Hour H2H	1.807E+02	2.081	2.081	1.000
24 Hour H1H	8.005E+01	2.534	2.463	0.972
24 Hour H2H	6.871E+01	2.721	2.714	0.998
Annual	8.103E+00	3.121	3.054	0.979

R35BFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.626E+02	1.575	1.575	1.000
1 Hour H2H	2.608E+02	1.537	1.537	1.000
3 Hour H1H	1.951E+02	2.006	2.006	1.000
3 Hour H2H	1.394E+02	2.411	2.411	1.000
24 Hour H1H	6.414E+01	2.650	2.618	0.988
24 Hour H2H	5.184E+01	2.995	2.936	0.980
Annual	5.464E+00	3.388	3.322	0.981

R100FO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	6.150E+01	0.917	0.816	0.889
1 Hour H2H	5.391E+01	0.901	0.805	0.894
3 Hour H1H	3.820E+01	1.153	1.020	0.884
3 Hour H2H	2.791E+01	1.413	1.290	0.913
24 Hour H1H	6.271E+00	2.107	2.128	1.010
24 Hour H2H	5.537E+00	2.347	2.313	0.986
Annual	6.320E-01	2.696	2.663	0.988

R100FP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	5.296E+01	0.931	0.815	0.875
1 Hour H2H	5.003E+01	0.925	0.816	0.882
3 Hour H1H	2.751E+01	1.474	1.309	0.888
3 Hour H2H	1.826E+01	1.907	1.724	0.904
24 Hour H1H	7.965E+00	1.759	1.622	0.922
24 Hour H2H	4.170E+00	2.628	2.395	0.911
Annual	4.000E-01	3.253	3.203	0.985

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R200FO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.441E+01	1.036	0.941	0.908
1 Hour H2H	2.074E+01	0.989	0.922	0.932
3 Hour H1H	1.335E+01	1.212	1.091	0.900
3 Hour H2H	1.043E+01	1.044	0.929	0.889
24 Hour H1H	2.594E+00	1.414	1.328	0.939
24 Hour H2H	1.907E+00	1.781	1.716	0.963
Annual	1.480E-01	3.162	3.088	0.976

R200FP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.479E+01	0.836	0.721	0.863
1 Hour H2H	3.131E+01	0.583	0.495	0.850
3 Hour H1H	1.160E+01	1.015	0.938	0.924
3 Hour H2H	1.098E+01	0.886	0.818	0.923
24 Hour H1H	3.174E+00	1.223	1.154	0.944
24 Hour H2H	1.714E+00	1.824	1.630	0.894
Annual	8.200E-02	3.890	3.829	0.984

R35TO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.863E+02	1.111	1.045	0.940
1 Hour H2H	2.522E+02	1.255	1.149	0.915
3 Hour H1H	1.606E+02	1.903	1.608	0.845
3 Hour H2H	1.471E+02	2.039	1.550	0.760
24 Hour H1H	5.868E+01	3.151	2.414	0.766
24 Hour H2H	5.074E+01	3.411	2.494	0.731
Annual	6.466E+00	3.394	2.526	0.744

R35TP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.984E+02	1.040	1.025	0.986
1 Hour H2H	2.835E+02	1.085	1.050	0.967
3 Hour H1H	2.087E+02	1.366	1.356	0.993
3 Hour H2H	1.668E+02	1.694	1.544	0.912
24 Hour H1H	6.858E+01	2.141	2.132	0.996
24 Hour H2H	5.750E+01	2.227	2.182	0.979
Annual	6.193E+00	2.289	2.265	0.990

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R200TO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.441E+01	1.004	0.918	0.915
1 Hour H2H	2.226E+01	0.910	0.888	0.976
3 Hour H1H	1.723E+01	0.923	0.831	0.900
3 Hour H2H	1.446E+01	0.746	0.677	0.907
24 Hour H1H	5.957E+00	0.626	0.549	0.878
24 Hour H2H	3.802E+00	0.931	0.828	0.890
Annual	5.140E-01	0.930	0.860	0.925

R200TP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.479E+01	0.830	0.720	0.867
1 Hour H2H	3.130E+01	0.577	0.495	0.859
3 Hour H1H	1.512E+01	0.755	0.705	0.934
3 Hour H2H	1.299E+01	0.774	0.723	0.933
24 Hour H1H	4.775E+00	0.852	0.811	0.952
24 Hour H2H	4.005E+00	0.812	0.728	0.897
Annual	3.440E-01	1.073	1.058	0.986

R10VOLFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	6.407E+04	0.909	0.909	1.000
1 Hour H2H	4.611E+04	1.249	1.249	1.000
3 Hour H1H	3.675E+04	1.154	1.154	1.000
3 Hour H2H	3.094E+04	1.296	1.206	0.931
24 Hour H1H	1.342E+04	1.142	1.054	0.923
24 Hour H2H	1.102E+04	1.150	1.109	0.964
Annual	2.496E+03	1.059	1.054	0.995

R10VOLFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	8.044E+04	0.900	0.900	1.000
1 Hour H2H	8.004E+04	0.768	0.768	1.000
3 Hour H1H	4.150E+04	1.276	1.276	1.000
3 Hour H2H	3.422E+04	1.168	1.168	1.000
24 Hour H1H	1.719E+04	1.070	1.063	0.994
24 Hour H2H	1.191E+04	1.025	1.010	0.986
Annual	1.656E+03	1.026	1.039	1.012

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R35VOLFO	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	1.347E+04	0.683	0.619	0.906
1 Hour H2H	8.979E+03	0.962	0.875	0.910
3 Hour H1H	6.060E+03	0.906	0.807	0.891
3 Hour H2H	4.795E+03	0.932	0.880	0.945
24 Hour H1H	2.022E+03	0.890	0.897	1.008
24 Hour H2H	1.728E+03	0.889	0.840	0.945
Annual	4.123E+02	0.925	0.920	0.994

R35VOLFP	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	1.457E+04	0.905	0.818	0.904
1 Hour H2H	1.024E+04	0.999	0.847	0.848
3 Hour H1H	6.079E+03	1.026	0.956	0.932
3 Hour H2H	5.010E+03	0.973	0.868	0.892
24 Hour H1H	2.178E+03	0.810	0.807	0.996
24 Hour H2H	1.807E+03	0.967	0.930	0.961
Annual	2.988E+02	0.915	0.913	0.998

RAREFO	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	1.374E+04	2.040	1.954	0.958
1 Hour H2H	1.374E+04	1.382	1.312	0.950
3 Hour H1H	1.317E+04	1.379	1.305	0.946
3 Hour H2H	1.218E+04	1.201	1.132	0.943
24 Hour H1H	6.654E+03	1.169	1.019	0.872
24 Hour H2H	5.904E+03	0.995	0.832	0.836
Annual	2.573E+03	0.646	0.614	0.950

RAREFP	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	2.047E+04	1.509	1.441	0.955
1 Hour H2H	1.983E+04	1.515	1.441	0.951
3 Hour H1H	1.532E+04	1.280	1.252	0.978
3 Hour H2H	1.257E+04	1.324	1.292	0.975
24 Hour H1H	7.766E+03	1.057	1.010	0.955
24 Hour H2H	7.353E+03	1.050	0.989	0.942
Annual	3.044E+03	0.715	0.682	0.954

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U05NDNBO	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	1.668E+05	2.096	0.887	0.423
1 Hour H2H	1.668E+05	2.078	0.852	0.410
3 Hour H1H	1.284E+05	1.869	0.804	0.430
3 Hour H2H	9.909E+04	2.130	0.813	0.382
24 Hour H1H	3.038E+04	2.103	1.091	0.519
24 Hour H2H	2.785E+04	1.818	1.041	0.573
Annual	5.129E+03	0.992	1.261	1.271

U05NDNBP	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	2.498E+05	2.743	0.592	0.216
1 Hour H2H	1.668E+05	3.152	0.873	0.277
3 Hour H1H	1.382E+05	2.318	0.857	0.370
3 Hour H2H	1.106E+05	1.841	0.849	0.461
24 Hour H1H	5.385E+04	1.537	0.801	0.521
24 Hour H2H	2.891E+04	1.502	1.013	0.674
Annual	3.033E+03	1.260	1.412	1.120

U10NDNBO	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	1.588E+05	1.127	0.533	0.473
1 Hour H2H	1.588E+05	1.125	0.516	0.459
3 Hour H1H	1.223E+05	1.061	0.523	0.493
3 Hour H2H	9.443E+04	1.322	0.634	0.479
24 Hour H1H	2.899E+04	1.497	0.864	0.577
24 Hour H2H	2.661E+04	1.163	0.860	0.739
Annual	4.942E+03	0.941	1.187	1.262

U10NDNBP	ISC3	99351AER/ISC3	02222AER/ISC3	02222AER/99351AER
1 Hour H1H	2.375E+05	1.255	0.356	0.284
1 Hour H2H	1.588E+05	1.696	0.525	0.310
3 Hour H1H	1.315E+05	1.319	0.575	0.436
3 Hour H2H	1.053E+05	1.136	0.598	0.526
24 Hour H1H	5.135E+04	0.949	0.570	0.601
24 Hour H2H	2.774E+04	1.344	0.809	0.602
Annual	2.923E+03	1.153	1.342	1.164

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U20NDNBO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	5.789E+04	0.522	0.582	1.116
1 Hour H2H	5.078E+04	0.422	0.588	1.392
3 Hour H1H	3.907E+04	0.485	0.384	0.792
3 Hour H2H	3.145E+04	0.432	0.431	0.996
24 Hour H1H	1.145E+04	0.658	0.511	0.777
24 Hour H2H	9.885E+03	0.713	0.544	0.763
Annual	2.119E+03	1.013	0.670	0.662

U20NDNBP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.568E+04	0.365	0.438	1.200
1 Hour H2H	5.516E+04	0.482	0.535	1.110
3 Hour H1H	4.189E+04	0.443	0.528	1.192
3 Hour H2H	3.361E+04	0.462	0.500	1.081
24 Hour H1H	1.730E+04	0.468	0.346	0.739
24 Hour H2H	1.089E+04	0.682	0.469	0.687
Annual	1.398E+03	0.997	0.799	0.801

U35MFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.222E+03	0.691	0.567	0.820
1 Hour H2H	1.859E+03	0.690	0.638	0.925
3 Hour H1H	1.462E+03	0.692	0.567	0.820
3 Hour H2H	1.403E+03	0.683	0.558	0.818
24 Hour H1H	8.936E+02	0.595	0.456	0.766
24 Hour H2H	8.090E+02	0.644	0.441	0.684
Annual	1.415E+02	0.795	0.401	0.504

U35MFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.358E+03	0.694	0.833	1.201
1 Hour H2H	1.859E+03	0.820	0.676	0.824
3 Hour H1H	1.644E+03	0.644	0.574	0.891
3 Hour H2H	1.401E+03	0.604	0.516	0.854
24 Hour H1H	9.331E+02	0.466	0.272	0.583
24 Hour H2H	7.561E+02	0.477	0.303	0.635
Annual	1.037E+02	0.611	0.399	0.653

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U35BFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	6.987E+02	0.686	0.539	0.786
1 Hour H2H	5.931E+02	0.754	0.621	0.823
3 Hour H1H	4.513E+02	0.925	0.724	0.782
3 Hour H2H	3.648E+02	1.111	0.841	0.758
24 Hour H1H	2.849E+02	1.027	0.548	0.533
24 Hour H2H	2.716E+02	0.997	0.477	0.479
Annual	3.748E+01	0.975	0.580	0.594

U35BFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	5.718E+02	0.787	0.615	0.782
1 Hour H2H	4.429E+02	0.990	0.773	0.781
3 Hour H1H	3.615E+02	1.128	0.866	0.768
3 Hour H2H	3.473E+02	1.094	0.894	0.817
24 Hour H1H	2.171E+02	1.046	0.593	0.567
24 Hour H2H	1.927E+02	1.066	0.614	0.576
Annual	2.568E+01	1.027	0.649	0.631

U100FO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	8.344E+01	0.644	0.601	0.934
1 Hour H2H	7.354E+01	0.709	0.591	0.833
3 Hour H1H	5.392E+01	0.912	0.722	0.792
3 Hour H2H	4.886E+01	0.953	0.737	0.773
24 Hour H1H	3.015E+01	0.601	0.383	0.638
24 Hour H2H	2.984E+01	0.519	0.367	0.707
Annual	4.082E+00	0.549	0.392	0.714

U100FP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	8.015E+01	0.664	0.571	0.859
1 Hour H2H	7.214E+01	0.703	0.607	0.864
3 Hour H1H	5.665E+01	0.812	0.636	0.783
3 Hour H2H	4.963E+01	0.820	0.634	0.773
24 Hour H1H	2.329E+01	0.736	0.555	0.754
24 Hour H2H	2.022E+01	0.670	0.494	0.738
Annual	2.602E+00	0.648	0.479	0.739

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U200FO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.134E+01	0.952	1.033	1.085
1 Hour H2H	2.972E+01	0.614	0.643	1.048
3 Hour H1H	2.152E+01	0.651	0.760	1.167
3 Hour H2H	1.978E+01	0.562	0.576	1.025
24 Hour H1H	1.107E+01	0.382	0.314	0.822
24 Hour H2H	9.360E+00	0.449	0.350	0.779
Annual	1.276E+00	0.490	0.378	0.771

U200FP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	3.104E+01	0.804	0.935	1.163
1 Hour H2H	2.726E+01	0.570	0.920	1.613
3 Hour H1H	2.028E+01	0.550	0.644	1.171
3 Hour H2H	1.941E+01	0.559	0.550	0.984
24 Hour H1H	8.419E+00	0.524	0.688	1.312
24 Hour H2H	6.496E+00	0.537	0.527	0.981
Annual	8.800E-01	0.527	0.435	0.825

U35TO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	4.808E+02	0.556	0.465	0.838
1 Hour H2H	4.364E+02	0.604	0.477	0.790
3 Hour H1H	3.433E+02	0.749	0.533	0.711
3 Hour H2H	2.541E+02	0.994	0.705	0.710
24 Hour H1H	1.271E+02	1.295	0.883	0.682
24 Hour H2H	1.107E+02	1.467	0.898	0.612
Annual	1.826E+01	1.520	0.759	0.499

U35TP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	6.314E+02	0.420	0.367	0.875
1 Hour H2H	4.922E+02	0.522	0.461	0.884
3 Hour H1H	3.071E+02	0.805	0.698	0.866
3 Hour H2H	2.784E+02	0.884	0.731	0.826
24 Hour H1H	1.516E+02	1.053	0.664	0.631
24 Hour H2H	1.333E+02	0.961	0.749	0.780
Annual	2.224E+01	0.762	0.554	0.728

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U200TO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.411E+01	0.385	0.426	1.106
1 Hour H2H	6.340E+01	0.320	0.312	0.974
3 Hour H1H	5.143E+01	0.260	0.326	1.253
3 Hour H2H	4.184E+01	0.267	0.282	1.055
24 Hour H1H	1.332E+01	0.328	0.262	0.798
24 Hour H2H	1.160E+01	0.369	0.296	0.803
Annual	1.855E+00	0.343	0.277	0.807

U200TP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.576E+01	0.323	0.389	1.205
1 Hour H2H	7.495E+01	0.279	0.334	1.195
3 Hour H1H	4.611E+01	0.275	0.266	0.966
3 Hour H2H	4.378E+01	0.264	0.244	0.925
24 Hour H1H	1.884E+01	0.238	0.330	1.384
24 Hour H2H	1.631E+01	0.218	0.203	0.933
Annual	1.673E+00	0.304	0.231	0.760

U10VOLFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	2.722E+04	1.140	1.040	0.913
1 Hour H2H	2.722E+04	1.132	1.027	0.908
3 Hour H1H	2.225E+04	1.104	1.007	0.912
3 Hour H2H	2.007E+04	1.189	1.070	0.900
24 Hour H1H	8.807E+03	1.261	1.146	0.909
24 Hour H2H	7.552E+03	1.159	1.151	0.993
Annual	1.775E+03	1.319	1.348	1.022

U10VOLFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	4.076E+04	1.070	0.850	0.794
1 Hour H2H	3.631E+04	1.114	0.861	0.773
3 Hour H1H	2.595E+04	1.148	1.031	0.898
3 Hour H2H	2.219E+04	1.062	0.990	0.932
24 Hour H1H	1.102E+04	1.043	0.974	0.934
24 Hour H2H	7.792E+03	1.108	1.109	1.001
Annual	1.106E+03	1.388	1.492	1.075

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U35VOLFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.079E+04	0.768	0.773	1.007
1 Hour H2H	8.430E+03	0.919	0.932	1.014
3 Hour H1H	5.600E+03	0.890	0.873	0.980
3 Hour H2H	5.198E+03	0.783	0.790	1.009
24 Hour H1H	2.736E+03	0.594	0.593	0.998
24 Hour H2H	2.149E+03	0.681	0.639	0.938
Annual	5.942E+02	0.653	0.593	0.909

U35VOLFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	1.079E+04	1.114	1.105	0.992
1 Hour H2H	9.609E+03	0.981	0.903	0.921
3 Hour H1H	6.187E+03	0.939	0.940	1.000
3 Hour H2H	5.280E+03	0.868	0.824	0.949
24 Hour H1H	2.839E+03	0.554	0.533	0.962
24 Hour H2H	2.302E+03	0.634	0.610	0.963
Annual	4.048E+02	0.680	0.650	0.955

UAREFO	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	4.902E+03	4.254	1.383	0.325
1 Hour H2H	4.902E+03	2.856	1.247	0.437
3 Hour H1H	4.787E+03	2.820	1.224	0.434
3 Hour H2H	4.411E+03	2.405	1.246	0.518
24 Hour H1H	2.651E+03	2.168	1.281	0.591
24 Hour H2H	2.276E+03	1.823	1.373	0.753
Annual	1.095E+03	1.151	1.434	1.246

UAREFP	ISC3	99351AER/ ISC3	02222AER/ ISC3	02222AER/ 99351AER
1 Hour H1H	7.322E+03	3.157	0.958	0.303
1 Hour H2H	7.202E+03	3.150	0.932	0.296
3 Hour H1H	5.631E+03	2.576	1.015	0.394
3 Hour H2H	4.691E+03	2.668	1.178	0.441
24 Hour H1H	3.005E+03	1.893	1.201	0.635
24 Hour H2H	2.882E+03	1.954	1.237	0.633
Annual	1.287E+03	1.272	1.417	1.114

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APPENDIX E

COMPLEX TERRAIN MODELING RESULTS:

LISTING OF REGULATORY DESIGN CONCENTRATIONS (UG/M3)

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

PHLLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	88.349	0.39	0.67	0.87
1 Hour H2H	87.987	0.32	0.55	0.74
3 Hour H1H	78.591	0.20	0.54	0.61
3 Hour H2H	73.306	0.19	0.48	0.61
24 Hour H1H	24.103	0.18	0.38	0.75
24 Hour H2H	18.047	0.20	0.44	0.89
Annual	2.703	0.19	0.41	0.89

MCLLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	51.612	0.51	1.04	0.85
1 Hour H2H	50.919	0.41	0.97	0.96
3 Hour H1H	48.584	0.21	0.63	0.87
3 Hour H2H	41.564	0.24	1.08	0.93
24 Hour H1H	12.846	0.16	0.53	0.91
24 Hour H2H	10.534	0.17	0.63	1.01
Annual	1.348	0.17	0.52	1.03

MALLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	43.626	0.26	0.41	0.91
1 Hour H2H	43.351	0.25	0.56	0.91
3 Hour H1H	37.516	0.11	0.47	0.92
3 Hour H2H	34.43	0.10	0.44	0.91
24 Hour H1H	9.473	0.11	0.79	0.99
24 Hour H2H	8.015	0.12	0.74	0.99
Annual	0.564	0.16	0.62	1.09

CCLLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	48.416	0.30	1.23	1.00
1 Hour H2H	48.416	0.24	1.22	1.00
3 Hour H1H	42.68	0.20	1.77	1.01
3 Hour H2H	32.291	0.19	1.78	1.05
24 Hour H1H	9.707	0.17	2.06	0.99
24 Hour H2H	7.256	0.16	1.57	1.02
Annual	0.48	0.20	1.18	1.18

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

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PHLLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	8.293	0.40	1.17	0.94
1 Hour H2H	7.971	0.33	1.13	0.81
3 Hour H1H	4.908	0.25	0.87	0.76
3 Hour H2H	3.841	0.27	0.84	0.90
24 Hour H1H	1.122	0.18	0.80	0.80
24 Hour H2H	0.739	0.26	0.96	0.91
Annual	0.067	0.27	1.20	1.00

MCLLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	8.024	0.47	1.23	0.90
1 Hour H2H	7.649	0.37	1.19	0.92
3 Hour H1H	5.108	0.26	0.73	0.90
3 Hour H2H	4.486	0.24	0.84	0.95
24 Hour H1H	1.133	0.32	1.00	1.01
24 Hour H2H	0.979	0.32	0.88	0.98
Annual	0.109	0.33	0.88	1.01

MALLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	7.78	0.19	0.74	0.99
1 Hour H2H	7.662	0.14	0.59	1.02
3 Hour H1H	4.03	0.17	1.02	1.00
3 Hour H2H	3.327	0.17	0.92	1.00
24 Hour H1H	0.842	0.20	1.61	1.00
24 Hour H2H	0.57	0.20	1.33	1.01
Annual	0.038	0.21	0.89	1.19

CCLLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	8.073	0.22	1.22	1.00
1 Hour H2H	7.663	0.21	1.40	1.10
3 Hour H1H	4.604	0.22	1.50	1.00
3 Hour H2H	3.016	0.22	1.68	1.01
24 Hour H1H	0.805	0.17	1.30	1.01
24 Hour H2H	0.762	0.12	1.07	1.12
Annual	0.037	0.24	1.13	1.36

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

PHLHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	18.709	0.31	0.66	1.01
1 Hour H2H	18.672	0.27	0.66	1.01
3 Hour H1H	17.274	0.20	0.77	1.00
3 Hour H2H	16.654	0.17	0.75	1.00
24 Hour H1H	5.399	0.13	0.70	1.00
24 Hour H2H	4.246	0.15	0.80	1.01
Annual	0.581	0.11	0.97	1.03

MCLHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	9.41	0.38	0.55	1.20
1 Hour H2H	9.385	0.28	0.58	1.02
3 Hour H1H	9.208	0.23	0.97	1.01
3 Hour H2H	9.164	0.20	1.10	1.01
24 Hour H1H	3.195	0.12	0.89	1.02
24 Hour H2H	2.775	0.13	0.95	1.02
Annual	0.249	0.10	0.75	1.05

MALHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	5.684	0.22	0.34	0.97
1 Hour H2H	5.684	0.19	0.30	1.00
3 Hour H1H	5.534	0.10	0.23	1.00
3 Hour H2H	4.72	0.11	0.39	1.01
24 Hour H1H	1.284	0.08	0.31	0.98
24 Hour H2H	0.836	0.09	0.28	0.98
Annual	0.052	0.13	0.39	1.00

CCLHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	0.878	0.38	0.22	0.71
1 Hour H2H	0.869	0.32	0.22	0.85
3 Hour H1H	0.788	0.15	0.14	0.76
3 Hour H2H	0.779	0.13	0.18	0.95
24 Hour H1H	0.304	0.09	0.18	0.87
24 Hour H2H	0.143	0.18	0.34	1.29
Annual	0.01	0.20	0.67	1.60

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

PHLHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	2.309	0.35	0.45	1.23
1 Hour H2H	2.309	0.27	0.39	1.09
3 Hour H1H	2.037	0.16	0.51	1.01
3 Hour H2H	1.867	0.16	0.57	1.39
24 Hour H1H	0.445	0.16	0.52	1.05
24 Hour H2H	0.36	0.14	0.63	1.22
Annual	0.026	0.12	0.75	1.17

MCLHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	1.547	0.54	0.60	1.80
1 Hour H2H	1.547	0.29	0.52	1.18
3 Hour H1H	1.477	0.20	0.66	1.12
3 Hour H2H	1.164	0.19	0.59	1.23
24 Hour H1H	0.408	0.12	0.78	1.07
24 Hour H2H	0.284	0.12	0.62	1.01
Annual	0.028	0.14	0.80	1.12

MALHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	1.381	0.22	0.31	1.00
1 Hour H2H	1.381	0.17	0.34	0.91
3 Hour H1H	1.321	0.08	0.31	0.84
3 Hour H2H	0.908	0.11	0.34	1.01
24 Hour H1H	0.307	0.07	0.42	0.84
24 Hour H2H	0.207	0.10	0.40	0.90
Annual	0.012	0.25	0.75	1.20

CCLHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	0.27	0.79	0.35	0.86
1 Hour H2H	0.262	0.73	0.47	1.00
3 Hour H1H	0.219	0.41	0.39	0.97
3 Hour H2H	0.217	0.37	0.41	0.95
24 Hour H1H	0.088	0.16	0.45	0.85
24 Hour H2H	0.044	0.27	0.48	0.97
Annual	0.003	0.33	1.00	1.46

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

PHHLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	49.86	0.35	0.90	1.00
1 Hour H2H	49.715	0.26	0.79	1.00
3 Hour H1H	28.962	0.31	0.96	1.00
3 Hour H2H	26.97	0.28	1.03	1.00
24 Hour H1H	9.578	0.30	0.94	1.00
24 Hour H2H	8.275	0.27	1.08	1.00
Annual	1.022	0.25	0.82	1.01

MCHLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	28.886	0.41	0.86	1.00
1 Hour H2H	28.812	0.36	2.13	1.00
3 Hour H1H	19.196	0.32	1.33	1.00
3 Hour H2H	16.396	0.33	1.76	1.00
24 Hour H1H	4.287	0.33	1.63	1.01
24 Hour H2H	3.845	0.31	1.49	1.00
Annual	0.579	0.17	0.92	1.01

MAHLC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	15.289	0.43	0.67	1.00
1 Hour H2H	15.289	0.28	0.78	1.00
3 Hour H1H	8.119	0.36	0.74	1.00
3 Hour H2H	6.722	0.28	0.88	1.00
24 Hour H1H	2.004	0.25	1.02	1.00
24 Hour H2H	1.815	0.16	0.71	1.00
Annual	0.128	0.19	0.71	1.01

PHHLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	7.064	0.33	0.80	1.00
1 Hour H2H	6.271	0.33	0.82	1.00
3 Hour H1H	2.727	0.32	0.85	1.00
3 Hour H2H	2.338	0.30	0.78	1.00
24 Hour H1H	0.64	0.20	0.78	1.01
24 Hour H2H	0.44	0.27	0.90	1.00
Annual	0.037	0.19	0.88	1.18

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

MCHLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	6.74	0.26	0.85	1.00
1 Hour H2H	6.254	0.28	1.58	1.00
3 Hour H1H	4.232	0.18	1.09	1.08
3 Hour H2H	2.611	0.22	1.39	1.00
24 Hour H1H	0.61	0.19	1.30	1.00
24 Hour H2H	0.566	0.16	1.39	1.23
Annual	0.058	0.12	1.00	1.00

MAHLF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	6.509	0.22	0.81	1.00
1 Hour H2H	6.371	0.14	0.82	1.00
3 Hour H1H	2.17	0.22	0.67	1.00
3 Hour H2H	2.16	0.19	0.92	1.00
24 Hour H1H	0.43	0.17	0.83	1.00
24 Hour H2H	0.423	0.14	0.72	0.99
Annual	0.022	0.27	0.86	1.10

PHHHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	8.606	0.23	0.32	1.25
1 Hour H2H	8.578	0.14	0.29	1.00
3 Hour H1H	6.329	0.11	0.31	1.07
3 Hour H2H	6.16	0.08	0.27	0.99
24 Hour H1H	2.065	0.18	0.91	1.00
24 Hour H2H	1.635	0.09	0.43	1.00
Annual	0.205	0.10	1.25	0.99

MCHHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	1.029	0.66	0.40	0.95
1 Hour H2H	1.026	0.28	0.25	0.91
3 Hour H1H	0.945	0.24	0.31	0.95
3 Hour H2H	0.935	0.15	0.25	0.98
24 Hour H1H	0.389	0.17	0.60	1.00
24 Hour H2H	0.371	0.11	0.44	0.95
Annual	0.022	0.18	0.50	1.02

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

Appendix E. Complex terrain results. The ISC3 concentrations are in ug/m3 and the last 3 columns are concentration ratios.

MAHHC	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	0.659	0.38	0.20	1.00
1 Hour H2H	0.643	0.32	0.23	0.93
3 Hour H1H	0.614	0.19	0.27	0.94
3 Hour H2H	0.525	0.16	0.24	0.93
24 Hour H1H	0.124	0.27	0.28	0.97
24 Hour H2H	0.077	0.38	0.35	0.96
Annual	0.006	0.33	0.40	0.97

PHHHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	1.625	0.27	0.33	2.66
1 Hour H2H	1.625	0.11	0.16	1.31
3 Hour H1H	1.083	0.14	0.23	1.71
3 Hour H2H	0.964	0.08	0.21	0.98
24 Hour H1H	0.204	0.11	0.24	1.50
24 Hour H2H	0.16	0.12	0.23	1.56
Annual	0.011	0.09	0.50	0.99

MCHHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	0.274	0.59	0.56	0.93
1 Hour H2H	0.272	0.51	0.71	0.82
3 Hour H1H	0.235	0.33	0.63	0.94
3 Hour H2H	0.233	0.30	0.85	0.96
24 Hour H1H	0.095	0.21	1.11	1.01
24 Hour H2H	0.053	0.25	0.72	1.02
Annual	0.007	0.29	1.00	1.22

MAHHF	ISC3	02222AER/ ISC3	02222AER/ CTDM+	02222AER/ 99351AER
1 Hour H1H	0.276	0.42	0.69	0.75
1 Hour H2H	0.266	0.42	0.86	0.88
3 Hour H1H	0.217	0.29	0.78	0.74
3 Hour H2H	0.193	0.24	0.73	0.85
24 Hour H1H	0.053	0.23	0.48	0.85
24 Hour H2H	0.034	0.35	0.67	1.00
Annual	0.003	0.33	0.50	0.66

The code for each scenario evaluated is as follows: The first 2 letters refer to the name of the hill: PH = Piedmont, MC = Montour Crosswind, MA = Montour Alongwind, CC = Cinder Cone Butte. The 3rd letter refers to the stack height: L = 30 meters, H = 150m. The fourth letter refers to the buoyancy: L = low, H = high. The fifth letter stands for the distance between the source and the hill: C = close or 1 kilometer, F = far or 10 km.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report is a consequence analysis for the implementation of a new air dispersion model. A consequence analysis is designed to give the user community a sense of how regulatory design concentrations from the new model compare to those from an established model via a series of "representative" examples. For this study, the new model is AERMOD with the PRIME algorithms. The existing regulatory models used in this report are ISCST3, ISC-PRIME, and CTDMPLUS. This analysis shows, for an extensive number of typical source scenarios, the effects of the new model as compared to the existing regulatory model which it replaces. Overall, except for complex terrain, the models produce rather similar results, although there are significant differences for individual source types and settings. As expected in complex terrain, AERMOD typically produces concentrations that are lower than ISCST3. The model evaluation results, where available, support the differences seen between the models.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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