

The HEM-3 User's Guide

Instructions for using the Human Exposure Model Version 1.3.1
(AERMOD version) for Single Facility Modeling

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1. Introduction

The Human Exposure Model, Version 1.3.1, (HEM-3) is a streamlined, but rigorous tool you can use for estimating ambient concentrations, human exposures and health risks that may result from air pollution emissions from a complex industrial facility, or a cluster of facilities located near one another. HEM-3 is designed for use by the EPA, states, local agencies, industry, and other stakeholders.

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1.1 Organization of the HEM-3 User's Guide

This User's Guide is organized into seven chapters:

Chapter 1	Provides a brief introduction to HEM-3, including the main features and requirements of the model.
Chapter 2	Provides instructions for installing HEM-3, including descriptions of the data libraries provided during installation.
Chapter 3	Provides instructions for preparing the input data files needed by HEM-3 and step-by-step instructions for running the model.
Chapter 4	Describes the calculations performed by HEM-3.
Chapter 5	Describes the outputs produced by HEM-3.
Chapter 6	Provides an instructive list of potential HEM-3 Error Messages
Chapter 7	References.

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1.2 Main Features of HEM-3

HEM-3 performs three main operations: dispersion modeling, estimation of population exposure, and estimation of human health risks. To perform these calculations, HEM-3 draws on three data libraries that are provided with the model. These three libraries are: a Chemical Health Effects Library, a Census Library, and a Meteorological Library. HEM-3 uses the Chemical Health Effects Library of pollutant unit risk estimates (URE) and reference concentrations (RfCs) to calculate population risks and health hazards. These risk factors and RfCs are based on the latest values recommended by the EPA for hazardous air pollutants (HAP) and other toxic air pollutants ([EPA 2014](#)).

The Census Library of census block internal point ("centroid") locations and populations provides the basis of human exposure calculations. The model includes census data from both the 2000 and 2010 censuses. Thus, you can base a HEM-3 modeling run on either census. The Census Library also includes the elevation of each census block, which you have the option of using in dispersion calculations. The Meteorology Library contains meteorological data used for

dispersion calculations from over 800 observation stations across the continental U.S., Alaska, Hawaii, and Puerto Rico.

HEM-3 uses the American Meteorological Society - U.S. EPA Regulatory Model (AERMOD) for dispersion modeling. The EPA's modeling guidance indicates that AERMOD represents the state-of-the-science; EPA recommends AERMOD for most industrial source modeling applications for air toxics applications ([EPA 2005](#)). AERMOD was developed under the auspices of the American Meteorological Society - Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) ([EPA 2004a](#), [EPA 2004b](#), [EPA 2004c](#), [EPA 2004d](#), [EPA 2004e](#), [EPA 2011a](#), [EPA 2013a](#), [EPA 2013b](#), [EPA 2013c](#)). AERMOD can handle a wide range of different source types that may be associated with an industrial source complex, including stack sources, area sources, and volume sources. Additionally, AERMOD is capable of modeling polygon source types. HEM-3 runs AERMOD as many times as is necessary to address the gaseous pollutants and particulate matter emitted from the modeled facility, and can (optionally) model both dry and wet deposition and plume depletion. HEM-3 will also accept user-provided dispersion modeling results or monitoring data for the concentrations of HAP and other toxic air pollutants.

The model identifies all census block locations within the study domain as defined by the default modeling radius around the facility or a radius that you specify. The Census Library includes locations and populations, elevations, and controlling hill heights for all of the approximately 5.5 million census blocks tabulated in the 2000 Census, and 6.3 million blocks tabulated in the 2010 Census ([Census 2000](#), [Census 2010](#)).

HEM-3 estimates cancer risks and non-cancer adverse health effects due to inhalation exposure at census block locations and at other receptor locations that you may specify. These predicted risk and health effect estimates are generally conservative with respect to the modeled emissions because they are not adjusted for attenuating exposure factors (such as indoor/outdoor concentration ratios, daily hours spent away from the residential receptor site, and years of lifetime spent living elsewhere than current residential receptor site). HEM-3 computes cancer risks using the EPA's recommended unit risk estimates (UREs) for HAP and other toxic air pollutants. The resulting estimates reflect the risk of developing cancer for an individual breathing the ambient air at a given receptor site 24 hours per day over a 70-year lifetime.

Optionally, HEM-3 can estimate acute (hourly) concentrations for each chemical and receptor site, including the location of the maximum acute concentration for each chemical emitted from the facility. In addition, the model outputs a listing of the associated acute benchmarks for each pollutant (below which certain acute adverse effects are not expected). From these acute concentrations and benchmarks, you can compute the ratio of the maximum acute concentration to the associated benchmark to determine the maximum acute hazard quotient (HQ) for each pollutant of concern.

HEM-3 identifies receptor locations at which the predicted lifetime cancer risk, chronic non-cancer hazard indices (HI), and (optionally) acute concentrations are highest. For these locations, the model gives the concentrations of different chemicals from various emission sources driving the overall cancer risks, chronic HI, and acute concentrations.

The model estimates the numbers of people exposed to various cancer risk levels and HI levels. In addition, HEM-3 estimates the average cancer risks, average HI, and the predicted annual cancer incidence for people living within different distances of the modeled emission sources.

1.3 Differences between Current and Previous Version of HEM-3

HEM was originally developed as a screening tool for exposure assessment in the 1980s ([EPA 1986](#)). The original model was upgraded to run in a Windows™ environment and several versions have been released by the EPA prior to this 2014 version, including in 2007 ([EPA 2007a](#)). The 2014 HEM-3 version differs from the 2007 model release in several important ways, as listed below and summarized in [Figure 1](#).

- We simplified the HEM-3 user interfaces to use the latest AERMOD version (dated 13350) for dispersion modeling, while the 2007 version allowed the use of ISC Short Term (ISCST). AERMOD is more rigorous than ISC and is considered the state-of-the-science dispersion model.
- We updated HEM-3 with the latest census data. It now incorporates both the 2010 and 2000 census databases, so you can choose which population data best serves your analytic needs.
- We updated and expanded HEM-3's meteorological database to include over 800 met stations used by AERMOD, compared to the 2007 version's 120 met stations.
- HEM-3 now allows you to use polygon source types in addition to point, area, and volume sources. You can use a polygon to represent complex area sources with between 3 and 9,999 vertices (e.g., mobile sources modeled uniformly over an entire census tract).
- HEM-3 now includes a default option for determining whether rural or urban dispersion coefficients are applied in AERMOD when using the 2010 Census. If you select this default option, HEM-3 will find the nearest census block to the facility center, determine whether that census block is in a designated urban area and obtain the appropriate population for the urban area, or model as rural, as appropriate.
- HEM-3 now requires you to base location coordinates on the 1983 North American Datum (NAD83) geographic projection system. You must convert coordinates based on 1927 NAD (NAD27) to NAD83 before being entered coordinates into HEM-3 for modeling.
- HEM-3 now accepts all versions of Microsoft Excel™ based input files. You can use input files with either the ".xls" or ".xlsx" file extension.
- HEM-3 can now vary the emission inputs by user-specified temporal factors (up to 672 factors) or wind speed factors (up to 6 factors) and produce diurnally-resolved outputs in user-specified blocks of time (1-hour through 24-hour blocks, with or without seasonal variations).
- HEM-3 is now run by default using a rigorous modeling of source dispersion by AERMOD, with fewer simplifying assumptions than used previously. The 2007 HEM-3 version automatically implemented AERMOD's FASTALL, which conserves model runtime by simplifying the algorithms used to represent meander of the pollutant plume.

The current HEM-3 version allows you to choose the FASTALL option, if faster runtimes are desired, or the more rigorous non-FASTALL default mode.

- HEM-3 now calculates a first modeling ring distance so that all emission sources are inside this ring. The 2007 HEM-3 version automatically set the first modeling ring distance to 100 meters, which often resulted in some emission sources being outside the 100 meter first ring.
- HEM-3 can now optionally produce a detailed Google Earth™ map centered on the facility, which displays the emission sources and inner receptors and the level of cancer risk and non-cancer hazard at each receptor.
- HEM-3 now gives you the option of providing gridded pollutant concentrations from an external model or from monitoring data. Under this option, instead of HEM-3 running AERMOD to predict ambient concentrations, HEM-3 uses the externally provided data to interpolate pollutant concentrations for all census blocks in the study domain.

Model Feature	2014 HEM-3	2007 HEM-3
Dispersion Modeling	AERMOD (v.13350)	AERMOD/ISCST
Census Year Data	2000 or 2010	2000
Met station database	Over 800 stations	120 stations
Source Types	point, area, volume and polygon	point, area and volume
Dispersion Environment Based On Land Use	May select rural, urban or default to allow model to determine (for 2010 Census)	Defaulted to rural
Location Coordinates Input Type	NAD83	NAD83/NAD27
MS Excel File Types	XLS/XLSX (any)	XLS (5/95)
User-Specified Temporal Factors	included	not included
AERMOD FASTALL	Optionally implemented	Automatically implemented
First Modeling Ring Distance	calculated based on location of emission sources and facility center (≥ 100 m)	100 meters
Google Earth Maps Option	included	not included
Pollutant Concentrations Input Option	may use external model/monitoring data	not included

Figure 1. Summary of Key Features for 2014 HEM-3 and 2007 HEM-3

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1.4 Strengths and Limitations of HEM-3

HEM-3 is designed to perform detailed and rigorous analyses of chronic and acute air pollution risks for populations located near industrial emission sources. The HEM-3 model has been updated with the goal of simplifying the running of AERMOD without sacrificing any of AERMOD's strengths. In keeping with this goal, you can now specify complex emission source configurations, including point sources for stacks, area and volume sources for fugitive

emissions, obliquely oriented area sources for roadways, as well as polygon sources for a variety of area source shapes including entire census tracts. As noted above, the model identifies all census blocks located near the facility. You can also specify the locations of individual houses, schools, plant boundaries, monitors, or other user-defined receptors to model. HEM-3 can account for impacts of terrain, building downwash effects, pollutant deposition and plume depletion. It also analyzes multiple pollutants concurrently, with the capability of including particulate and gaseous pollutants in the same model run.

However, HEM-3's framework has some limitations. First, AERMOD, like all air pollutant dispersion models, is subject to uncertainties. Likewise, pollutant UREs for cancer, RfCs for non-cancer HI, and benchmarks for acute health effects are subject to uncertainties. Another limitation of HEM-3 is that the model estimates pollutant concentrations and risks for a census block centroid, as defined by the U.S. Census Bureau. Values calculated for this internal point are not representative of the range of values over the entire block, and may not represent where most people reside within a block. Further, these values do not account for the movement of people from their home census blocks to other census blocks, due to commuting or other daily activities. In addition, as noted above, HEM-3 calculates outdoor concentrations of air pollutants. These concentrations do not account for indoor sources of pollution, or the reduction of outdoor pollution in indoor air.

HEM-3 performs a number of tests on user input data—such as emissions data and stack parameters—before using AERMOD to calculate air pollution impacts. However, there are some potential problems with input files that HEM-3 may not detect in these initial tests. The model may sometimes run for an hour or more before detecting a problem with the input data. To avoid this, carefully review the model input guidelines to make sure that the contents and format of input files meet these guidelines.

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1.5 Requirements for Running HEM-3

You can use HEM-3 on any Windows™-based personal computer running Windows 98™ or later. Disk space requirements will depend on the number of census and meteorological files that you use. If using HEM-3 only to model plants in a single state, the model requires, at minimum, 20 megabytes of disk space. The model also will need a minimum of 132 megabytes of RAM. Once installed, you can use HEM-3 to model risks and exposures for any location in the U.S., and for a wide range of emission source configurations.

For each model analysis, you should provide emissions inputs and emission source locations in the form of Excel™ spreadsheet files. (If Excel™ is not available, you can use another spreadsheet program, such as Lotus 1-2-3™, to prepare the tables; however, you must save these files in XLS or XLSX format.) HEM-3 requires separate estimates of emission rates of each pollutant, from each emission source. The model also requires detailed information on each emission source, including location, height, emission velocity, emission temperature, and the configuration of fugitive emission sources. You can also use an optional spreadsheet file to provide the dimensions of buildings near emission sources, for use in computing building downwash effects. When modeling particulate emissions, you can use an optional spreadsheet file to provide particle size information and deposition parameters. In addition to these input files, the model will ask you to design the model receptor network and to select other modeling options through a series of user input screens, which are discussed in more detail in Section 3 *Running HEM-3*.

This manual is designed to provide all of the information you may need to run HEM-3. However, some of the options for running HEM-3 draw on advanced features of AERMOD, such as the incorporation of building downwash effects or plume depletion due to deposition. If unfamiliar with the AERMOD dispersion model, you may need to refer to the AERMOD manual (available at www.epa.gov/scram001/dispersion_prefrec.htm#aermod) in order to develop some of the inputs needed for HEM-3 ([EPA 2004a](#), [EPA 2013a](#), [EPA 2013b](#)). This is particularly true for some of the more complex modeling options, such as plume deposition and depletion, building downwash, and complex source configurations.

2. Installing HEM-3

This section provides instructions for downloading and installing the HEM-3 model and required data libraries from the EPA's HEM Download Page.

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2.1 Downloading the HEM-3 Program

The HEM-3 model is available from the HEM Download Page of EPA's Fate, Exposure, and Risk Analysis (FERA) Technology Transfer Network (TTN), which you can access via the link http://www.epa.gov/ttn/fera/hem_download.html. The HEM Download Page includes general installation instructions under section 2, and a link to install HEM-3 under section 3 "Software available for download." Click on the HEM-3 link, then select "run" to begin the installation program for HEM-3. The default location for HEM-3 installation is "C:\Program Files\HEM3\."

To change this location, click on the "Change..." button and indicate an alternate location. The model will place the basic files needed to run HEM-3 in the selected directory, and create a number of subdirectories. A screen called "Installing HEM3" is displayed while the files are being copied to the destination folder. When the installation is complete, the window called "InstallShield Wizard Completed" appears.

In addition to user-provided inputs describing the nature and location of the emissions (discussed in Section 3.1), HEM-3 relies upon several data libraries that supply required inputs for a modeling run. To complete the installation of HEM-3, download the following data libraries:

- a Chemical Health Effects Library containing the dose response benchmark values and affected organs for known HAP (a.k.a. "Toxicity Value Files");
- a Census Library containing nationwide files that provide the population numbers and terrain elevation data surrounding a facility location (both 2000 and 2010 census files are available for download); and
- a Meteorological Library containing met station files with data that characterize typical weather patterns (including, in particular, wind speed and direction) in the vicinity of a facility.

You can find links to these data libraries under section 4 on the HEM Download Page. The following sections provide instructions for downloading these files, along with a brief description of each of these data libraries.

2.2 Downloading Chemical Health Effects Data

HEM-3 uses a chemical health effects library of pollutant UREs and RfCs to calculate population risks. To download these dose response values, click on the “Toxicity Value Files” link under section 4 on FERA’s HEM Download Page (http://www.epa.gov/ttn/fera/hem_download.html). Before initiating a modeling run, check for updated versions of these files on EPA’s Dose Response Assessment webpage ([EPA 2014](#)). When updated files become available, copy these into the “Reference” directory under the HEM-3 directory that you selected during installation. Be sure to unzip the files and verify they are located in the specified directory when finished. The default directory for chemical health effects data is “C:\Program Files\HEM3\Reference”.

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2.2.1 Description of Chemical Health Effects Library

For each pollutant, the Chemical Health Effects Library includes the following parameters, where available:

- unit risk estimate (URE) for cancer;
- reference concentration (RfC) for chronic non-cancer health effects;
- reference benchmark concentration for acute health effects; and
- target organs affected by the chemical (for chronic non-cancer effects).

These parameters are based on the EPA’s database of recommended dose response values for HAP ([EPA 2014](#)), which is updated periodically, consistent with continued research on these parameters. The URE represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) in air (e.g., if the URE = 1.5×10^{-6} per $\mu\text{g}/\text{m}^3$, 1.5 excess tumors are expected to develop per 1 million people if all 1 million people were exposed daily for a lifetime to 1 microgram of the chemical in 1 cubic meter of air) ([EPA 2011b](#)).

The RfC is a concentration estimate of a continuous inhalation exposure to the human population that is likely to be without an appreciable “risk” of deleterious non-cancer health effects during a lifetime. No adverse effects are expected as a result of exposure if the ratio of the potential exposure concentration to the RfC, defined as the hazard quotient (HQ), is less than 1 ([EPA 2011b](#)).

The reference benchmark concentration for acute health effects, similar to the chronic RfC, is the concentration below which no adverse health effects are anticipated when an individual is exposed to the benchmark concentration for 1 hour (or 8 hours, depending on the specific acute benchmark used and the formulation of that benchmark). Target organs are those organs (e.g., kidney) or organ systems (e.g., respiratory) which may be impacted with chronic non-cancer health effects by exposure to the chemical in question. A more in-depth discussion of the development and use of these parameters for estimating cancer risk and non-cancer hazard may be found in the EPA’s Air Toxics Risk Assessment Library ([EPA 2004f](#)), available for download at www.epa.gov/ttn/fera/risk_atra_vol1.html.

You can add pollutants and associated health effect values, as needed, to the two Excel™ spreadsheets comprising HEM-3's Chemical Health Effects Library: the dose response library spreadsheet and (if applicable) the target organ endpoints spreadsheet. These files are located in HEM-3's Reference directory:

- C:\Program Files\HEM3\Reference\Dose_Response_Library.xls; and
- C:\Program Files\HEM3\Reference\Target_Organ_Endpoints.xls.

The dose response library file includes a listing of HAP and other toxic pollutants and the various URE values, RfC values, and acute benchmark values associated with these pollutants. The target organ endpoint table includes a listing of HAP and other toxic pollutants and the organs or organ systems that may be impacted with chronic non-cancer health effects by exposure to these pollutants.

Note that each pollutant you list in the input files (discussed in [Section 3.1](#)) needs to match exactly a pollutant name in the dose response library table. The target organ endpoints table need not contain every pollutant listed in the inputs. Only pollutants having chronic non-cancer health effects are listed in the target organ endpoints table.

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2.3 Downloading Census Data

You will need census files for the region or regions you wish to model. You can obtain nationwide files on the HEM Download Page (http://www.epa.gov/ttn/fera/hem_download.html) of the FERA website, for both the 2000 and 2010 census.

Nationwide files are provided on a state-by-state basis in database format (DBF). HEM-3 will access census files to cover the area within 50 kilometers of each facility you are modeling. Multiple states may be needed to model a particular facility (if the facility is located within 50 kilometers of a state boundary).

Download, unzip and copy the nationwide census files into the "Census_2000" and "Census_2010" subfolders, as appropriate, under the HEM-3 directory you selected during installation. Once unzipped, check to be sure that these files are now located in the specified directories when finished. The default census subdirectories are:

- C:\Program Files\HEM3\Census_2000; and
- C:\Program Files\HEM3\Census_2010.

Take care to place the downloaded 2000 Census files in your Census_2000 folder and the downloaded 2010 Census files in your Census_2010 folder. Do not mix these census data sets.

Do not delete the Census_key.dbf files (C:\Program Files\HEM3\Census_2000\census_key.dbf and C:\Program Files\HEM3\Census_2010\census_key.dbf). These were created when HEM-3 was installed and are required for HEM-3 modeling runs. Note that the North Carolina files for both the 2010 Census and 2000 Census are also included with the installation package to allow running of the template input files (discussed in Section 3) with or without downloading of all nationwide Census files.

2.3.1 Description of Census Library

The HEM-3 Census Library includes census block identification codes, locations, populations, elevations, and controlling hill heights for all of the over 5 million census blocks identified in the 2000 Census, and the over 6 million census blocks identified in the 2010 Census. The location coordinates reflect the internal “centroid” of the block, which is a point selected by the census to be roughly in the center of the block. For complex shapes, the internal point may not be in the geographic center of the block. Locations and population data for census blocks in the 50 states and Puerto Rico are extracted from the LandView® database for Census 2000 ([Census 2000](#)) and from the U.S. Census Bureau website for Census 2010 ([Census 2010](#)). Locations and populations for blocks in the U.S. Virgin Islands are from the U.S. Census Bureau website.

U.S. Geological Survey data was used to estimate the elevation of each census block in the continental U.S. and Hawaii. The data used for the 2000 Census elevations have a resolution of 3 arc seconds, or about 90 meters ([USGS 2006](#)). The data used for the 2010 Census elevations have a resolution of 1/3 of an arc second, or about 10 meters ([USGS 2010](#)). Using analysis tools (ArcGIS® 9.1 software application for the 2000 Census, and ArcGIS® 10 for the 2010 Census), elevation was estimated for each census block in Alaska and the U.S. Virgin Islands. The point locations of the census blocks in Alaska and the U.S. Virgin Islands were overlaid with a raster layer of North American Digital Elevation Model (DEM) elevations (in meters) ([USGS 2006](#)). An elevation value was assigned to each census block point based on the closest point in the ArcGIS elevation raster file.

An algorithm used in AERMAP, the AERMOD terrain processor ([EPA 2004c](#), [EPA 2011a](#)) is used to determine controlling hill heights. These values are used for flow calculations within AERMOD. To save run time and resources, the HEM-3 census block elevation database is substituted for the DEM data generally used in AERMAP. As noted above, the census block elevations were originally derived from the DEM database. To determine the controlling hill height for each census block, a cone is projected away from the block centroid location, representing a 10% elevation grade. The controlling hill height is selected based on the highest elevation above that 10% grade (in accordance with the AERMAP methodology). The distance cutoff for this calculation is 100 km. (This corresponds to an elevation difference at a 10% grade of 10,000 m, which considerably exceeds the maximum elevation difference in North America.)

In addition to census block location, population, elevation and controlling hill height data, the HEM-3 Census Library also includes the locations for over 125,000 schools and 1,000 monitors. School location data is for public and private schools spanning pre-kindergarten through high school, and are from the National Center for Education Statistics (NCES) 2006 data for the Census 2000 dataset ([NCES 2006a](#), [NCES 2006b](#)), and from the NCES 2009 data for the Census 2010 dataset ([NCES 2009a](#), [NCES 2009b](#)). You can obtain monitoring locations from the Air Toxics Data section of the EPA’s Technology Transfer Network Ambient Monitoring Technology Information Center ([EPA 2011c](#)). Note that the precision of the latitude/longitude location of these monitors varies and in some cases is precise to only two decimal places (roughly ± 600 meters), making comparison with HEM-3 modeling results inexact.

2.4 Downloading Meteorological Data

You can obtain nationwide meteorological data files from the HEM Download Page (http://www.epa.gov/ttn/fera/hem_download.html). Each meteorological file contains surface data and upper air data and is named beginning with the state abbreviation for the state in which the station is located. Generally, the closest set of stations will be most representative of the meteorology in the modeling domain. However, there are a number of situations where a different combination of meteorological stations will be more representative. For instance, if the modeling domain is located on the Gulf of Mexico, a surface station near the Gulf may be more representative than an inland station, even if there is a closer inland station.

Download the nationwide meteorological files into the “MetData” subdirectory under the HEM-3 directory you selected during installation. Unzip the meteorological files. After unzipping, verify that they are located in the specified directory. The default meteorological subdirectory is “C:\Program Files\HEM3\MetData.” AERMOD uses two files for each meteorological station and these files have extensions of SFC (surface data) and PFL (upper air data).

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2.4.1 Description of Meteorological Library

AERMOD requires surface and upper air meteorological data that meet specific format requirements. HEM-3 includes a library of meteorological data from National Weather Service (NWS) observation stations. The current HEM-3 AERMOD Meteorological Library includes over 800 nationwide locations, depicted in [Figure 2](#).

USEPA meteorologists obtained calendar year 2011 Integrated Surface Hourly Data (ISHD) for over 800 Automated Surface Observation System (ASOS) (<http://www.nws.noaa.gov/asos/>) stations spanning the entire US, as well as Puerto Rico and the US Virgin Islands, from the National Climatic Data Center (NCDC). The AERMOD meteorological processor, AERMET ([EPA 2004d](#), [EPA 2013c](#)) and its supporting modeling system (AERSURFACE and AERMINUTE) were used to process the meteorological data.

To estimate the boundary layer parameters required by AERMOD, AERMET requires hourly surface weather observations (which may include hourly values calculated from 1-minute data) and the full (i.e., meteorological variables reported at all levels) twice-daily upper air soundings. The surface and upper air stations are paired to produce the required input data for AERMOD. To support AERMET, ASOS 1-minute data for each surface station were obtained from NCDC in a DSI 6405 format. Further, upper air sounding data for the same time period for over 80 observation sites were obtained from the National Oceanic & Atmospheric Administration (NOAA) Earth System Research Laboratory’s (ESRL) online Radiosonde Database (see http://www.esrl.noaa.gov/raobs/General_Information.html). These datasets were produced by ESRL in Forecast Systems Laboratory (FSL) format.

AERMET Processing

Utilizing the AERMET meteorological data pre-processor, and the ASOS surface and FSL upper air stations, surface and profile files for input into AERMOD were generated nationwide. The surface stations were paired with representative upper air stations by taking the upper air station

closest to each surface station. The AERSURFACE tool was used to estimate the surface characteristics for input into AERMET utilizing land cover data surrounding the surface station. In addition, the AERMINUTE pre-processor was used to process 1-minute ASOS wind data for input into AERMET. The following lists the inputs used by each of the data pre-processors and tools used to generate the AERMOD meteorological data.

- AERMET Options: Version 13350 used to process ASOS site data; surface data in NCDC TD-3505 (ISHD) format; upper air data in FSL (all levels, tenths m/s) format; used the ADJ_U* non-Default BETA option to adjust the surface friction velocity (u^* or u_{star}) for low wind speed stable conditions.
- AERMINUTE Options: Version 11325 used for 1 minute ASOS data in TD-6405 format where available.
- AERSURFACE Options: Version 13016; land cover data in USGS NLCD92 GeoTIFF format (except Alaska and Hawaii which use 2001 land cover data); 1 kilometer radius used for surface roughness calculations; most but not all met station sites are located at airports; arid region site characteristics are used for all sites in Arizona, New Mexico, and Utah only; monthly (12 sector) temporal resolution; average surface moisture used; all states used late winter/winter snow cover without continuous cover (except Alaska where continuous snow cover was used).

The surface files were examined for completeness. If more than 10 percent of the data were missing, the station was not considered suitable for the HEM-3 meteorological database. In all, 824 met station pairs were found suitable and are included in the HEM-3 meteorological library, and shown in [Figure 2](#).

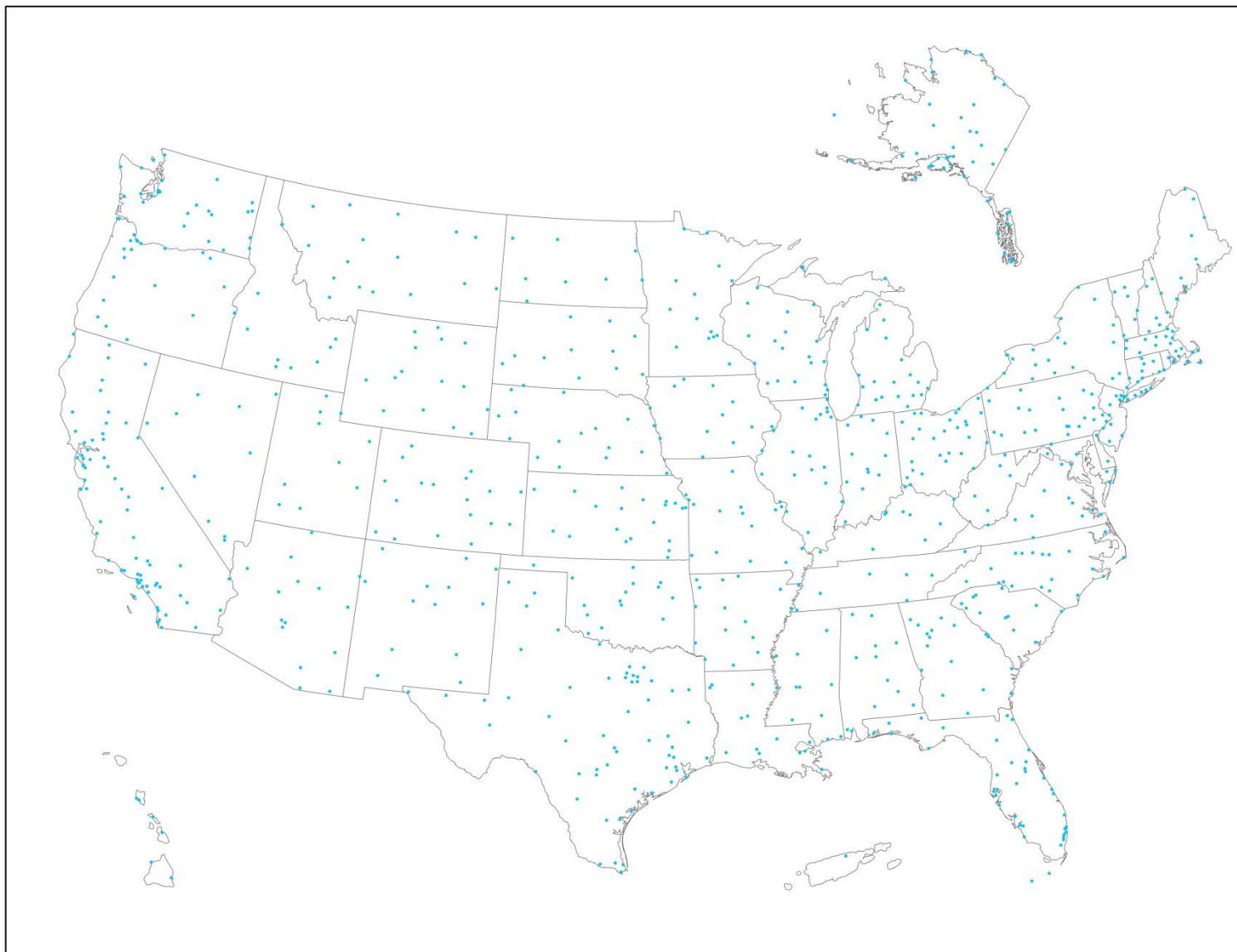


Figure 2. AERMOD Meteorological Stations

3. Running HEM-3

This section explains how to prepare the required and optional user-supplied input files for HEM-3. It also gives step-by-step instructions for running HEM-3, and provides guidance on the modeling of multiple facilities.

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3.1 Preparing Input Files

HEM-3 requires a series of Excel™ spreadsheet files to specify the emissions and configuration of the facility (or facilities) you are modeling. If Excel™ is not available, you can prepare the files using another spreadsheet program such as Lotus 1-2-3™. However, you must save the input in XLS or XLSX format.

HEM-3 accepts all Microsoft Excel™ versions (e.g., Excel™ 2013, 2010 and 2007, Excel™ 97-2003, Excel™ 5.0/95). However, earlier versions of MS Excel have built-in limitations. For example, Excel™ 5.0/95 version has a 16,000-row limitation, while later versions can handle 64,000 rows, and the current version (Excel 2010 or 2013) has a 1,048,576-row capacity.

To use HEM-3 to calculate ambient pollutant concentrations (using AERMOD), you will need the following two files at minimum:

- an emissions location file, which provides emission source locations and configurations for the facility (or facilities) being modeled; and
- a HAP emissions file, which provides the names and amounts of the pollutants emitted from each emission source at the modeled facility (or facilities).

You may also need the following additional input files, depending on the options you choose to use in your modeling run:

- a polygon vertices file – specifies the location of the polygon; required if the emissions location file contains an area source configured as a polygon, rather than a rectangular-shaped area source;
- a particle size file – specifies the particle size distribution for various size ranges; required to model particulate deposition;
- land use and month-to-season files – describe the land use and vegetative land cover surrounding the facility's emission source(s); required to model dry deposition of gaseous/vapor pollutants;
- a building dimension file – describes building dimensions or other obstructions near emission sources that would produce wake effects; required to model building downwash effects;
- a user-defined receptors file – specifies the locations of additional receptors; required if you want HEM-3 to compute pollutant concentrations and risks at specific user-defined locations (e.g., houses, schools, or other sites near the facility); and
- a temporal variations file – provides emission rate factors for individual sources; required to model temporally-varying emissions (e.g., emissions reflecting diurnal, weekly, monthly and seasonal variations or wind speed variations).

You can also optionally revise the chemical health effect input files – the dose response and target organ assumptions – used in the model (as described below in Section 3.1.11).

Finally, as an alternative to running HEM-3 in the standard way, using the emissions location and HAP emissions input files (and optional input files) described above, you can run HEM-3 using previously modeled or monitored pollutant concentrations as inputs. If you choose to run HEM-3 using this previously modeled/monitored data, you will not be able to use the optional input files described above. However, you will have the option of updating or altering dose response and target organ assumptions.

HEM-3 will prompt you to provide the required and optional input file names in a series of input screens. Directly inputting data from the spreadsheets avoids having to retype the emission rates and other calculated parameters. However, this method of input has its drawbacks. Notably, HEM-3 will not run successfully unless you have formatted the input files exactly as specified in the format guidelines. Section 3.1.1 describes general rules you should follow to avoid common mistakes. To make formatting easier, specific formatting requirements are exemplified in template input files, which are provided in the default “C:\Program Files\HEM3\Inputs” subdirectory. **Note:** If this is your first time running HEM-3, it is highly recommended that you first run the model with the template input files provided, as practice, and to confirm that HEM-3 installed properly on your computer.

Sections 3.1.2 through 3.1.9 provide detailed guidance on how to prepare the input files when using AERMOD to estimate ambient pollutant concentrations—that is, running HEM-3 in the standard way using a HAP emissions file and an emissions location file (plus optional input files, as desired). Section 3.1.10 describes how to prepare the input file if providing ambient pollutant concentrations from an external source—that is, if you are going to run HEM-3 using previously modeled or monitored concentration data. Template file names are also provided. Section 3.1.11 explains how to change the dose response benchmark values and target organ assumptions in the Chemical Health Effects Library, and how to add pollutants to the Chemical Health Effects Library.

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3.1.1 General Rules for Input Files

- Use a separate Excel™ workbook for each input file.
- Use only one input file worksheet per workbook.
- Match columns with the format specified for the input file. You can use the template input files and substitute actual data for template data. Delete any extra lines of template data.
- Do not insert columns between data columns. HEM-3 will read these and even any extra hidden columns as data.
- Use only one header line at the top of each file.
- Do not include text in numerical data fields (for instance "<0.001"). HEM-3 may read these fields as 0s (zeroes) or may accept only a portion of the number.
- Enter latitudes and longitudes in decimal degrees. HEM-3 will also accept Universal Transverse Mercator (UTM) coordinates. You must enter coordinates in 1983 North American Datum (NAD83) geographic projection system format. Do not use 1927 North American Datum (NAD27) formatted data. If inputs locations are based on the NAD27, convert to NAD83 before use.
- Match the units used for parameters, such as emission rates and stack parameters, with the units given in the file format guidelines provided in the below sections (for example: meters/second, meters, etc.).

3.1.2 Emissions Location File

Tables 1 and 2 display the [format guidelines](#) for the emissions location file and a [sample](#) emissions location input file, respectively. A template input file is provided in the HEM-3 Inputs directory ("C:\Program Files\HEM3\Inputs\Template_emission_location_file.xls"). HEM-3 can model the ambient impacts of multiple emission sources at a single facility or at a cluster of neighboring facilities. The emissions location file should include one record for each individual source (e.g., stack) to be modeled.* This record provides information on the location, size, height, and configuration for each source. (Pollutant data, including the specific chemicals emitted, are provided in the separate HAP emissions file described in [Section 3.1.3](#).)

The "Source ID" is a key parameter in the emissions location file, because HEM-3 uses the source ID to link the locations to other input files, such as the HAP emissions input file (described below in [Section 3.1.3](#)) and other optional input files. Give each Source ID a distinct name. Give different sources unique IDs even if they will be modeled at the same location. The Source ID is currently restricted to eight characters (or fewer) and must contain at least one alphabetic character. Do not use spaces at the beginning or in the middle of the Source ID. Do not include "-" or other typographic characters. In addition, HEM-3 cannot discriminate between upper and lowercase characters. So "ABC" and "abc" would be treated as the same Source ID. If modeling a cluster of facilities, you can use the first few characters of the Source ID to distinguish among the different facilities. For instance, the Source IDs could begin with "F1" for the first plant, "F2" for the second plant, and so on. This will help in the interpretation of model results for the facilities making up the cluster.

You can enter locations as UTM coordinates, or as latitude and longitude. Complete the "coordinate system" field for each source record, and specify which coordinates you are entering. Enter "U" for UTM or "L" for latitude/longitude. If using UTM coordinates, specify the UTM zone (in each emission source record). You must base all coordinates on the NAD83 geographic projection system. Convert any coordinates based on NAD27 to NAD83, before entering them into HEM-3. The National Geodetic Survey (NGS) has developed a computer program called NADCON to convert coordinates between the two NAD systems ([NGS 2011](#)). In addition, various commercial computer programs can perform this conversion. The difference between coordinates calculated using the 1927 and 1983 projection systems will vary from location to location, but can be as large as 100 meters.

Use the source type field to indicate whether the emission source is a point source (P), an area source (A), a volume source (V), or a polygon source (I, for upper case "i"). A stack is an example of a point (P) source, while fugitive emissions are often modeled as rectangular area (A) sources. A conveyor belt may be considered a volume (V) source. A polygon (I) can be used to represent a complex (non-rectangular) area source with many vertices. A polygon may also be used to represent an entire census tract from which a source is modeled as a uniform emission (e.g., for mobile sources).

* If modeling deposition (described further below in Sections 3.1.5, 3.1.6 and 3.2.3), and pollutant properties are known to vary, we recommend you include a separate record for each pollutant and source—that is, a unique source ID—for each pollutant being emitted from the same source. This is generally recommended for modeling of gaseous deposition and for modeling of particulate deposition if the size or density distributions are known and variable. If you are not modeling deposition of gaseous phase pollutants, and the same particulate properties are assumed for all pollutants, one record per source in the emissions location input file is sufficient.

Table 1. Format Guidelines for the Emissions Location File

Field	Type	Length, decimal places	Source types*	Description or comment
Source ID**	Character	8	all	Unique alphanumeric string up to 8 characters—no spaces or typographical symbols. Must contain a letter and match the Source ID in other input files (e.g., the HAP emissions file).
Coordinate system	Character	1	all	U = UTM, L = latitude / longitude
X-coordinate	Numeric	15,6	all	UTM easting coordinate, in meters (m) (if coordinate system = U) or decimal longitude (if coordinate system = L) of the center of point or volume sources, or the southwest corner of area sources, or the first vertex of a polygon source.
Y-coordinate	Numeric	15,6	all	UTM northing coordinate, in meters (if coordinate system = U) or decimal latitude (if coordinate system = L) of the center of point or volume sources, or the southwest corner of area sources, or the first vertex of a polygon source.
UTM zone	Numeric	2,0	all	UTM zone if coordinate system = U (blank if coordinate system = L)
Source type	Character	1	all	P = point, A = area, V = volume, I (capital i) = polygon
X-dimension	Numeric	7,0	A	Length in the easterly (or southeasterly) direction for area sources (m)
Y-dimension	Numeric	7,0	A	Length in the northerly (or northeasterly) direction for area sources (m)
Angle	Numeric	5,2	A	Angle of rotation (area sources only)
Lateral	Numeric	7,0	V	Horizontal dimension of volume source (m)
Vertical	Numeric	7,0	V, A, I	Vertical dimension of volume source (m) and optionally for area and polygon sources
Release height	Numeric	5,0	V, A, I	Release height (above ground) for area and volume sources (m) and optionally for polygon sources.
Stack height	Numeric	5,0	P	Stack release height above ground (m)
Diameter	Numeric	5,1	P	Diameter of stack for point sources (m)
Velocity	Numeric	7,2	P	Velocity at which emissions are coming from the stack (m/s) for point sources.
Temperature	Numeric	4,0	P	Temperature of emissions for point sources (°K)
Elevation	Numeric	6,0	all	Elevation of the ground above sea level at the source location (m). Use when modeling terrain effects; HEM-3 will calculate if not user-specified.

* Source types for which the parameter is needed: A = area, P = point, V = volume, I = polygon

** If you are modeling deposition, and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If you are not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

Table 2. Sample Emissions Location Input File

Source ID	Coordinate system U= UTM, L= lat/lon	X-coordinate (dec.) or UTM E (m) ^a	Y-coordinate (dec.) or UTM N (m) ^a	UTM zone	Source type P=point A=area V= volume I = polygon	X-dimen. A sources (m)	Y-dimen. A sources (m)	Angle A sources (deg)	Lateral V sources (m)	Vertical V, A or I sources, (m)	Release ht V, A, or I sources (m) ^b	<i>continued</i>
SAMPLE1	U	559966	4400652	16	P							...
SAMPLE2	U	559880	4400565	16	A	130	120	0			2	...
SAMPLE3	U	559871	4400581	16	V				20	3	10	
SAMPLE4	L	-64.611465	17.787359	0	I ^c						30	

<i>continued from above</i>	Stack height P sources (m)	Diameter P sources (m)	Velocity P sources (m/s)	Temperature P sources (°K)	Elevation (m)
...	50	2.8	21.83	322	
...					
...					
...					

^a Use the center of the source for point and volume sources and the southwest corner for area sources.

^b Use the top of the source for area and polygon sources and the vertical center for volume sources.

^c Polygon sources must have an associated polygon vertices file, which defines the shape and location of the polygon. See [Section 3.1.4](#).

If the source is a point source, such as a stack or vent, your emissions location file must also include the stack height, diameter, exit velocity, and emission release temperature.

An area source represents a rectangular area from which emissions are released at ambient temperature and with negligible velocity (e.g., fugitive emissions from a building or tank farm). In AERMOD, area sources can be at ground level, or at a height above ground level. Specifying a release height is optional and defaults to 0. The default orientation for area sources is with one axis in the north-south direction, but you can rotate these sources using the “angle” parameter, which specifies the rotation of the source from north (in the clockwise direction). This feature allows you to simulate emissions from a roadway, using a long, narrow area source. The location coordinates (UTM or latitude and longitude) you choose should reflect the southwest corner of the area source. The X-dimension should reflect the length of the source in the easterly direction, or in the southeasterly direction if the source is rotated. The Y-dimension should reflect the length in the northerly direction, or the northeasterly direction if the source is rotated.

Unlike AERMOD, where 360 degree rotation is allowed, the angle parameter for HEM-3 area sources must be between 0 and 90 degrees. You can use this angle to represent any possible orientation by switching the X- and Y-dimension (shown in [Figure 3](#)). For instance, to model a road segment running from southwest to northeast, use the Y-dimension to specify the road length, and the X-dimension to specify the road width. To model a road segment running from northwest to southeast, use the X-dimension to specify road length and the Y-dimension to specify road width.

Volume sources – such as building roof monitors, multiple vents, and conveyor belts – are specified by a horizontal / lateral dimension, a vertical dimension, and a height. Emissions from a volume source are assumed to be released at ambient temperature and with zero velocity. Both the height and the source location coordinates (UTM or latitude and longitude) should reflect the center of the source.

You can create a polygon source file to represent a polygon with 3 sides or more ($\leq 9,999$). This source type provides considerable flexibility in specifying the shape of an area source. You can use a polygon source type to reflect census tract boundaries, for example, when modeling mobile source emissions provided at the tract level. An associated polygon vertices input file is required when modeling polygon source types. [Section 3.1.4](#) discusses this in more detail. The shape of the polygon source, as defined in the polygon vertices input file, is determined by a list of X and Y coordinates representing the vertices of the polygon. You can order these X and Y coordinates in either a clockwise or counterclockwise direction. However, the first coordinates entered in the polygon vertices input file must match the coordinates entered in the emissions location file as the location of the first vertex of the polygon.

If considering terrain impacts in your modeling, you can specify the elevation above sea level for each emission source. Enter elevations for every source or for no sources (not a partial list). If you do not enter elevation data for any emission sources, then HEM-3 will estimate an elevation for the emission sources based on the elevations of nearby census blocks, unless you answer “No” to the question on Screen 1 (described in [Section 3.2.1](#)) “Do you want to include elevations in the model run?” [Note: HEM-3 will model area, volume and polygon sources as flat surfaces, which can result in strangely located (underground) impacts if the source is located, for example, on a hillside with varying elevations. To avoid this, either model with HEM-3’s default elevation option turned off on [Screen 1](#), or break-up the source into smaller pieces with uniform elevations.]

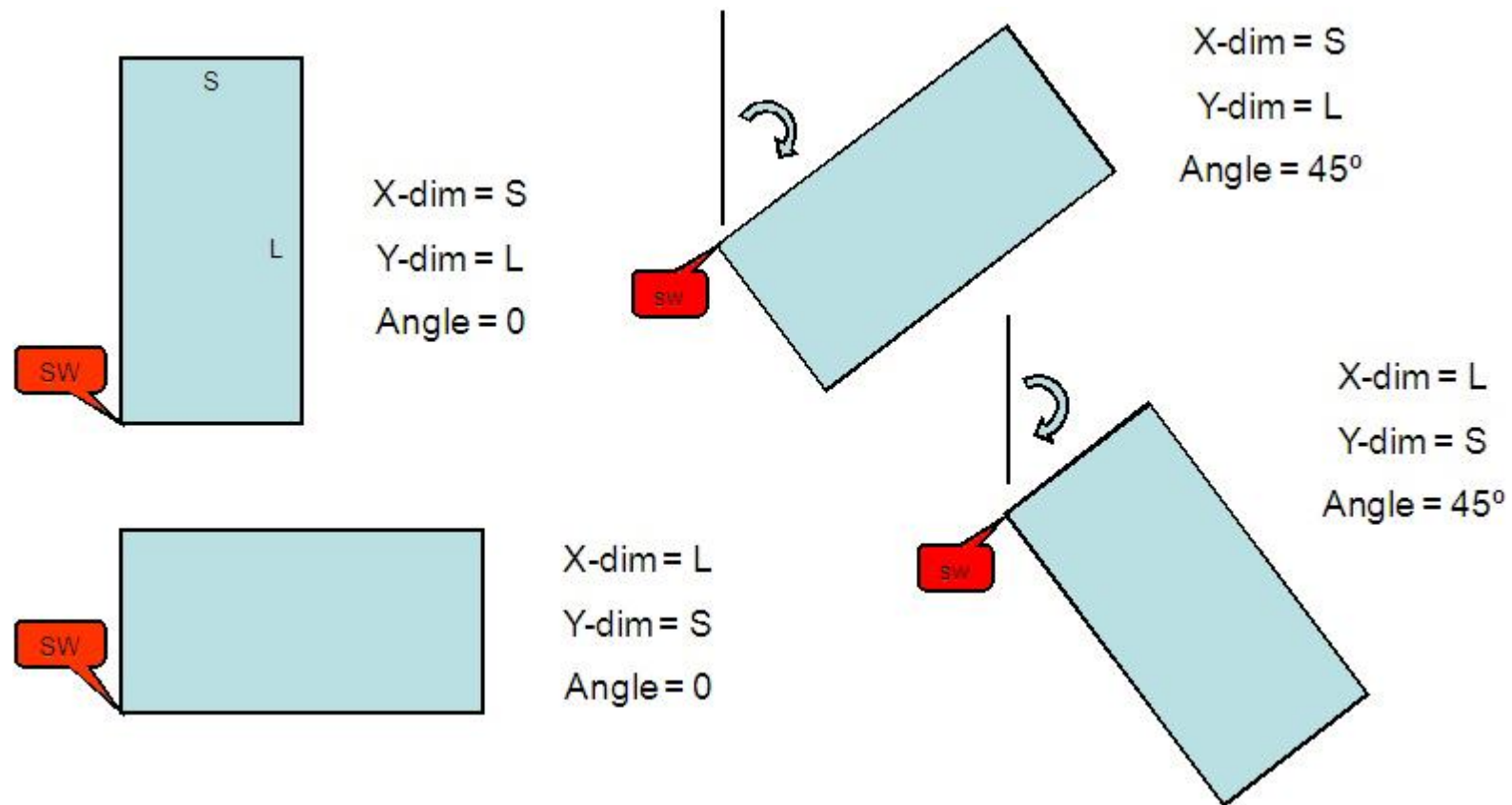


Figure 3. Example Orientations of Area Emission Sources for the HEM-3 Model

3.1.3 HAP Emissions File

Tables 3 and 4 give the [format guidelines](#) for the HAP emissions file and a [sample](#) HAP emissions input file, respectively. A template input file is provided in the HEM-3 Inputs directory ("C:\Program Files\HEM3\Inputs\Template_HAP_emission_file.xls").

Include one record for each combination of emission source and chemical in your HAP emissions file. Enter each Source ID, taking care to match each named Source ID with a corresponding Source ID in the [emissions location file](#), described in Section 3.1.2.

Each chemical you name in the HAP emissions file must match one of the chemical names listed in the dose response table located in the HEM-3 Reference directory. The dose response values are part of HEM-3's [Chemical Health Effects Library](#), described in Section 2.2. If necessary, you can add pollutants to the two Excel™ spreadsheets comprising HEM-3's Chemical Health Effects Library: the dose response table and the target organ endpoints table. [Section 3.1.11](#) explains how to make changes to the Chemical Health Effects Library.

Emissions values are expressed in tons/year. The smallest value you can model is 1E-15. If modeling deposition, or if you want separate records for particle phase and vapor phase at each location in the concentration outputs, then you must provide HEM-3 with the breakdown of emissions between vapor and particulate matter. This breakdown is expressed as the fraction emitted as particulate for each emission record (each combination of source and chemical). If you are not modeling deposition and have left this field blank, then HEM-3 will ignore the field. If you are modeling deposition and have left this field blank, then HEM-3 assumes a default value of 0% particulate.

If modeling deposition, you will need additional input files depending on the type of deposition to be modeled, as described in [Section 3.1.5](#) and [Section 3.1.6](#). If you are not modeling deposition and depletion, you will need no additional input file.

Table 3. Format Guidelines for the HAP Emissions Input File

Field	Type	Length, decimal places	Description or comment
Source ID*	Character	8	Must match Source IDs used in the emissions location file
Pollutant	Character	50	Chemical name of the emitted pollutant. Must match a pollutant name in the dose response library . ("C:\Program Files\HEM3\Reference\Dose_Response_Library.xls")
Emissions	Numeric	20,15	tons/year
Fraction emitted as particulate matter (%)	Numeric	7,3	%, optional. Required only if modeling deposition, or want particulate/gaseous % breakdown in the concentration outputs (otherwise HEM-3 ignores the field)

* If you are modeling deposition and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If you are not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

Table 4. Sample HAP Emissions Input File

Source ID	Chemical name	Emissions (tons/year)	Fraction particulate (%)
SAMPLE1	Antimony compounds	1.2E-01	100.0
SAMPLE1	Chromium (VI) compounds	3.2E-04	100.0
SAMPLE1	Mercury (elemental)	4.2E-02	50.0
SAMPLE1	Dibenzofuran	1.1E-01	90.0
SAMPLE1	Xylenes (mixed)	1.3E+00	0.0
SAMPLE1	Benz(a)anthracene	7.3E-06	11.9
SAMPLE1	Benzo(a)pyrene	2.5E-08	23.9
SAMPLE1	Benzo(b)fluoranthene	2.8E-06	17.8
SAMPLE1	Chrysene	3.2E-05	52.3
SAMPLE1	Dibenz(a,h)anthracene	3.6E-08	99.3
SAMPLE1	Indeno(1,2,3-cd)pyrene	1.1E-07	98.9
SAMPLE2	Chromium (VI) compounds	3.8E-05	100.0
SAMPLE2	Mercury (elemental)	3.6E-04	50.0
SAMPLE2	Nickel compounds	4.8E-03	100.0
SAMPLE2	Selenium compounds	2.1E-04	100.0

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3.1.4 Polygon Vertices Input File for Modeling Polygon Emission Sources

Polygons are useful for complex source configurations at a facility, and for modeling census tracts as sources (e.g., for mobile source emissions modeled uniformly across a tract). If your emissions location file includes one or more polygon sources, you will need to provide HEM-3 with the locations of the polygon vertices in the form of a polygon vertex file.

Include a separate record for each vertex of the polygon in the polygon vertex file. A polygon may have any number of vertices (≥ 3 and $\leq 9,999$). Each record must include information for one vertex of the polygon. As noted in [Section 3.1.2](#), you can order the X and Y vertex coordinates in either a clockwise or counterclockwise direction. The first and last vertex must have identical coordinates, and these coordinates must match the coordinates listed as the location of the first vertex of the polygon source in the [emissions location file](#). The first record for each polygon source must also include the number of vertices for the polygon and the total area of the polygon, in meters squared. You can enter coordinates as UTM coordinates, or using latitude and longitude. If using UTM coordinates, you must specify the UTM zone. Base all coordinates on the NAD83 reference system. Convert any coordinates based on NAD27 to NAD83, before entering them into HEM-3 (as explained in [Section 3.1.2](#)).

Tables 5 and 6 give the [format guidelines](#) for the polygon vertex file, and a [sample](#) polygon vertex input table. A template input file is provided in the HEM-3 Inputs directory ("C:\Program Files\HEM3\Inputs\Template_poly_vertex_file.xls"). In the same directory, you will find a sample polygon emissions locations file and a sample HAP emissions file, which can be run with the sample polygon vertices input file. These files are named "Template_polygon_location_file.xls" and "Template_polygon_HAP_emission_file.xls" respectively.

Table 5. Format Guidelines for the Polygon Vertex Input File

Field	Type	Length, decimal places	Description or comment
Source ID*	Character	8	An alphanumeric character string, up to 8 characters in length, which must contain a letter—no spaces. Must list Source IDs as polygon (I) source types in the emissions location input file.
Coordinate System	Character	1	Type of location coordinate: L = latitude, longitude; U = UTM.
X-coordinate	Numeric	15,6	UTM easting coordinate, in meters (if coordinate system = U) or decimal longitude (if coordinate system = L). If longitude, Recommend 5 decimal place accuracy (corresponds to 1 m accuracy).
Y-coordinate	Numeric	15,6	UTM northing coordinate, in meters (if coordinate system=U) or decimal latitude (if coordinate system = L). If latitude, recommend 5 decimal place accuracy (corresponds to 1 m accuracy).
UTM zone	Numeric	2,0	UTM zone where the source is located if coordinate system = U (blank if coordinate system = L).
Num of Vertices	Numeric	4,0	Number of vertices in the polygon (≥ 3 and $\leq 9,999$). ^{**}
Area	Numeric	15,5	Size of area within polygon, in m ² .
Census Tract ID	Character	11	Character ID, up to 11 characters, indicating the census tract, or "Fipstct" for FIPS tract, being modeled as a polygon (optional).

* If you are modeling deposition and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If you are not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

^{**} For additional information on these variables, please see the AERMOD User's Guide.

Table 6. Sample Polygon Vertex Input File

Source ID	Coordinate System	Longitude	Latitude	UTM zone	Number of Vertices	Area	FIPS of tract
SAMPLE4	L	-64.611465	17.787359	0	7	743840.02	
SAMPLE4	L	-64.614164	17.788700	0	0	0	
SAMPLE4	L	-64.623822	17.790304	0	0	0	
SAMPLE4	L	-64.628109	17.789104	0	0	0	
SAMPLE4	L	-64.626732	17.786323	0	0	0	
SAMPLE4	L	-64.622243	17.783783	0	0	0	
SAMPLE4	L	-64.611465	17.787359	0	0	0	

3.1.5 Particle Size Input File for Modeling Particulate Deposition and Depletion

AERMOD can implement dry and wet deposition of both particulate and gaseous emissions and the resulting plume depletion ([EPA 2004a](#)). This section describes the input file needed for modeling particulate deposition.

If you are modeling deposition and plume depletion of particulate emissions, you must provide HEM-3 with a separate input file describing the particle size distribution. In this file, include a separate record for each particle size range emitted by each emission source. Each record must include an average particle diameter for the size range, the percentage that the size range represents in terms of the total mass of particulate matter from the given emission source, and the average density of particles in the size range. The mass percentages must total to 100 for each emission source.

You must provide information for each of the sources listed in the [emissions location file](#) that emit particulate matter (as specified in the particulate fraction column of the [HAP emissions input file](#)). Specify particulate information separately for each source that emits particulate matter; if the particle size and deposition information is the same for all emissions at the facility, then repeat this information for each emission source. Tables 7 and 8 provide [format guidelines](#) for the particle size input file and a [sample](#) input file, respectively. A template file ("C:\Program Files\HEM3\Inputs\Template_particle_data.xls") is provided in the HEM-3 Inputs directory.

Table 7. Format Guidelines for the Particle Size Input File
(needed only for deposition and depletion modeling of particle-phase emissions)

Field	Type	Length, decimal places	Description or comment
Source ID*	Character	8	Must match a Source ID in the emissions location file.
Average particle diameter	Numeric	5,2	units = μm
Mass fraction (%)	Numeric	5,1	The percentage (by mass) of particulate matter in this size range. Must add up to 100% for each Source ID.
Average particle density	Numeric	5,2	units = g/cm^3

* If you are modeling deposition and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if you are modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If you are not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

Table 8. Sample Input File for Particle Size

Source ID	Average Particle diameter (μm)	Mass fraction (%)	Average Particle density (g/cm^3)
SAMPLE1	0.5	72	1
SAMPLE1	1.5	8	1
SAMPLE1	2.5	20	1
SAMPLE2	0.5	60	1
SAMPLE2	1.5	18	1
SAMPLE2	2.5	22	1

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3.1.6 Input Files for Modeling Gaseous Deposition and Depletion

As mentioned in Section 3.1.5, AERMOD can model dry and wet deposition of both particulate and gaseous emissions and the resulting plume depletion ([EPA 2004a](#)). This section describes the inputs required for modeling gaseous deposition. To model deposition and depletion of gaseous-phase pollutants, you must provide HEM-3 with the necessary information to evaluate the scavenging of these pollutants in precipitation and deposition on vegetation and other surfaces.

When modeling wet, dry, or both wet and dry deposition of gaseous emissions and the resulting plume depletion, HEM-3 accesses a gas parameter file, which is included in the model's installation files. The model reads pollutant properties related to gaseous deposition from the "Gas_Param.dbf" file in HEM-3's Reference directory. (The default file pathway is "C:\Program Files\HEM3\Reference\Gas_Param".) This file includes the following four parameters for each pollutant:

- diffusion coefficient in air (D_a , in cm^2/sec)
- diffusion coefficient in water (D_w , in cm^2/sec)
- cuticular resistance to uptake by lipids for individual leaves (r_{cl} , in sec/m)
- Henry's Law coefficient (H , in $\text{Pascal}\cdot\text{m}^3/\text{mol}$)

Data are provided for 123 pollutants, based on a study by Argonne National Laboratories ([Wesely 2002](#)). You can calculate parameters for additional pollutants and add these to the Gas_Param.dbf file, or revise the values in the Gas_Param file, as appropriate. If modeling a gaseous pollutant that is not listed in the Gas_Param file, HEM-3 will use the following default parameters:

$D_a = 0.07 \text{ cm}^2/\text{sec}$, $D_w = 0.7 \text{ cm}^2/\text{sec}$, $r_{cl} = 2,000 \text{ sec}/\text{m}$, $H = 5.0 \text{ Pascal}\cdot\text{m}^3/\text{mol}$.

To quantify dry deposition of gaseous pollutants to vegetation, AERMOD also requires information on the land use and vegetation surrounding the emission source. You must provide this information in Excel™ spreadsheets. In the land use input file, you will enter a code characterizing the average land use for 36 directions from the emission source, at increments of 10 degrees (compass bearing). Table 9 gives the [format guidelines](#) for the land use file, and

Table 10 shows a [sample](#) land use file. A template land use file is provided (“C:\Program Files\HEM3\Inputs\Template_landuse.xls”) in the HEM-3 Inputs directory.

The month-to-season input file provides further information on the typical stage of vegetation in the modeled region during each month of the year. As the [format guidelines](#) in Table 11 show, this file associates each month with a season code. Table 12 shows a [sample](#) input table for the month-to-season file. A template input file is also provided in the HEM-3 Inputs directory (“C:\Program Files\HEM3\Inputs\Template_season.xls”).

The land use and month-to-season input files are required only if you choose to model dry deposition of gaseous pollutants and the resulting plume depletion. These files are not required for modeling of wet deposition of gaseous emissions, nor are they required for modeling of wet or dry deposition of particulate emissions.

Table 9. Format Guidelines for Land Use File
(needed only for dry deposition and depletion modeling of gaseous-phase emissions)

Field	Type	Length, decimal places	Description or comment
Direction Sector 1	Numeric	1,0	Land use code for the modeling domain at a compass bearing of 10 degrees from the emission release point: <ul style="list-style-type: none"> 1 Urban land, no vegetation 2 Agricultural land 3 Rangeland 4 Forest 5 Suburban areas, grassy 6 Suburban areas, forested 7 Bodies of water 8 Barren land, mostly desert 9 Non-forested wetlands
Direction Sector n (n = 2 thru 35)	Numeric	1,0	Land use code at a bearing of n × 10
Direction Sector 36	Numeric	1,0	Land use code at a bearing of 360 degrees

Table 10. Sample Land Use File

D01 (10°)	D02 (20°)	D03 (30°)	D04 (40°)	D05 (50°)	...	D36 (360°)
1	1	5	5	6	...	1

Table 11. Format Guidelines for the Month-to-Season Assignment File**(needed only for dry deposition and depletion modeling of gaseous-phase emissions)**

Field	Type	Length, decimal places	Description or comment
Month 1	Numeric	1,0	Season code for January (month 1): 1 Midsummer with lush vegetation 2 Autumn with unharvested crop land 3 Late autumn after frost and harvest, or with no snow 4 Winter with snow on ground 5 Transitional spring with partial green coverage or short annuals
Month n (n=2 thru 11)	Numeric	1,0	Season codes for February through November (months 2 through 11); see above list, 1 to 5
Month 12	Numeric	1,0	Season code for December (month 12); see above list, 1 to 5

Table 12. Sample Month-to-Season Assignment File

Jan	Feb	March	April	May	...	Dec
4	4	5	5	1	...	3

3.1.7 Input File for Modeling Building Downwash

Under AERMOD's regulatory option, the effects of building downwash should be taken into account when a building is close enough to impact dispersion from an emission source. Building downwash will affect dispersion predictions when:

- the stack height is less than either 2.5 times the building height or the sum of the building height and 1.5 times the building width; and
- the distance between the stack and the nearest part of the building is less than or equal to five times the lesser of the height or the projected width of the building ([EPA 1995](#), pg. 1-22 and 1-23).

AERMOD incorporates the Plume Rise Model Enhancements (PRIME) algorithms ([Schulman 2000](#)) for estimating enhanced plume growth and restricted plume rise for plumes affected by building wakes ([EPA 2004b](#)). A building may impact emissions from multiple sources. To model the impact of building downwash, HEM-3 requires information on the configuration of the building when viewed from different wind directions. The following parameters are required:

- height (keyword=BUILDHGT)
- projected width perpendicular to the direction of flow (keyword=BUILDWID)
- length in the direction of flow (keyword=BUILDLEN)
- distance from the stack to the center of the upwind face of the building parallel to the direction of flow (keyword=XBADJ)
- distance from the stack to the center of the upwind face of the building perpendicular to the direction of flow (keyword=YBADJ)

You must provide these parameters for 36 wind directions, at increments of 10 degrees (compass bearing). Calculate these parameters using the EPA's Building Profile Input Program (BPIP). You can download the BPIP model code and documentation from the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website at http://www.epa.gov/ttn/scram/dispersion_related.htm.

Enter building dimensions using the building downwash input file, which can be either an Excel™ file or a text file. Table 13 gives the [format guidelines](#) for the Excel™ building downwash input file, and Table 14 shows a [sample](#) Excel™ building downwash file. A template building downwash file ("C:\Program Files\HEM3\Inputs\Template_bldg_dimensions.xls") is provided in the HEM-3 Inputs directory.

Table 15 gives format guidelines for a building downwash file in [text format](#), which is modeled on a BPIP output file. The main difference in the file formats is that the spreadsheet uses a single record to list the 36 directional values for each parameter, while the text file uses six records for each parameter, with six directions per record. Table 16 shows a sample building downwash [text file](#). The text file can be taken from a BPIP output, or extracted from an existing AERMOD input file. If extracting the building input from an AERMOD input file, remove any lines not related to the building parameters.

Table 13. Format Guidelines for the Building Downwash File – Spreadsheet Option

Field	Type	Length, decimal places	Description or comment
Keyword	Character	8	Specifies which values are given in this record (8 characters maximum), as follows: BUILDHGT = building height BUILDWID = projected width perpendicular to the direction of flow BUILDLEN = length in the direction of flow XBADJ = along-flow distance from the stack to the upwind face of the building YBADJ = across-flow distance from the stack to the upwind face of the building
Source ID*	Character	8	Must match Source IDs used in the emissions location file
Value 1	Numeric	6,2	Dimension or distance (depending on the Keyword parameter) viewed from a compass bearing of 10 degrees from north (clockwise direction) of the emission release point
Value 2	Numeric	6,2	Dimension or distance at a bearing of 20 degrees
Value n (n = 3 thru 35)	Numeric	6,2	Dimension or distance at a bearing of n x 10
Value 36	Numeric	6,2	Dimension or distance at a bearing of 360 degrees

* If you are not modeling deposition and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

Table 14. Sample Input File for Building Downwash – Spreadsheet Option

Keyword	Source ID	Value 1 (10°)	Value 2 (20°)	Value 3 (30°)	...	Value 36 (360°)
BUILDHGT	SAMPLE1	16.8	16.8	16.8	...	16.8
BUILDWID	SAMPLE1	107.2	111.1	108.7	...	100.0
BUILDLEN	SAMPLE1	66.6	81.2	93.3	...	50.0
XBADJ	SAMPLE1	50.8	53.2	57.7	...	50.0
YBADJ	SAMPLE1	8.9	17.1	25.0	...	0.0

Table 15. Format Guidelines for the Building Downwash File – Text Option

Field	Type	Length	Description or comment
Pathway	Character	2	“SO” – This represents a source pathway record, which corresponds to the code used in the AERMOD and ISCST3 input files and the BPIP output file.
Keyword	Character	8	Specifies which values are given in this record (8 characters maximum), as follows: BUILDHGT = building height BUILDWID = projected width perpendicular to the direction of flow BUILDLEN = length in the direction of flow XBADJ = along-flow distance from the stack to the upwind face of the building YBADJ = across-flow distance from the stack to the upwind face of the building 6 records are needed for each keyword.
Source ID	Character	8	Must match Source IDs used in the emissions location file.
Values, 6 per record	Numeric	any length separated by at least one space	Dimension or distance (depending on the Keyword parameter) for every 10 degrees of compass bearing, beginning at a bearing of 10 degrees from the emission release point. Values for bearings of 10 through 60 degrees are given on the first record, 70 through 120 degrees on the second record, and so on through the 6 th record.

Table 16. Sample Input File for Building Downwash – Text Option

Path-way	Keyword	Source ID	Value 1	Value 2	Value 3	Value 4	Value 5	Value 6
SO	BUILDHGT	SAMPLE1	Value at 10°	Value at 20°	Value at 30°	Value at 40°	Value at 50°	Value at 60°
SO	BUILDHGT	SAMPLE1	Value at 70°	Value at 80°	Value at 90°	Value at 100°	Value at 110°	Value at 120°
SO	BUILDHGT	SAMPLE1	Value at 130°	Value at 140°	Value at 150°	Value at 160°	Value at 170°	Value at 180°
SO	BUILDHGT	SAMPLE1	Value at 190°	Value at 200°	Value at 210°	Value at 220°	Value at 230°	Value at 240°
SO	BUILDHGT	SAMPLE1	Value at 250°	Value at 260°	Value at 270°	Value at 280°	Value at 290°	Value at 300°
SO	BUILDHGT	SAMPLE1	Value at 310°	Value at 320°	Value at 330°	Value at 340°	Value at 350°	Value at 360°
SO	BUILDWID	SAMPLE1	Value at 10°	Value at 20°	Value at 30°	Value at 40°	Value at 50°	Value at 60°
5 additional BUILDWID records, up to and including value at 360°								
SO	BUILDLEN	SAMPLE1	Value at 10°	Value at 20°	Value at 30°	Value at 40°	Value at 50°	Value at 60°
5 additional BUILDLEN records, up to and including value at 360°								
SO	XBADJ	SAMPLE1	Value at 10°	Value at 20°	Value at 30°	Value at 40°	Value at 50°	Value at 60°
5 additional XBADJ records, up to and including value at 360°								
SO	YBADJ	SAMPLE1	Value at 10°	Value at 20°	Value at 30°	Value at 40°	Value at 50°	Value at 60°
5 additional YBADJ records, up to and including value at 360°								

3.1.8 User-Defined Receptors File

HEM-3 will automatically calculate ambient concentrations and resultant cancer risks and non-cancer hazard indices for all census blocks within the defined modeling domain. You can also specify additional receptor sites to model, such as schools, ambient monitors, residential areas other than the census block's centroid, or facility boundaries. Specify the locations of these sites in the user-defined receptors input file. Use a separate record to indicate the location of each user-defined receptor.

As noted in [Section 3.1.2](#), you must enter locations of each user-defined receptor using UTM coordinates, or in latitude and longitude. If using UTM coordinates, you must specify the UTM zone. Base all coordinates on the NAD83 reference system. Convert any coordinates based on NAD27 to NAD83, before entering them into HEM-3 (as explained in [Section 3.1.2](#)).

If you are including elevations in your model run (i.e., if you answer “yes” to “Do you want to include elevations in model run?” on input screen 1, described in [Section 3.2.1](#)), you can enter the elevation above sea level for each user-defined receptor. If you leave this field blank in the user-defined receptors input file (and answer “yes” to the elevation question), then HEM-3 will calculate an elevation for each user-defined receptor based on the surrounding census block elevations. Note: If you include more than one user-defined receptor for your facility, you should enter an elevation for all of the receptors, or leave the elevation field blank for all of the receptors to allow HEM-3 to calculate the elevations. (Otherwise, if you enter an elevation for some but not all user-defined receptors, HEM-3 will assign a 0 value to the receptors you left blank.)

In addition, HEM-3 will calculate the controlling hill height for each receptor you enter in the user-defined receptors file. AERMOD uses the controlling hill height for flow calculations. Controlling hill height is defined as the highest elevation that is above a 10% grade from the receptor.

You must specify a “receptor type code” indicating the type of receptor. A code of “P” represents populated sites, “B” represents facility boundary sites, and “M” represents ambient monitors. Use “P” for any receptor that is being used to represent a location where people may be impacted. These receptors can include houses, schools, businesses, or other populated locations.

Tables 17 and 18 give [format guidelines](#) for the user-defined receptors file and a [sample](#) user-defined receptors table, respectively. A template input file (“C:\Program Files\HEM3\Inputs\Template_user _receptors.xls”) is provided in the HEM-3 Inputs directory.

Table 17. Format Guidelines for the User–Defined Receptors File

Field	Type	Length, decimal places	Description or comment
Coordinate system	Character	1	U = UTM, L = latitude / longitude
X-coordinate	Numeric	15,6	UTM easting coordinate, in meters (if coordinate system = U) or decimal longitude (if coordinate system = L) of the receptor
Y-coordinate	Numeric	15,6	UTM northing coordinate, in meters (if coordinate system = U) or decimal latitude (if coordinate system = L) of the receptor
UTM zone	Numeric	2,0	UTM zone where the source is located if coordinate system = U (blank if coordinate system = L)
Elevation	Numeric	6,0	Optional, elevation of receptor above sea level (meters). If not provided and modeling terrain effects, HEM-3 calculates based on nearby census blocks.
Receptor type code	Character	1	P = school, house, or other populated site; B = facility boundary; M = monitor

Table 18. Sample Input File for User–Defined Receptors

Location type	Longitude or UTM east (m)	Latitude or UTM north (m)	UTM zone	Elevation (m)	Type of receptor
U	560000	441010	16	244	P
U	560005	441000	16	244	M

3.1.9 Input Files for Modeling Temporal and Wind Speed Variations in Emissions

AERMOD computes hourly concentration data based on user-provided emission inputs. AERMOD also gives you the option of specifying variable emission rate factors for individual sources. You can base these factors on different temporal scales—such as season, month, day of the week, and hour of day—or on wind speed. For HEM-3 to calculate temporal or wind speed emission variations, AERMOD requires information on the type of variation and the factors to use for each variation. You will supply this information in a Temporal Variation Input file in the form of an Excel™ spreadsheet. The types of variations are:

- SEASON – emission rates vary seasonally (Winter = Dec., Jan., Feb.; Spring = Mar., Apr., May); Summer = Jun., Jul., Aug.; Fall = Sep., Oct., Nov.); number of factors is 4;
- MONTH – emission rates vary monthly, number of factors is 12;
- HROFDY – emission rates vary by hour of the day, number of factors is 24;
- SEASHR – emission rates vary by season (4) and hour of day (24); number of factors is 96;
- SHRDOW – emission rates vary by season (4), hour of day (24), and type of day of week (weekday, Sat, Sun) (3), number factors is 288;
- SHRDOW7 – emission rates vary by season (4), hour of day (24), and days of the week (7), number of factors is 672; and
- WSPEED – emission rates vary by wind speed (user-defined or default upper bounds in m/s of 1.54, 3.09, 5.14, 8.23, 10.8 and no upper bound), number of factors is 6.

Table 19 provides the [format guidelines](#) for the temporal variation input file. Tables 20, 21, 22, and 23 provide [sample](#) temporal variation input files for seasonal emission variations (4 factors), hour of day emission variations (24 factors), monthly emission variations (24 factors), and both season and hour of day emission variations (96 factors), respectively. Template input files are also provided (e.g., “C:\Program Files\HEM3\Inputs\Template_temporal_month.xls”) in the HEM-3 Inputs directory.

Table 24 provides a sample input file for emission variations by [wind speed](#). A template input file (“C:\Program Files\HEM3\Inputs\Template_temporal_wspspeed.xls”) is provided in the HEM-3 Inputs directory. See the AERMOD User’s Guide ([EPA 2004a](#)) for more detailed information on the full list of temporal factors available for varying emissions.

Table 19. Format Guidelines for the Temporal Variation Input Files

Field	Type	Length	Description or comment
Source ID*	Character	8	Source ID is a unique alphanumeric character string up to 8 characters long. Must contain at least one letter—no spaces. Must match Source IDs used in the emissions location file.
Variation	Character	8	Type of variable emission rates being used (HROFDY, SEASON, MONTH, SEASHR, SHRDOW OR SHRDOW7, WSPEED).**
Factor 1	Character	8	First factor to be applied to emission rate (e.g., Winter factor when Variation = SEASON, January factor when Variation = MONTH, Hour 1 factor when Variation = HROFDY, etc.).
Factor 2	Character	8	Second factor to be applied to emission rate.
Factor 3	Character	8	Third factor to be applied to emission rate.
Factor 4	Character	8	Fourth factor to be applied to emission rate.
Factor 5	Character	8	Fifth factor to be applied to emission rate.
...
Factor n**	Character	8	n th factor to be applied to emission rate.

* If you are modeling deposition and pollutant properties are known to vary, we recommend a separate record for each pollutant and source. Thus, if modeling gaseous deposition, use a unique Source ID for each pollutant emitted from a given source (e.g., SAMPLE3A for benzene, SAMPLE3B for 1,3-butadiene). The same is true for particulate deposition if the particulate properties (size and density distributions) are known and vary for pollutants. If not modeling gaseous deposition and the same properties are assumed for all particulates emitted from a source, one Source ID per emission source is sufficient (e.g., SAMPLE3 for all modeled pollutants from the same source).

** Each emission type has a set number of factors, specific to each type. The number (n) of factors for each type of variable emission rate are: SEASON=4, MONTH=12, HROFDY=24, SEASHR=96, SHRDOW=288, SHRDOW7=672, WSPEED=6. The AERMOD User's Guide ([EPA 2004a](#)) provides additional information on these variables.

Table 20. Sample Input File for Temporal Variations by Season (4 factors)

Source ID	Variation	Winter	Spring	Summer	Fall
SAMPLE1	SEASON	0.50	0.50	1.00	0.75

Table 21. Sample Input File for Temporal Variations by Hour of Day (24 factors)

Source ID	Variation	1	2	3	4	5	6	...	12
SAMPLE1	HROFDY	0.0	0.0	0.0	0.0	0.0	0.5	...	1.0
		13	14	15	16	17	18	...	24
SAMPLE1	HROFDY	1.0	1.0	1.0	1.0	1.0	0.5	...	0.0

Table 22. Sample Input File for Temporal Variations by Month (12 factors)

Source ID	Variation	JAN	FEB	MAR	APR	MAY	JUN	...	DEC
SAMPLE1	MONTH	0.1	0.2	0.3	0.4	0.5	0.5	...	1.0

Table 23. Sample Input File for Temporal Variations by Season and Hour of Day (96 factors)

Source ID	Variation	Winter 1	Winter 2	Winter 3	Winter 4	Winter 5	Winter 6	...	Winter 12
SAMPLE1	SEASHR	0.00	0.00	0.00	0.00	0.00	0.20	...	0.50
		Winter 13	Winter 14	Winter 15	Winter 16	Winter 17	Winter 18	...	Winter 24
SAMPLE1	SEASHR	0.50	0.50	0.50	0.60	0.60	0.60	...	0.00
		Spring 1	Spring 2	Spring 3	Spring 4	Spring 5	Spring 6	...	Spring 12
SAMPLE1	SEASHR	0.00	0.00	0.00	0.00	0.30	0.40	...	0.75
		Spring 13	Spring 14	Spring 15	Spring 16	Spring 17	Spring 18	...	Spring 24
SAMPLE1	SEASHR	0.75	1.00	1.00	1.00	1.00	1.00	...	0.00
...
		Fall 13	Fall 14	Fall 15	Fall 16	Fall 17	Fall 18	...	Fall 24
SAMPLE1	SEASHR	0.75	1.00	1.00	1.00	1.00	1.00	...	0.00

Table 24. Sample Input File for Temporal Variations by Wind Speed Category (6 factors)

Source ID	Variation	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5	Cat. 6
SAMPLE1	WSPEED	0.5	0.6	0.7	0.8	0.9	1.0

3.1.10 User-Provided Modeled or Monitored Pollutant Concentration Input File

Most applications of HEM-3 use emission source information to compute ambient pollutant concentration impacts using AERMOD. Alternatively, you can provide pollutant concentrations from an external model (previously run AERMOD, ISCST3, or other model). You can also provide pollutant concentrations obtained from monitoring data. However, if you do provide HEM-3 with previously modeled or monitored concentration data, HEM-3 cannot compute the contributions of different emission sources (see discussion in [Section 5 Outputs of HEM-3](#)).

You can provide pollutant concentrations for an array of monitored or modeled locations. HEM-3 uses a Voronoi Neighborhood Averaging approach to interpolate pollutant concentrations and associated risks for all census blocks located within the study domain. [Section 4.4](#) discusses the Voronoi averaging approach in more detail. This approach is intended to be used with monitoring data or gridded modeling data for a large collection of emission sources. It is not intended to be used with modeling data produced with a polar coordinate system for a single facility. In that situation, you should run HEM-3 in the standard way. [Forcing polar array data into the Voronoi averaging system will cause a loss of data integrity regarding the spatial relationship between the emission source(s) and the receptors.]

Table 25 gives [format guidelines](#) for the user-supplied pollutant concentration file, and Table 26 shows a [sample](#) user-supplied pollutant concentration input file. A template input file is provided ("C:\ProgramFiles\HEM3\Inputs\Template_user_concentrations.xls") in the HEM-3 Inputs directory. Use this format for rectilinear grids or for arbitrary locations of input concentration data. You will need one record for each combination of pollutant and location.

The first column of the input file specifies the coordinate system used: latitude and longitude ("L") or UTM ("U"). If you select UTM coordinates, you must specify the UTM zone. Base all coordinates on the NAD83 reference system. Convert any coordinates based on NAD27 to NAD83, before entering them into HEM-3 (as explained in [Section 3.1.2](#)).

In the second column, you must assign a unique numerical identifier for each separate location for which you are providing concentration data. Next, specify the coordinates of the pollutant concentration locations in columns 3 and 4. Enter the UTM zone in column 5 (if you selected UTM coordinates in column 1, otherwise leave blank). Enter the pollutant name in column 6. This name must match a pollutant name in the [dose response library](#) in HEM-3's Reference directory.

To model multiple pollutants in a single run, you must provide a concentration for all of the modeled pollutants at all of the modeled or monitored locations. When modeling multiple pollutants, use the same location ID in all of the pollutant records for a given location. The final two columns of the input file include the annual average pollutant concentration, and the optional maximum short-term (generally hourly) concentration. If you are not modeling short-term (acute) impacts, leave the last column blank.

Table 25. Format Guidelines for User-Provided Pollutant Concentration Data

Field	Type	Length, decimals	Description or comment
Coordinate system	Character	1	U = UTM, L = latitude / longitude
Location ID	Numeric	4	Unique numeric identifier for the receptor location. These will generally start with 1, and continue up to the number of receptors for which data are provided. If multiple pollutants are included in the file, use the same ID for all pollutants entered for a given receptor.
X-coordinate	Numeric	15,6	The receptor's UTM easting coordinate, in meters (if coordinate system = U) or decimal longitude (if coordinate system = L).
Y-coordinate	Numeric	15,6	The receptor's UTM northing coordinate, in meters (if coordinate system = U) or decimal latitude (if coordinate system = L).
UTM zone	Number	2	Used only when coordinates are provided in UTM (Coordinate system = U).
Pollutant	Character	50	Chemical name of the emitted pollutant. Must match a pollutant name in the dose response library ("C:\ProgramFiles\HEM3\Reference\Dose_Response_Library.xls" file).
Chronic	Number	15,10	Annual average pollutant concentration ($\mu\text{g}/\text{m}^3$).
Acute*	Number	15,10	Short-term maximum (generally hourly) pollutant concentration ($\mu\text{g}/\text{m}^3$); optional, required only if modeling acute impacts in addition to chronic impacts.

Table 26. Sample Input File for User-Provided Pollutant Concentration Data

Location type	Receptor ID	Longitude or UTM east (m)	Latitude or UTM north (m)	UTM zone	Pollutant	Annual average concentration ($\mu\text{g}/\text{m}^3$)	Max. hourly concentration* ($\mu\text{g}/\text{m}^3$)
U	1	560000	4401000	16	Benzene	5.3	53
-	-	-	-	-	-	-	-
U	16	563000	4404000	16	Benzene	3.1	33
U	1	560000	4401000	16	Toluene	8.4	110
U	2	561000	4401000	16	Toluene	9.1	104
-	-	-	-	-	-	-	-

*Optional; required only if modeling acute impacts in addition to chronic impacts.

3.1.11 Changing the Chemical Unit Risk Estimates and Health Benchmarks Input Files

As discussed in Section 2.2.1, the Chemical Health Effects Library contains [chemical health effects data](#), including dose response toxicity values. You can make changes to the Chemical Health Effects Library by editing the Excel™ spreadsheet files that comprise the library—entitled “Dose_Response_library.xls” and “Target_organs_endpoints.xls”. These files are located in HEM-3’s Reference directory. Add new chemicals to these files, as necessary, by checking for updated toxicity values on EPA’s Dose Response Assessment webpage ([EPA 2014](#)).

When adding new chemical names to the library, use the same spelling as used in the [HAP emissions input file](#). The Chemical Abstracts Service (CAS) number field in the Chemical Health Effects Library is optional. If you do not specify a cancer URE for a new chemical, then the URE will be assumed to be 0 (zero) and cancer risks will not be evaluated for that chemical. Similarly, if you do not specify a non-cancer RfC for a new chemical, HEM-3 will not calculate adverse non-cancer health effects. If a non-cancer RfC is indicated in the dose response table for a user-added pollutant, enter the pollutant in the target organ endpoints table and indicate what organs or organ systems may be impacted.

Make any changes to the Chemical Health Effects Library prior to running HEM-3 via the user interface screens (described next in Section 3.2).

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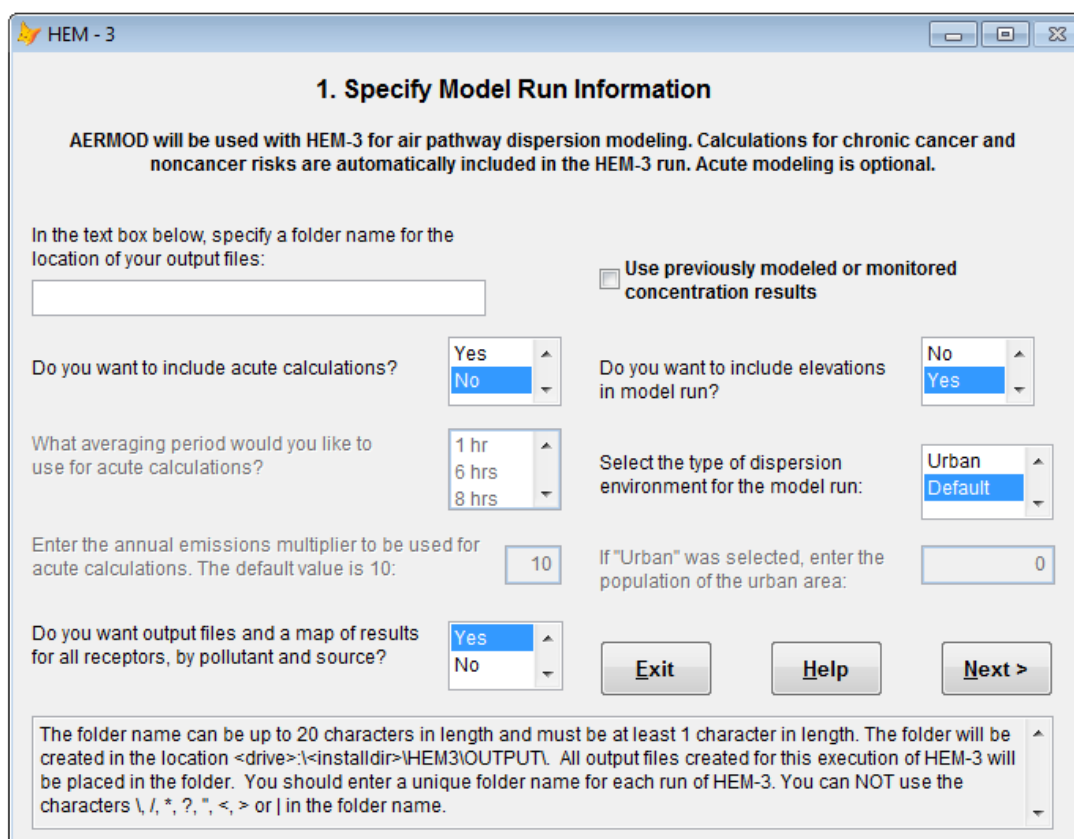
3.2 Step-by-Step Instructions for Running HEM-3

After you have prepared the input files for the modeling application, start HEM-3 by double clicking on the HEM-3 icon on your desktop (if you created the icon) or clicking on the *HEM3.exe* file in Windows Explorer™. Following the title screen, the model will display a series of input screens that require you to select modeling options and to provide additional input data, depending on the modeling options selected. These model options and selections are discussed below. If necessary, refer to [Section 3.1](#) for descriptions of the requested input files while proceeding through these screens.

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3.2.1 Specify Model Run Information (Screen 1)

On Screen 1 (**1. Specify Model Run Information**), shown below in Figure 4, enter general information about your run, including whether HEM-3 will be computing pollutant concentrations using AERMOD or whether you will provide concentration data and locations (based on previously modeled concentration results or monitoring data). In most applications of HEM-3, ambient pollutant impacts will be computed within the model using AERMOD. Therefore, the instructions in this section describe how to initiate a HEM-3 run using AERMOD to calculate concentrations. Alternatively, to provide external data, click on the box on Screen 1 labeled “use previously modeled or monitored concentration results” (no other inputs on Screen 1 are necessary for this option), and then skip ahead to [Section 3.5](#) for further instructions.



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1. Specify Model Run Information

AERMOD will be used with HEM-3 for air pathway dispersion modeling. Calculations for chronic cancer and noncancer risks are automatically included in the HEM-3 run. Acute modeling is optional.

In the text box below, specify a folder name for the location of your output files:

☐ Use previously modeled or monitored concentration results

Do you want to include acute calculations? Yes No

Do you want to include elevations in model run? No Yes

What averaging period would you like to use for acute calculations? 1 hr 6 hrs 8 hrs

Select the type of dispersion environment for the model run: Urban Default

Enter the annual emissions multiplier to be used for acute calculations. The default value is 10: 10

If "Urban" was selected, enter the population of the urban area: 0

Do you want output files and a map of results for all receptors, by pollutant and source? Yes No

Exit Help Next >

The folder name can be up to 20 characters in length and must be at least 1 character in length. The folder will be created in the location <drive>:\<installdir>\HEM3\OUTPUT. All output files created for this execution of HEM-3 will be placed in the folder. You should enter a unique folder name for each run of HEM-3. You can NOT use the characters \, /, *, ?, ", <, > or | in the folder name.

Figure 4. Screen 1 - Specify Model Run Information

First, specify a folder name for your HEM-3 output files. You can use HEM-3 to estimate *chronic* health risks and, optionally, *acute* health risks. Chronic health risks are estimated based on long-term average concentrations, as predicted by AERMOD. The time frame of this average is determined by the number of years covered by the meteorological data file selected for the model run; generally one year when running AERMOD.

Select "Yes" or "No" to indicate whether you want to include acute calculations based on the maximum short term ambient concentrations predicted by AERMOD. If you select "Yes", next select one of four options for the time frame of the short-term average: 1-hour, 6-hour, 8-hour, and 24-hour. Generally, the 1-hour averaging period is used for modeling of acute impacts. Then specify the multiplier for acute calculations, which accounts for the high end of the short-term variations in emissions. Use the HEM-3 default or provide a multiplier in the appropriate box. The default multiplier is 10, meaning that the maximum hourly emissions could be 10 times the average emission rate entered in the HAP emissions input file (as well as any temporal variation factors applied on Screen 6, as described further in [Section 3.2.6](#)). HEM-3 assumes that this maximum emission rate can occur at the same time as the worst-case meteorological condition; therefore, the acute results produced using an emission multiplier can be viewed as conservative estimates.

If you want HEM-3 to produce detailed output files, in addition to the summary output files that it produces automatically, specify "Yes" to the all receptors question on Screen 1. These detailed output files include concentration, risk and HI results for *all receptors* by pollutant and emission source, as well as a Google Earth™ map of these results. Producing these output files requires

additional computer storage space and modeling run time compared to producing the summary output files. The summary output files include risk and HI for each receptor, as well as the contribution of each pollutant and emission source to the receptor experiencing maximum impact. The summary output files, however, do not include concentration, risk and HI results by pollutant and source for all receptors. (See [Section 5](#) for a more detailed discussion of HEM-3's output files.)

Note: If you are modeling deposition and depletion (as discussed on [Screen 3](#) below), the summary output files take into account plume depletion as a result of the modeled deposition, but do not include an output file showing the deposition flux (other than aermod.out). Deposition flux (in g/m²/y) is displayed in the all receptors output file. Therefore, select "Yes" in response to the all receptors question on this screen if you want deposition flux values in the outputs.

Next, select "Yes" or "No" to indicate whether you want to include the impacts of terrain elevations in your modeling run. Elevated terrain around the facility can cause local impacts to increase, though impacts will differ for each set of sources and elevations. Select "Yes" for the elevation option if the height of receptors around the facility may exceed the height of any stacks at the facility. Consult the EPA's *Guideline on Air Quality Models* (also published as Appendix W of 40 CFR Part 51) ([EPA 2005](#)) for more explicit directions on when the use of terrain elevations is recommended. The guideline is available at <http://www.epa.gov/scram001/dispersionindex.htm>.

If you choose to include elevations in the model run, you can provide elevations for each source in the [emissions location file](#). If you do not provide elevations, HEM-3 will calculate source elevations from neighboring census block elevations.

Select "Urban", "Rural" or "Default" to specify whether HEM-3 uses *urban* or *rural* dispersion coefficients for the model run. The EPA provides guidance on whether to select urban or rural dispersion coefficients in its [Guideline on Air Quality Models](#). In general, use the urban option if (1) the land use is classified as urban for more than 50% of the land within a 3-kilometer radius of the emission source, or (2) the population density within a 3-kilometer radius is greater than 750 people per square kilometer. Of these two criteria, the land use criterion is more definitive.

If you choose the urban dispersion environment for the model run, you must specify the population of the urban area surrounding the facility. If you do not know the population of the urban area, or whether the area is rural or urban, select the "Default" option. If you select the default option and also choose the 2010 Census (on the next input Screen 2 discussed below in [Section 3.2.2](#)), HEM-3 will find the nearest census block to the facility center and determine whether that census block is in an urban area, as designated by the 2010 Census ([FR 77:59](#)). The population of the designated urban area will be used to specify the population input for AERMOD's urban mode. If you choose to use the 2000 Census (on the next Input Screen 2), the model defaults to a rural dispersion environment unless you select "Urban" and supply an urban population.

After completing this and every screen, click "Next" to go to the next input screen.

[Note: If you selected "use previously modeled or monitored concentration results" on Screen 1 as noted above, an [alternate Screen 2](#) appears after clicking "Next", rather than the Screen 2 described below in [Section 3.2.2](#). In this case, skip ahead to [Section 3.5](#) which provides instructions for using the alternate screen 2 for previously modeled or monitored concentrations.]

3.2.2 Specify Census and Emissions Inputs (Screen 2)

On Screen 2 (**2. Specify Census and Emissions Input Files**), shown below in Figure 5, select “2000” or “2010” to indicate the census year you are using to model the facility or facilities of interest. Use only Census 2000 or only Census 2010 for all census files, including the census key file and any census state files needed for the modeling run (as described in [Section 2.3 Downloading Census Data](#)). Do not combine Census 2000 and Census 2010 files in the same modeling run. [Note: If you choose the 2000 Census and chose a default dispersion environment on [Screen 1](#), the model will default to a rural dispersion environment. If you choose the 2010 Census and a default dispersion environment on [Screen 1](#), the model will select an urban or rural environment based on whether the nearest census block to the facility is in an urban area.]

Next, enter the names and paths for the [HAP emissions](#) and [emissions location](#) files for the modeling run. If there are polygon sources in your emissions location file, enter the name and path for the [polygon vertices file](#), otherwise leave blank.

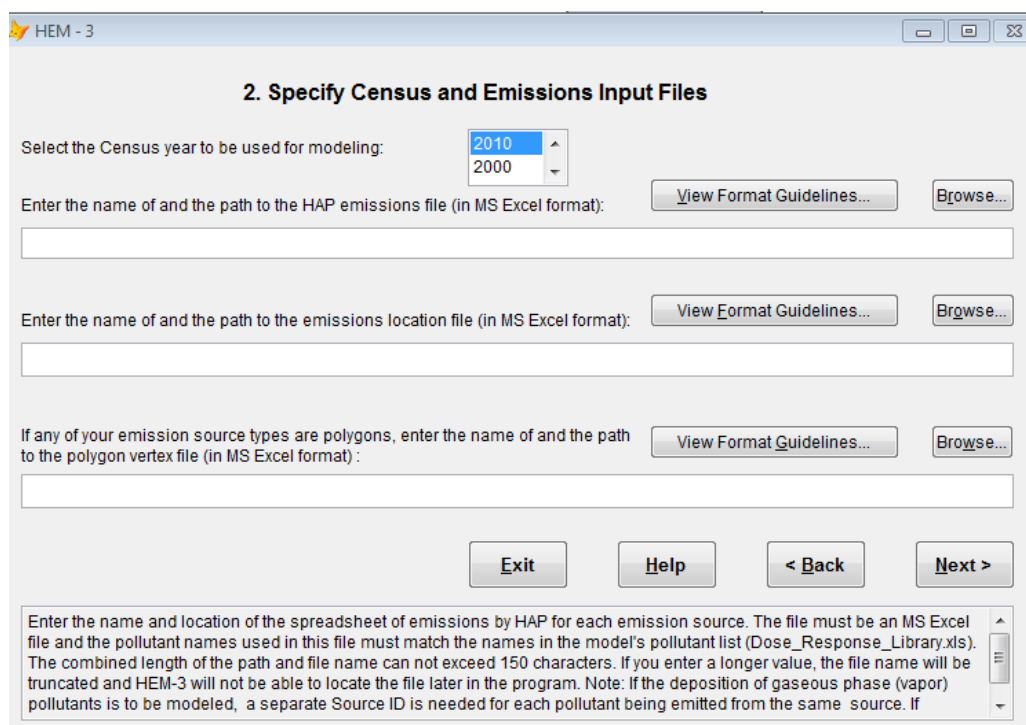


Figure 5. Screen 2 – Specify Census and Emissions Input Files

3.2.3 Specify Optional Deposition and Depletion (Screen 3)

On Screen 3 (**3. Specify Optional Deposition and Depletion**), shown below in Figure 6, select “Yes” or “No” to choose whether the model will calculate the impacts of deposition and plume depletion. These processes reduce the ambient impacts from the emission source by removing pollutants from the plume. Air concentrations will be depleted as pollutants are deposited to the

ground. The modeled deposition flux may be then used as an input to a separate multipathway model such as the Total Risk Integrated Methodology (TRIM) ([EPA 2010](#)). HEM-3 uses AERMOD to calculate deposition and depletion effects for particulate matter, gaseous (vapor) pollutants, or both.

Select “No” if you do not want deposition and depletion modeling, and do not need more detailed concentration outputs. You can direct HEM-3 to produce more detailed concentration outputs, showing the breakdown of particles and vapor at each location, even if you do not model deposition and depletion. To do so, select “Yes” to indicate that you want to calculate deposition and depletion. Next, select “none” for the type(s) of deposition and depletion to use for particle and/or vapor emissions. The outputs will show distinct rows for particles and vapor at each location (rather than a combined row) if you entered percentage values for the “Fraction Particulate” in the [HAP emissions input file](#).

The screenshot shows the HEM-3 software interface for Screen 3, titled "3. Specify Optional Deposition and Depletion". The interface includes the following elements:

- Do you want to calculate deposition and depletion in the model run?** A dropdown menu with "No" and "Yes" options. "Yes" is selected.
- Do you want to calculate deposition and depletion for particle emissions, vapor emissions, or both ?** A dropdown menu with "Both", "Particle", and "Vapor" options. "Both" is selected.
- What type of deposition and depletion will be used for particle emissions?** A dropdown menu with "none", "wet and dry", and "dry only" options. "wet and dry" is selected.
- Enter the name and location of the file with particle size, mass fraction and density data for particulate matter emissions:** A text input field with a "Browse..." button next to it.
- What type of deposition and depletion will be used for vapor emissions?** A dropdown menu with "none", "wet and dry", and "dry only" options. "wet and dry" is selected.
- Buttons:** "Exit", "Help", "< Back", and "Next >" are located at the bottom.
- View Format Guidelines...:** A button located next to the file input field.
- Help Text:** A scrollable text area at the bottom provides instructions: "Select 'Yes' if you want the deposition and depletion of pollutants to be modeled. You may also select 'Yes' if you'd like HEM-3 to produce separate records for particlephase and vapor phase at each location in the concentration outputs (i.e., select 'Yes' here and then 'none' below for the type of deposition, if deposition modeling is not needed by separate particle and vapor phase records are needed). Select 'No' if you do not want deposition and depletion to be modeled and you do not need separate records of particles."

Figure 6. Screen 3 – Specify Optional Deposition and Depletion

Select “Yes” to model deposition and depletion, then next select “Both”, “Particle”, or “Vapor” to indicate the type of deposition and depletion you want calculate. Take care to choose a deposition type (particle, vapor, or both) that is consistent with the emissions. For example, if only particle phase pollutants are in your HAP emissions input file, select “Particle”, not “Both” or “Vapor” in response to the second question on this screen).

Next, select the type of deposition and depletion – “none”, “wet and dry”, “dry only”, or “wet only” – to be modeled for your particle phase and/or vapor phase emissions.

If your HAP emissions input file contains particle phase pollutants and you want to model deposition and depletion of particulate matter, HEM-3 requires a [particle size input file](#)

containing particle size information, mass fraction and particle density data. Enter the name and path to the particle size input file in the text box on Screen 3.

If your HAP emissions input file contains vapor/gaseous phase pollutants and you want to model dry deposition and depletion of these vapor pollutants, you must specify the names of a [land use](#) file and a [month-to-season](#) file. The additional vapor phase input screen (Screen 3a) is shown below in Figure 7. These additional input files are needed to quantify dry (or “wet and dry”) gaseous deposition. If you wish to model “wet only” deposition and depletion of vapor pollutants, these additional input files are not needed, so Screen 3a will not appear.

Enter the names of these additional files in the appropriate text boxes on Screen 3a. Also, check to make sure that the pollutants being modeled are included in the gas parameter ([Gas_Param](#)) reference file. If these pollutants are not included but parameters for them are available in the literature, add the pollutants and appropriate parameters to the Gas_Param file. Otherwise, default parameters will be used.

Figure 7. Screen 3a – Specify Files for Vapor Deposition

Note that HEM-3 requires more time to run if you are modeling acute impacts (i.e., you selected “Yes” to include acute calculations on [Screen 1 Specify Model Run Information](#)) and you opt to model deposition and depletion. The exact run time will depend on the particular source configuration and modeling domain, but the combination of acute calculations and deposition/depletion will generally increase run times from a few minutes to over an hour.

Deposition and plume depletion has more of an effect on ambient concentrations farther from the facility than it does closer to the facility where the maximum impact generally occurs. Therefore, if you select the deposition and depletion option for a model run, you may save time by performing two separate runs. For example, use the first HEM-3 run to calculate chronic effects and include deposition and plume depletion. Use the second run to calculate acute effects without deposition and depletion.

3.2.4 Specify Additional Modeling Options (Screen 4)

On Screen 4 (**4. Specify Additional Modeling Options**), shown below in Figure 8, you can select other modeling options for the run that allow for more sophisticated and detailed model predictions.

Figure 8. Screen 4 – Specify Additional Modeling Options

Select “Yes” or “No” to indicate whether you want to include the effects of building downwash in your calculations. [Section 3.1.7](#) summarizes situations where we recommend accounting for building downwash. If you select “Yes” to include building downwash calculations, then enter the name and location of the [building dimension input file](#) in the text box on Screen 4.

Next, select “Yes” or “No” to indicate whether you want to run HEM-3 with or without AERMOD’s FASTALL control option. FASTALL conserves model runtime by simplifying the AERMOD algorithms used to represent meander of the pollutant plume ([EPA 2004a](#)). The FASTALL option eliminates the upwind component of dispersion for point and volume sources, and reduces the requirement for uniformity of emissions over the extent of area sources. HEM-3 defaults to “No” on this option for more rigorous modeling. For faster runs however, you may want to select the FASTALL option which includes these plume and source simplifications. (See AERMOD’s model documentation at www.epa.gov/scram001/dispersion_prefrec.htm#aermod.)

Finally, select “Yes” or “No” to indicate whether you want to create a detailed histogram of cancer risk estimates. This option directs the model to produce a more detailed histogram of the estimated numbers of people exposed to different levels of maximum individual cancer risk, in addition to the basic risk histogram HEM-3 automatically produces. See [Section 5.6.3](#) for a description of this optional output file.

3.2.5 Define the Modeling Domain (Screen 5)

On Screen 5 (**5. Define the Modeling Domain**), shown below in Figure 9, select the parameters that will define your modeling domain. The modeling domain is circular and centered on the facility, with a user-specified radius. HEM-3 identifies all of the census block locations in the modeling domain from its census database, and divides the blocks into two groups based on their distance from the facility. For the inner group of census blocks (closest to the facility), each block location is modeled as a separate receptor in AERMOD.

On Screen 5, specify the cutoff distance for modeling individual census blocks. You can also indicate an “overlap” distance, within which census block coordinates will be determined to be on facility property. For census blocks in the outer group, beyond the modeling cutoff distance, emission impacts are interpolated based on modeling results for a polar receptor network, which you will also define on this screen.

Finally, on this screen you can specify the inclusion of user-defined receptors. This additional input file, described in [Section 3.1.8](#), identifies additional locations to be included as model receptors in AERMOD. These additional discrete receptors may include facility boundary locations, monitoring sites, individual residences, schools, or other locations of interest.

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5. Define the Modeling Domain

Enter the maximum radius (in meters) to be modeled: 50000

Enter the minimum radius (in meters) to be modeled: 0

Enter the distance (in meters) within which census blocks will be modeled individually: 3000

Enter the distance (in meters) where source and receptor are considered to be overlapping: 30

Enter the number of concentric circles in the area to be modeled: 13

Enter the number of radials in the area to be modeled: 16

Do you want to use additional (user defined) receptor locations? Yes

Enter the name and the path of the file containing user defined receptors: [View Format Guidelines...](#) [Browse...](#)

[Exit](#) [Help](#) [< Back](#) [Next >](#)

Select "Yes" to include a user defined receptor locations file in the model run. Select "No" to omit them. The default is "No". If you select "Yes", you will need to enter the name of a spreadsheet containing receptor locations information in the text box below.

Figure 9. Screen 5 – Define the Modeling Domain

Enter the maximum radius (in meters) to be modeled. Specify the outside maximum radius of the modeling domain. This is the circular study area for which HEM-3 will model ambient impacts (either at census block centroid receptors or polar grid receptors, as explained below). This radial distance is usually 30 to 50 kilometers (entered in meters). The center of this area is generally the geographical center of the facility (or facilities) you are modeling, but you can change this center location on a later screen. [Note: The maximum radius you enter should be \leq 50 km because as a Gaussian dispersion model AERMOD is not recommended beyond 50 km.]

Enter the minimum radius (in meters) to be modeled. You can also specify an inside minimum radius for the modeling domain. Generally, this radius should be set to 0 (zero), although you have the option of entering a value greater than 0. This feature is useful if you want to divide a modeling job into two runs, possibly to make more efficient use of computer resources. For instance, in one run you could model all receptors from 0 to 10,000 meters from a facility. In a second run, you could model receptors located between 10,000 and 50,000 meters from the same facility. In this case, the MIR would be the maximum value for the two runs, and the population exposure to any given risk level would be the sum of population exposures at each risk level for the two runs. (The risk and population exposure outputs are described in more detail in [Section 5](#) below.)

Enter the distance (in meters) within which census blocks will be modeled individually. Enter the cutoff distance for individual modeling of census blocks. Within this radial distance measured from the facility center, AERMOD will model each census block centroid explicitly as a receptor. Outside of this radius, AERMOD will not model the census blocks directly; ambient impacts at the block centroid will instead be interpolated using dispersion modeling results for the polar receptor network, described below.

Larger values for this cutoff distance will require more time to model, because the number of census block receptors requiring explicit AERMOD modeling will be higher. However, set this cutoff value at a large enough distance so that the maximum risk receptor (discussed in [Section 4.2.3](#)) will be modeled individually. This distance will vary depending on the configuration of the sources, but is generally between 1,500 and 2,000 meters. A typical modeling cutoff distance for larger facilities is 3,000 meters (or 3 km). When modeling large sources configured as polygons (e.g., census tracts), set this modeling cutoff distance to be greater than the largest distance across the polygon, to ensure discrete modeling of all census blocks within the polygon.

Enter the distance (in meters) where source and receptor are considered to be overlapping. Enter a distance (\leq 500 meters) within which sources and receptors will be considered to be overlapping, as measured from each source at the facility (e.g., stack, edges of area and volume sources). This feature is provided to address situations wherein census blocks are very close to a facility and have complex shapes. In such cases, the centroid of a census block may be much closer to the facility than the nearest actual dwelling. (In fact, if a census block surrounds a portion of the facility, the centroid of the block may be on facility property.) The default value for the overlap distance is 30 meters, or approximately equal to the width of a narrow buffer and a roadway. If a receptor falls within this distance, HEM-3 will not calculate risks based on the location of that receptor, but will instead assume that the risks associated with the receptor are the same as the highest predicted value for any receptor that does not overlap facility property (even if it is not a population receptor). An exception to this occurs when modeling polygon sources. Unlike other sources, when modeling polygons, the overlap function is disabled. This allows the impacts for a census tract modeled as a polygon source (e.g. mobile source emissions modeled uniformly across a census tract) to be calculated within the census tract being modeled.

Enter the number of concentric circles in the area to be modeled. In addition to ambient impacts at census block centroids within the modeling cutoff distance, HEM-3 (using AERMOD) also explicitly models ambient impacts at polar grid receptors within a polar network. This polar network extends beyond the modeling cutoff distance to the maximum (outside) radius. The polar receptor network in HEM-3 serves three functions: (1) it is used to estimate default impacts if one or more census locations are inside the overlap cutoff distance; (2) it is used to evaluate potential acute effects that may occur due to short-term exposures in unpopulated locations outside the facility boundary; and (3) the polar receptor network is used to interpolate long- and short-term impacts at census block locations that are outside the cutoff distance for modeling of individual blocks.

Enter the number of polar rings (concentric circles) to be analyzed and the *number of radial directions* to be included. The polar grid receptors of the polar network are located at the intersection of a polar ring and radial. HEM-3 will calculate the inner radius of the polar network. This model-calculated first ring distance is based on the location of the emission sources and the facility center. HEM-3 selects the distance that places the first modeling ring just beyond all emission sources, but not less than 100 meters from the facility center. A typical run would include 13 concentric rings and 12 or 16 radial directions. HEM-3 will distribute the radial directions evenly around the facility. For instance, if you select 16 directions, receptors will be modeled at compass bearings of 0, 22.5, 45, 67.5, 90, 112.5, 135, 157.5, 180, 202.5, 225, 247.5, 270, 292.5, 315, and 337.5. You have the option to change HEM-3's calculated ring distances in a later input screen. [Section 3.2.10](#) provides further discussion on the selection of different ring distances.

Do you want to use additional (user-defined) receptor locations? In addition to modeling impacts at census block centroid receptors and polar grid receptors, HEM-3 can model impacts at additional user-defined locations. Select "Yes" or "No" to indicate whether you want to include additional user-defined receptors. If you answer "Yes", next enter the name and path of the user-defined receptors file (as described in [Section 3.1.8](#)) in the text box on Screen 5.

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3.2.6 Specify Optional Temporal Variations (Screen 6)

Use Screen 6 (**6. Specify Optional Temporal Variations**), shown below in Figure 10, to include temporal variations in the emission inputs AERMOD uses, and/or to show hourly and seasonal resolution in the ambient concentration outputs AERMOD produces.

- You can provide HEM-3 a [temporal variations input file](#) that varies the emissions AERMOD uses from specific sources by different user-supplied time scales (e.g., by season, month, hour of day, and/or day of week) or by different wind speeds (6 ranges).
- You can direct HEM-3 to provide an output file from AERMOD displaying diurnal and/or seasonal variations (based on the user-supplied temporal variations specified above and/or meteorological fluctuations) in the ambient concentration results.

Select "Yes" or "No" on the upper portion of Screen 6 to indicate whether you want to vary the emission inputs. If you select "Yes", then enter the name and path of the temporal variations input file in the text box on Screen 6. Templates for the various possible temporal variation input

files are provided in HEM-3's Inputs directory (under 'Template_temporal_variation'.xls). [Section 3.1.9](#) describes these input files in more detail.

Note: Regarding short-term (acute) emission rates, the factors applied by the temporal variation input file will compound the acute multiplier specified on input [Screen 1](#). For example, whatever factors you supply in the temporal variation input file will be multiplied by an acute multiplier of 10 (if the default multiplier is used) to derive the short-term emission rate. Therefore, if applying hour of day temporal factors via [Screen 6](#), you may want to set the acute multiplier to 1 (by clicking on the "Back" button to [Screen 1](#)), unless it is reasonable to assume that the short-term rate may still exceed the hour of day factors by an additional multiple.

Figure 10. Screen 6 – Specify Optional Temporal Variations

Select "Yes" on the lower portion of Screen 6 to direct AERMOD to provide finer temporal resolution in the ambient concentration outputs than is otherwise provided by default. AERMOD calculates hourly concentration data based on the emissions inputs, but does not retain this hourly data for the output files (due to its large file size) unless you request it via this option. If you select "Yes" for this option, the ambient concentration outputs will show diurnal or diurnal plus seasonal variation, depending on your selections on the following two sub-questions on the screen.

What diurnal (hourly) resolution would you like in the output file? The diurnal resolutions available are: 1-hour (24 concentrations per 24 hours); 2-hour (12 concentrations per 24 hours); 3-hour (8 concentrations per 24 hours); 4-hour (6 concentrations per 24 hours); 6-hour (4 concentrations per 24 hours); 8-hour (3 concentrations per 24 hours); 12-hour (2 concentrations per 24 hours); or 24-hour (1 concentration per 24 hours). Scroll through and click on your selection in the dropdown box.

Do you want the diurnally-resolved concentration output to show seasonal variation? Select “Yes” or “No” to indicate whether you want to show seasonal variations in the diurnally-resolved concentration output. If you select “Yes” for the diurnal question but “No” for the seasonal variation question, a diurnally-resolved concentration output is provided with the indicated resolution, but no seasonal variations will be provided.

You can select the second option alone or in combination with the first option. If you select only the second option—not in combination with a temporal variation input file—then the temporal variations in the ambient concentration outputs will result from the effects of meteorological fluctuations calculated by AERMOD (i.e., based on meteorological parameters provided by the selected met station). If you select the second option in combination with a temporal variations input file you provide, then the temporal variations in the ambient concentration outputs will result from both the effects of meteorological fluctuations and your time or wind speed factors applied to the emissions.

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3.2.7 Verify Modeling Options (Screen 7)

Verify your modeling options on Screen 7 (**7. Verify Modeling Options**). This screen consists of three pages, with the last of the three pages shown below in Figure 11. Review your selections. Click “Next” to accept all options. To revise a selection, check the appropriate box, then click “Change.” Enter your revision, then click “Next” to return to the verification screen. After you have made all necessary revisions, click “Next” to accept all displayed options and proceed to Screen 8.

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7. Verify Modeling Options

Listed below are the options you have chosen. If you wish to change an option, select the corresponding checkbox and then select the Change button. If you want to accept the values, select the Next button.

User Options - Page 1		User Options - Page 2		User Options - Page 3	
The maximum radius of the area to be modeled:	50000		<input type="checkbox"/>		
The minimum radius of the area to be modeled:	0		<input type="checkbox"/>		
The distance within which blocks are modeled individually:	3000		<input type="checkbox"/>		
The distance at which the source and receptor are considered to be overlapping:	30		<input type="checkbox"/>		
The number of concentric circles (in polar network) in the area to be modeled:	13		<input type="checkbox"/>		
The number of radials (in polar network) in the area to be modeled:	16		<input type="checkbox"/>		
Include user defined discrete receptor locations in the modeling?	N		<input type="checkbox"/>		
The name of the user-specified discrete receptors file:	C:\HEM3_BETA\INPUTS\TEMPLATE_USER_RECEPTORS.XLS				
			<input type="checkbox"/>		
Use temporal variations for the modeling run?:	N		<input type="checkbox"/>		
The name of the emissions variations file:	C:\HEM3_BETA\INPUTS\TEMPLATE_TEMPORAL_HROFDY.XLS				
			<input type="checkbox"/>		
Use temporal variations for the modeled output concentrations?:	Y		<input type="checkbox"/>		

Exit Help < Back Change Next >

Figure 11. Screen 7 – Verify Modeling Options (page 3 of 3)

3.2.8 Verify Modeling Domain Center (Screen 8)

Use Screen 8 (**8. Verify Modeling Domain Center**), shown below in Figure 12, to verify the calculated geographic center of the emission sources as the modeling domain center, or to specify alternate coordinates based on your needs. HEM-3 calculates the geographic center using the combination of all emission source coordinates that you provided in the [emissions location](#) file. The modeling domain center will be used in interpolating risks at census blocks outside the modeling cutoff distance, within the polar grid network. In addition, HEM-3 will calculate the total population and average risks within various distances from the modeling domain center.

You may want to change the modeling domain center if the facility includes an outlying emission source, such as a storage tank farm or a ship loading facility. By default, HEM-3 would place the domain center midway between the main process operation and the outlying source. However, you may want to move the modeling domain center closer to the main process operation, especially if the outlying facility is a small source of emissions.

Review the given modeling domain center. Click within a box to revise the modeling domain center. When finished, or if no changes are needed, click “Next” to continue to Screen 9.

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8. Verify Modeling Domain Center

The coordinates displayed define the edges of the region within which all emission sources of the facility are located.

Minimum UTM East Coordinate: 690934

Maximum UTM East Coordinate: 691099

Minimum UTM North Coordinate: 3974872

Maximum UTM North Coordinate: 3975014

Modeling Domain Center: 691016 3974948

[Exit](#) [Help](#) [Next >](#)

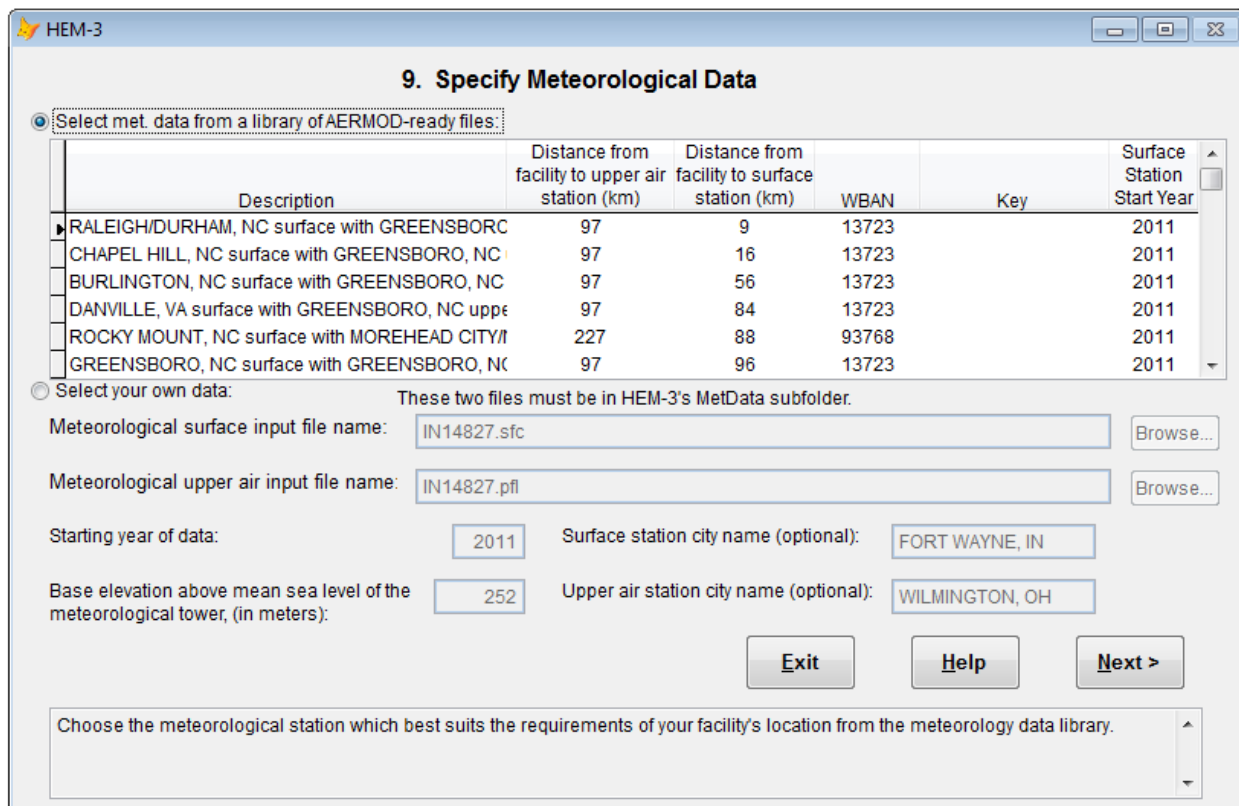
This is the X value for the modeling domain center. You may change this value if you wish to use another location for the center of the polar grid receptor network. The new value must be within the emission source region defined above.

Figure 12. Screen 8 – Verify Modeling Domain Center

3.2.9 Specify Meteorological Data (Screen 9)

Use Screen 9 (**9. Specify Meteorological Data**), shown below in Figure 13, to select a meteorological input file for the modeling domain. HEM-3 includes a library of processed meteorological data covering 190 sites used by AERMOD. The meteorological input files include upper air data and surface data, as discussed in [Section 2.4.1](#). HEM-3 calculates the distances from all of the surface and upper air stations to the center of the modeling domain. The meteorological input screen then ranks the available files according to their proximity to the modeling domain.

Generally, the closest set of stations will be most representative of the meteorology in the modeling domain. However, there are a number of situations where a different combination of meteorological stations will be more representative. For instance, if the modeling domain is located on the Gulf of Mexico, you should select a surface station near the Gulf, even if there is a closer inland station. You can also provide a meteorological data file for the specific facility location on this screen. (This file must be preprocessed and formatted for AERMOD—see [Section 2.4.1](#) for more detail—and placed in the “C:\Program Files\HEM3\Metdata” subdirectory). If you do not specify a particular set of surface and upper air station, HEM-3 defaults to the closest available set of stations, and these stations are already indicated with a pointer in the left most column on this screen.



9. Specify Meteorological Data

☒ Select met. data from a library of AERMOD-ready files:

Description	Distance from facility to upper air station (km)	Distance from facility to surface station (km)	WBAN	Key	Surface Station Start Year
RALEIGH/DURHAM, NC surface with GREENSBORO, NC	97	9	13723		2011
CHAPEL HILL, NC surface with GREENSBORO, NC	97	16	13723		2011
BURLINGTON, NC surface with GREENSBORO, NC	97	56	13723		2011
DANVILLE, VA surface with GREENSBORO, NC upper air	97	84	13723		2011
ROCKY MOUNT, NC surface with MOREHEAD CITY, NC	227	88	93768		2011
GREENSBORO, NC surface with GREENSBORO, NC	97	96	13723		2011

☐ Select your own data: These two files must be in HEM-3's MetData subfolder.

Meteorological surface input file name:

Meteorological upper air input file name:

Starting year of data: Surface station city name (optional):

Base elevation above mean sea level of the meteorological tower, (in meters): Upper air station city name (optional):

Choose the meteorological station which best suits the requirements of your facility's location from the meteorology data library.

Figure 13. Screen 9 – Specify Meteorological Data

3.2.10 Verify Polar Ring Distances (Screen 10)

In Screen 10 (**10. Verify Polar Ring Distances**), shown below in Figure 14, HEM-3 will suggest a list of polar ring (concentric circle) distances based on the number of rings that you specified in the [modeling domain input screen](#), under Section 3.2.5 above. The suggested list will be a logarithmic progression of distances starting at the inner ring distance and ending at the outer radius of the modeling domain. Use this screen to adjust the suggested ring distances to fit the specific size and surroundings of the facility (or facilities) that you are modeling.

As noted in Section 3.2.5, HEM-3 calculates the distance from the facility center for the first ring to be just outside the emission source locations you provided in the [emissions location file](#), but not less than 100 meters from the facility center. Set the first receptor ring to less than 100 meters (or conversely greater than what HEM-3 calculates), if appropriate to the size and shape of the facility property. Place the nearest polar receptor ring as close as possible to the facility boundary— this inner radius of the polar network should be the minimum distance from the facility center that is generally outside of facility property. The first ring distance must be less than the modeling cutoff distance (for explicit modeling of receptors).

For complex or irregularly shaped facilities however, you may find it useful to specify an inner ring that encroaches on facility property in some directions. Furthermore, you may want to specify a set of boundary receptors with the user-defined receptors file (as input in the [modeling domain input screen](#), Section 3.2.5).

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10. Verify Polar Ring Distances

Below are suggested distances (in meters) for the concentric circles of the polar receptor network. You may change the values except for the outermost circle.

1)	113	11)	19700
2)	200	12)	31500
3)	350	13)	50000
4)	600		
5)	1040		
6)	1800		
7)	3000		
8)	4800		
9)	7700		
10)	12300		

Exit

Help

Next >

Figure 14. Screen 10 – Verify Polar Ring Distances

Although the polar grid receptors are used primarily for interpolating risks at census blocks outside of the modeling cutoff distance, it is important to include some rings close to the facility. HEM-3 generally estimates maximum individual risks and hazard indices (described below in Section 4) using concentrations calculated at census blocks. However, HEM-3 will default to the next most impacted receptor if a census block is located within the “overlap distance” of any of the emission sources (as specified in the [modeling domain input screen](#), Section 3.2.5). This next most impacted receptor can be either a census block or a polar grid receptor. The polar receptors are also included in the calculation of maximum offsite impacts (also described in Section 4), which can be used in analyzing the risks of short-term exposure.

Unknown Pollutant(s) Warning Screen:

After you have completed Screen 10, click “Next” to proceed to Screen 11. If a different (un-numbered) screen appears, this means that some of the pollutants in your HAP emissions input file are not in HEM-3’s dose response library. Figure 15 displays a sample warning screen listing unknown pollutants.

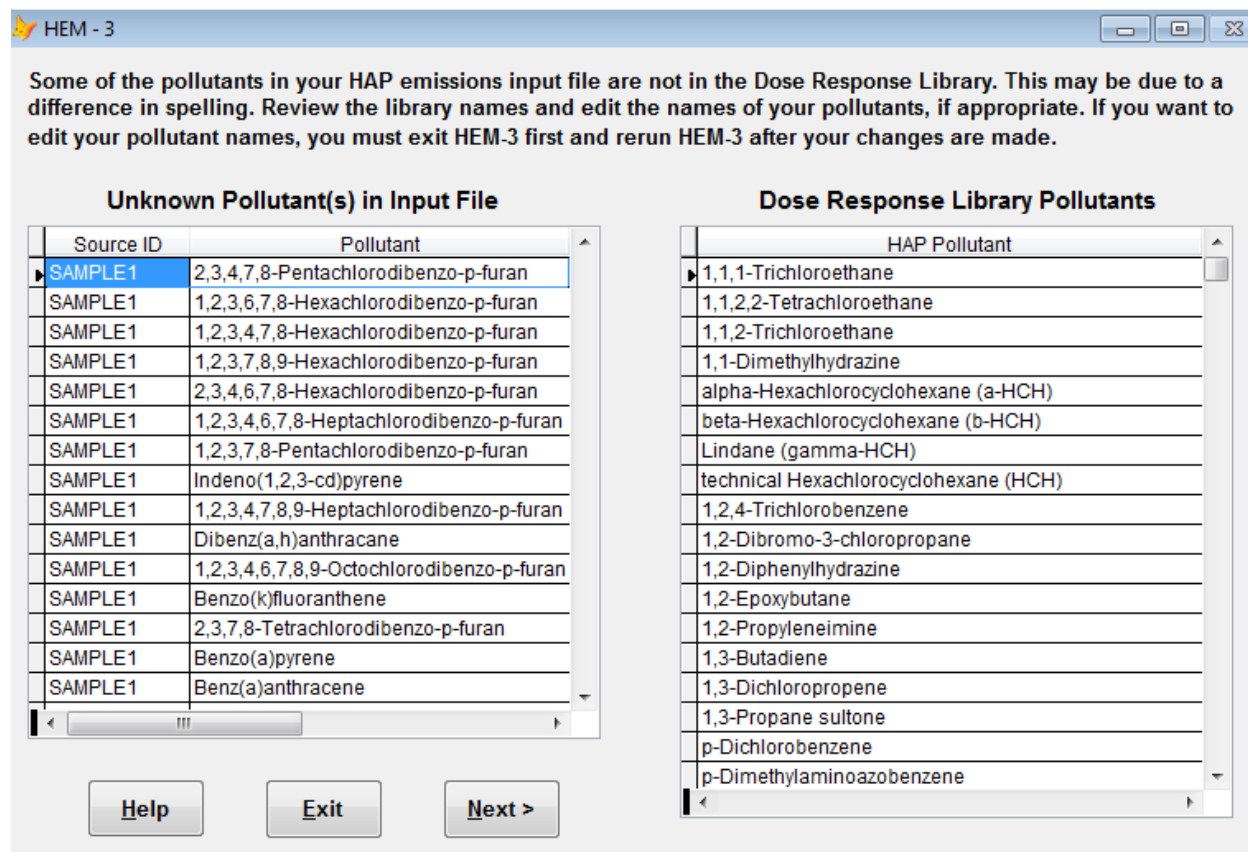


Figure 15. Unknown Pollutant Warning Screen

If you have received this screen, you may want to exit and then re-initiate the model after editing either the HAP emissions input file or the dose response library (located in HEM-3’s Reference directory) to ensure that the pollutant spellings between these two files match, and/or that each pollutant that is listed in the HAP emissions input file is listed in the dose response library.

However, this is not mandatory. Review the displayed unknown pollutants and decide whether any editing or addition of pollutant names and re-initiating of the model is necessary. For example, you may decide that the pollutants that HEM-3 lists on the left side of this screen (as not identified in the dose response library) are not actually toxic pollutants of interest. In this case, click “Next” to continue running the model, and these pollutants will be ignored and excluded from the analysis.

If you decide that editing and/or addition of pollutants is necessary for the analysis, exit the program and make these changes. For example, you can correct misspelled pollutants in the HAP emissions input file using search and replace commands, so that they match the spelling in the dose response library.

You can add a pollutant to the dose response library to reflect a pollutant included in the HAP emission input file. In this case, include appropriate dose response values (and, if necessary, target organ endpoints for non-cancer health effects) for the added pollutant(s), as discussed in [Section 3.1.11](#) *Changing the chemical unit risk estimates and health benchmarks input files*.

After making all revisions to the HAP emissions input file and/or the dose response library, re-initiate your model run.

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3.2.11 Check Emissions Source Configuration and Nearby Receptors (Screen 11)

Once you have entered all input data, verified the modeling options, modeling domain, meteorological station and polar ring distances (Screens 1 through 10), HEM-3 identifies the census blocks within the modeling domain. At this point, the model will inform you that the program is looking for census data (this may take a few minutes). Once HEM-3 has retrieved the relevant census data, the model produces a plot displaying the source configuration and the locations of the nearest census block receptors on Screen 11, as shown below in Figure 16. Click on the “Google Earth™” command button (on this screen) to view the facility location and the nearest receptors.

If any of the receptors overlap the facility, as defined in [Section 3.2.5](#), HEM-3 will not calculate risks based on the location of that receptor, but will instead assume that the risks associated with the receptor are the same as the highest predicted value for any receptor that does not overlap facility property. Therefore, if there are overlapping receptors, enter a series of boundary receptors to make sure that the maximum risks for the overlapping receptors are properly characterized. In this case, click “Exit” to end the current model run. Re-initiate the model run, this time entering boundary receptors via Screen 5 in a user-defined receptors file, as described in [Section 3.2.5](#).

If the emission source configuration and nearby receptors are sufficient for your analysis—that is, no user-defined boundary receptors are necessary—then click “Next” on Screen 11 to initiate AERMOD’s processing within HEM-3.

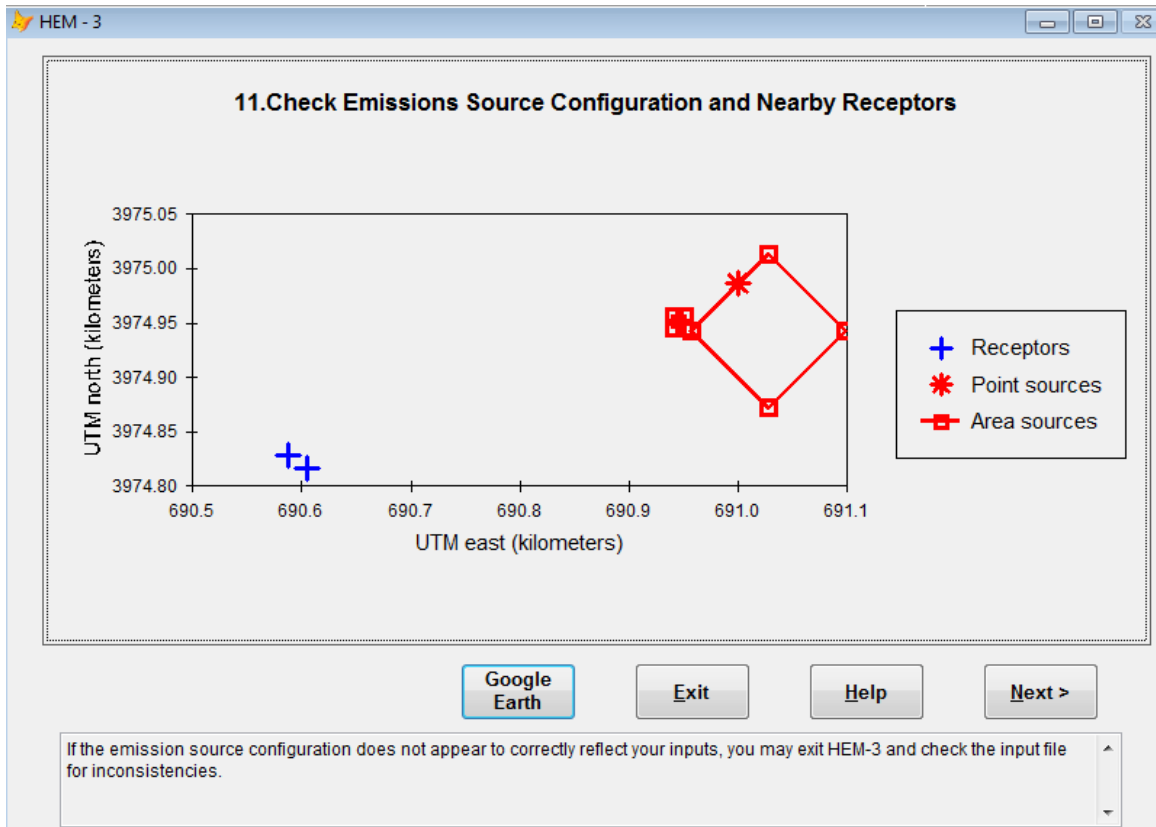


Figure 16. Screen 11 – Check Emissions Source Configuration and Nearby Receptors

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3.3 Commencement and Completion of Modeling Run using AERMOD

After clicking “Next” on Screen 11, a message box appears informing you that AERMOD will begin processing the input data. This may take several minutes to several hours, depending on the complexity of the emission sources and the modeling options you selected. Click “No” on this message box to stop HEM-3 and exit from the program. Click “Yes” to initiate the model run and begin producing the requested outputs.

When AERMOD completes, HEM-3 will display a message box stating “The AERMOD program completed successfully. Output information is being processed prior to display. This may take a few minutes.” The next screen to be displayed (Screen 12) is an output screen. [Section 4](#) describes the calculations that HEM-3 performs to produce these outputs. [Section 5](#) lists and describes HEM-3’s outputs.

3.4 Modeling Multiple Facilities

You can use HEM-3 to analyze the impacts of a single industrial facility or a cluster of facilities located near one another. The larger the number of facilities you choose to model at one time, the greater time AERMOD will be required to run; take this into consideration when creating a run. The required runtime will be roughly proportional to the product of the number of emission source locations and the number of receptors modeled. The number of receptors modeled includes all of the census blocks modeled individually, the polar receptor network, and any receptor locations you have defined (as discussed [Section 3.2.5](#)).

The cutoff distance for individual modeling of census blocks applies to all emission source locations, not just to the center of the modeling domain. Thus, HEM-3 ensures that calculated risks and hazard indices are based on actual dispersion model results, rather than interpolation. Due to this feature, the number of individually modeled census blocks will depend on how close the facilities are to one another. For instance, if you have chosen a model cutoff distance of 2 kilometers for a cluster of two facilities located 100 meters apart, the number of individually modeled census blocks will not be much larger than if modeling only one facility. However, the number of individually modeled census blocks will likely double if the facilities are 2 kilometers apart. (The exact numbers will depend on the population density in the modeling domain.)

The [interpolations](#) performed in HEM-3 will become less accurate as distances increase between the modeled facilities. This will primarily affect exposure calculations, such as the number of people estimated to be exposed to different risk levels. The accuracy of MIR and maximum HI will generally be unaffected, because these values are not interpolated unless the selected cutoff distance is too small. (HEM-3 will show a warning message when this occurs.)

You can use the HEM-3 output files to distinguish the contributions of different emission sources to the MIR or maximum HI (see [Sections 5.1 and 5.2](#)). When modeling a cluster of facilities, use the first few characters of the [Source ID](#) to distinguish among different facilities. For instance, "F1" for the first plant, "F2" for the second plant, and so on. This will help you in interpreting model results for the facilities making up the cluster.

The location of the MIR for a cluster of facilities may differ from the location of the MIR for any single facility in the cluster (due to emissions from multiple facilities impacting the same receptors). Therefore, you may wish to model the facilities in the cluster separately as well as together.

3.5 Instructions for Using Previously Modeled or Monitored Concentration Data

On [Screen 1](#), you have the choice of using AERMOD in the HEM-3 run to compute ambient concentrations, or using previously modeled or monitored concentration data. If you checked the box indicating that you would be using previously modeled or monitored concentration data, an alternate Screen 2 (**2. User-supplied pollutant concentration inputs**) appears (Figure 17).

Figure 17. User-Supplied Pollutant Concentration Inputs Screen

Select the census year to be used for modeling (2000 or 2010).

Enter the name and location of the input file containing the previously modeled or monitored concentrations. See [Section 3.1.10](#) for a description of this file. When choosing user-supplied concentration results under this option, no modeling by AERMOD will occur. Instead, HEM-3 will interpolate these external concentration results to all census block centroid locations within the study domain using a Voronoi Neighborhood Averaging approach. [Section 4.4](#) describes these Voronoi averaging calculations in more detail. HEM-3 will then compute risk and HI results based on these interpolated values. [Note: This option is not intended to be used with modeled data produced with a polar coordinate system. Furthermore, no polar grid receptors will be created under this option.]

Click “Next” to commence the HEM-3 modeling run. Unlike a HEM-3 run using AERMOD, the screen will not display outputs. Instead, when the run is complete, HEM-3 will notify you that the outputs have been placed in HEM-3’s output directory. See [Section 5.7](#) for a brief discussion of the output files resulting from a HEM-3 run using previously modeled or monitored concentration data.

4. Calculations Performed by HEM-3

This section describes the dispersion modeling calculations that HEM-3 implements automatically, as well as the post-dispersion modeling cancer risk and non-cancer hazard calculations HEM-3 performs to generate its outputs.

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4.1 Dispersion Modeling

HEM-3 carries out dispersion modeling by running the AERMOD dispersion model. Section 3 describes a number of options you can specify for running AERMOD—for instance, incorporating deposition and depletion, and using urban or rural dispersion parameters. This section describes the options that HEM-3 implements by default. In addition, we describe the dilution factor methodology used in HEM-3 for modeling multiple pollutants.

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4.1.1 Regulatory Default Option

HEM-3 uses the regulatory default options when running AERMOD. These options include the following:

- Use stack-tip downwash (except for Schulman-Scire downwash)
- Use buoyancy-induced dispersion (except for Schulman-Scire downwash)
- Do not use gradual plume rise (except for building downwash)
- Use the “calms processing” routines
- Use upper-bound concentration estimates for sources influenced by building downwash from super-squat buildings
- Use default wind profile exponents
- Use low wind speed threshold
- Use default vertical potential temperature gradients
- Use missing-data processing routines.

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4.1.2 FASTALL Option in AERMOD

If selected, HEM-3 implements AERMOD’s FASTALL. This option conserves model runtime by simplifying the AERMOD algorithms used to represent meander of the pollutant plume. This simplification is achieved by eliminating the upwind component of dispersion for point and volume sources, and by reducing the requirement for uniformity of emissions over the extent of area sources ([EPA 2004a](#)). More information on AERMOD’s FASTALL option is available for download at www.epa.gov/scram001/dispersion_prefrec.htm#aermod in AERMOD’s model documentation. FASTALL is not implemented by default in the current HEM-3 (as noted in [Section 3.2.4](#)). AERMOD’s dispersion calculations in HEM-3 are rigorous and do not include FASTALL’s plume and source simplifications.

4.1.3 Dilution Factors

HEM-3 uses AERMOD to compute a series of dilution factors, specific to each emission source and receptor. This approach more quickly analyzes the impacts of multiple pollutants than if separately modeling each pollutant. The dilution factor for a particular emission source and receptor is defined as the predicted ambient impact from the given source and at the given receptor, divided by the emission rate from the given source.

If you choose not to analyze deposition or depletion, then the dilution factor does not vary from pollutant to pollutant. If you do select deposition or depletion, HEM-3 will compute separate dilution factors for gaseous and particulate pollutants. In addition, you can specify different particle sizes and densities for each particulate matter emission source. To use pollutant-specific parameters for particulates and/or gases, requires a separate source ID for each pollutant at a given source. You can create multiple source IDs using the same locations and stack parameters to accommodate different pollutants.

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4.2 Estimating Risks and Hazard Indices

HEM-3 estimates total cancer risks and HI for all census block locations in the modeling domain, all user-defined receptors, and all points in the polar receptor network. [Section 4.2.1](#) describes methods used to calculate cancer risks and HI for receptors that AERMOD explicitly models. [Section 4.2.2](#) describes the interpolation approach used to estimate cancer risks and HI at census blocks not explicitly modeled.

Based on the results for census blocks and other receptors, HEM-3 estimates the MIR and maximum HI for populated receptors ([Section 4.2.3](#)); as well as the maximum impacts for all offsite receptors, including unpopulated locations ([Section 4.2.4](#)). For these locations, the model calculates the contributions of individual chemicals and emission sources to cancer risks and HI ([Section 4.2.5](#)).

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4.2.1 Inner Census Blocks and Other Modeled Receptors

HEM-3 calculates cancer risks and target-organ-specific HI for three types of discrete receptors. These are (1) census blocks within the user-defined [cutoff distance](#) for modeling of individual blocks, (2) all [user-defined receptors](#), and (3) the user-defined [polar receptor network](#).

As noted in [Section 4.1.3, Dilution Factors](#), HEM-3 combines pollutants into two categories—gases and particulates—for the purposes of dispersion modeling. To conserve computer memory, the model retains these categories to calculate cancer risks and non-cancer HI. HEM-3 uses the following algorithms:

For cancer risk:

$$CR_T = \sum_{i,j} CR_{i,j}$$

$$CR_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} \times URE_k]$$

For non-cancer hazard indices:

$$HI_T = \sum_{i,j} HI_{i,j}$$

$$HI_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} / RC_k]$$

where:

- CR_T = total cancer risk at a given receptor (probability for one person)
- $\sum_{i,j}$ = the sum over all sources i and pollutant types j (particulate or gas)
- $CR_{i,j}$ = cancer risk at the given receptor for source i and pollutant type j
- $DF_{i,j}$ = dilution factor [$(\mu\text{g}/\text{m}^3) / (\text{g}/\text{sec})$] at the given receptor for source i and pollutant type j
- CF = conversion factor, $0.02877 [(\text{g}/\text{sec}) / (\text{ton}/\text{year})]$
- \sum_k = sum over all pollutants k within pollutant group j (particulate or gas)
- $E_{i,k}$ = emissions of pollutant k from source i
- URE_k = cancer unit risk factor for pollutant k
- HI_T = TOSHI at a given receptor and for a given organ
- $HI_{i,j}$ = organ-specific hazard index at the given receptor for source i and pollutant type j
- RC_k = non-cancer health effect reference concentration for pollutant k

The above equations are equivalent to the following simpler equations:

$$CR_T = \sum_{i,k} AC_{i,k} \times URE_k$$

$$HI_T = \sum_{i,k} AC_{i,k} / RC_k$$

where:

$AC_{i,k}$ = ambient concentration ($\mu\text{g}/\text{m}^3$) for pollutant k at the given receptor. This is the same as $[E_{i,k} \times DF_{i,j} \times CF]$

However, use of these simpler equations would require modeling all pollutants individually in AERMOD, and performing separate risk calculations for each pollutant.

If the cancer unit risk factor is not available for a given chemical, then that chemical is not included in the calculation of cancer risk. Likewise, if the non-cancer RfC is not available for a given chemical, that chemical is not included in the calculation of HI. Note that separate reference concentrations are used for acute and chronic HI.

4.2.2 Outer Census Blocks

For census blocks outside of the user-defined [cutoff distance](#) for individual block modeling, HEM-3 estimates cancer risks and HI by interpolation from the [polar receptor network](#). HEM-3 estimates impacts at the polar grid receptors using AERMOD modeling results and the algorithms described in Section 4.2.1. If you select the terrain elevation option, then an elevation is estimated for each polar receptor. HEM-3 estimates elevations and controlling hill heights for the polar grid receptors based on values from the census library. HEM-3 divides the modeling domain into sectors based on the polar grid receptor network, with each census block assigned to the sector corresponding to the closest polar grid receptor.

HEM-3 then assigns each polar grid receptor an elevation based on the highest elevation for any census block in its sector. The controlling hill height is also set to the maximum hill height within the sector. If a sector does not contain any blocks, the model defaults to the elevation and controlling hill height of the nearest block outside the sector.

HEM-3 interpolates the impacts at each outer census block from the four nearest polar grid receptors. The interpolation is linear in the angular direction, and logarithmic in the radial direction, as summarized in the following equations:

$$I_{a,r} = I_{A1,r} + (I_{A2,r} - I_{A1,r}) \times (a - A1) / (A2 - A1)$$

$$I_{A1,r} = \exp\{\ln(I_{A1,R1}) + [\ln(I_{A1,R2}) - \ln(I_{A1,R1})] \times [(\ln r) - \ln(R1)] / [\ln(R2) - \ln(R1)]\}$$

$$I_{A2,r} = \exp\{\ln(I_{A2,R1}) + [\ln(I_{A2,R2}) - \ln(I_{A2,R1})] \times [(\ln r) - \ln(R1)] / [\ln(R2) - \ln(R1)]\}$$

where:

- $I_{a,r}$ = the impact (cancer risk or hazard index) at an angle, a , from north, and radius, r , from the center of the modeling domain
- a = the angle of the target receptor, from north
- r = the radius of the target receptor, from the center of the modeling domain
- $A1$ = the angle of the polar network receptors immediately counterclockwise from the target receptor
- $A2$ = the angle of the polar network receptors immediately clockwise from the target receptor
- $R1$ = the radius of the polar network receptors immediately inside the target receptor
- $R2$ = the radius of the polar network receptors immediately outside the target receptor

4.2.3 Maximum Individual Risks and Hazard Indices

HEM-3 evaluates the predicted impacts for all populated receptors to identify the locations of the MIR and the highest HI for various target organs. For these calculations, populated receptors include all census block locations, and any user-defined receptors designated as type-P (population-oriented). In general, type-P receptors should include houses near the facility boundary, as well as nearby schools, public places, or other populated sites.

The maximum cancer risk may occur at a location other than the maximum HI for a given organ. Likewise, the location of the maximum HI for one organ will not necessarily be the same as the location for a different organ. HEM-3 performs a separate evaluation of the maximum impact location for each health effect.

The model also tests for instances where census blocks or other type-P receptors appear to be located on plant property. To do so, HEM-3 calculates the distance between each receptor and each emission source. These distances are compared with an [overlap distance](#) that you can specify. If a population-oriented receptor is located within the overlap distance, then HEM-3 does not use these calculated results for this receptor to estimate the maximum individual cancer risk or maximum HI for populated areas. Instead, the model assumes the impacts at the overlapping receptor to be equal to the maximum impacts for any receptors that do not overlap plant property. This could include both populated and unpopulated receptors, as long as they do not overlap plant property.

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4.2.4 Maximum Offsite Impacts

In addition to evaluating the maximum cancer risks and HI for populated receptors, HEM-3 evaluates maximum offsite impacts for all receptors. All census blocks, all user-defined receptors (populated and unpopulated), and all points on the polar receptor network are included in the evaluation of maximum offsite impacts, except for those receptors that are found to be overlapping emission sources.

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4.2.5 Contributions of Different Chemicals and Emission Sources

HEM-3 calculates the contributions of different chemicals and emission sources to cancer risks and HI at the receptors where impacts are highest, both for populated receptors and for all offsite receptors. As noted in [Section 4.2.1](#), HEM-3 conserves computer memory by grouping chemicals together when calculating total risks and HI for the large number of receptors that are typically included in an overall modeling domain. Thus, the model does not compute the contributions of individual chemicals and emission sources for all receptors. However, HEM-3 retains the information needed to determine the contributions of individual chemicals and emission sources at the receptors where impacts are highest. HEM-3 calculates these contributions using the following equations:

$$AC_{i, k, m} = E_{i, k} \times DF_{i, j, m} \times CF$$

$$CR_{i, k, m} = AC_{i, k, m} \times URE_k$$

$$HQ_{i, k, m} = AC_{i, k, m} / RC_k$$

where:

- $AC_{i, k, m}$ = predicted ambient concentration for pollutant k, from source i, at receptor m
- $E_{i, k}$ = emissions of pollutant k from source i
- $DF_{i, j, m}$ = the dilution factor for source i, receptor m, and pollutant group j, which includes pollutant k
- CF = conversion factor, 0.02877 [(g/sec) / (ton/year)]

- $CR_{i, k, m}$ = estimated cancer risk from source i, and pollutant k, at receptor m
 URE_k = cancer unit risk factor for pollutant k
 $HQ_{i, k, m}$ = organ-specific hazard quotient as a result of emissions of pollutant k, from source i, at receptor m
 RC_k = non-cancer health effect reference concentration for pollutant k

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4.3 Population Exposures, Average Impacts and Incidence

Using the predicted impacts for census blocks, HEM-3 estimates the populations exposed to various cancer risk levels and HI levels. To do so, the model adds up the populations for receptors that have predicted cancer risks or HI above the given threshold.

The model also calculates the average cancer risks, average HI, and annual cancer incidence for census blocks located within various distances of the emission sources using the following equations:

$$MCR_d = \sum_m [CR_m \times P_m] / \sum_m P_m$$

$$MHI_d = \sum_m [HI_m \times P_m] / \sum_m P_m$$

$$TCR_d = \sum_m [CR_m \times P_m] / LT$$

where:

- MCR_d = the population-weighted average cancer risk for the population located within distance d of the center of the modeling domain
 \sum_m = the sum over all census blocks m within distance d
 CR_m = the total lifetime cancer risk (from all modeled pollutants and emission sources) at census block m
 P_m = the population at census block m
 MHI_d = the population-weighted average HI (for a particular organ) for the population located within distance d
 HI_m = the total HI for the given organ (from all modeled pollutants and emission sources) at census block m
 TCR_d = the estimated annual cancer incidence (cancers/year) of the population living within distance d
 LT = the average lifetime used to develop the cancer unit risk factor, 70 years

HEM-3 also estimates the contributions of different chemicals and emission sources to total annual cancer incidence for the overall modeling domain using the following equations:

$$TCR_{i, j} = \sum_k [(\sum_k E_{i, k} \times URE_k) \times DF_{i, j, m} \times CF / LT]$$

$$TCR_{i, k} = TCR_{i, j} \times E_{i, k} \times URE_k / (\sum_k E_{i, k} \times URE_k)$$

where:

$TCR_{i,j}$ = the estimated total annual cancer incidence (cancers/year) to the population in the modeling domain due to emissions from pollutant type j (1 = particulate, 2 = gas) and emission source i
 \sum_m = the sum over all census blocks m in the modeling domain
 \sum_k = the sum over all pollutant k , within pollutant type j
 $E_{i,k}$ = emissions of pollutant k from source i (tons/year)
 URE_k = unit risk factor for pollutant k
 $DF_{i,j,m}$ = dilution factor at receptor m , for emissions of pollutant type j (which includes pollutant k), from source i
 CF = conversion factor, 0.02877 [(g/sec) / (ton/year)]
 $TCR_{i,k}$ = the estimated annual cancer incidence (cancers/year) of the population in the modeling domain due to emissions of pollutant k (in pollutant type j) from emission source i

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4.4 Interpolation of Concentrations from User-Provided Pollutant Concentration Data

You can optionally provide HEM-3 with pollutant concentrations from an external model or monitoring data. If you choose this option, HEM-3 will not run AERMOD. HEM-3 will use the external model or monitoring data to interpolate pollutant concentrations for all census blocks in the study domain. Note: This approach is intended to be used with monitoring data or gridded modeling data for a large collection of emission sources. It is not intended to be used with modeling data produced with a polar coordinate system for a single facility. In that situation, you should run HEM-3 in the standard way. [Forcing polar array data into the Voronoi averaging system will cause a loss of data integrity regarding the spatial relationship between the emission source(s) and the receptors.]

You can provide HEM-3 with optional pollutant concentrations using a rectilinear grid, or an arbitrary array of monitored or modeled locations. In either case, HEM-3 analyzes the user-supplied input file to determine the geographic boundaries of the study domain. The model then develops a list of all census blocks with centroids in the study domain.

The model uses a Voronoi Neighborhood Averaging approach to interpolate pollutant concentrations at the census block centroids based on the concentration data you provided. In the interpolation procedure, HEM-3 handles each census block separately. HEM-3 identifies the available pollutant concentration sites near the census block centroid, then creates a Voronoi diagram for the census block centroid and the nearby concentration sites. Essentially, the creation of this Voronoi diagram involves drawing a polygon around the census block centroid. The sides of the polygon are the perpendicular bisects of the line segments from the centroid to the nearest concentration sites. Any concentration site that shares a polygon boundary with the census block centroid (when taking into account all other neighboring boundaries) is considered a "Voronoi" neighbor. Figure 18 shows an example Voronoi diagram for an array of arbitrarily located concentration sites.

Once all Voronoi neighbors have been identified for a given census block centroid, the model estimates the concentration of each pollutant at the centroid. HEM-3 calculates the average

concentration, weighted by the inverse of the distance from the census block centroid to each neighboring location, using the following equation:

$$AC = \exp\left\{\sum_k \left[\ln(VC_k) / D_k\right] / \left(\sum_k 1 / D_k\right)\right\}$$

where:

- AC = estimated ambient pollutant concentration at a given census block centroid ($\mu\text{g}/\text{m}^3$)
- \sum_k = the sum over all Voronoi neighbors, k, of the given census block
- VC_k = pollutant concentration for site k ($\mu\text{g}/\text{m}^3$)
- D_k = distance between the census block centroid and site k (m)

HEM-3 calculates the cancer risks and HI from the estimated ambient concentration using the algorithms given in [Section 4.2.1](#).

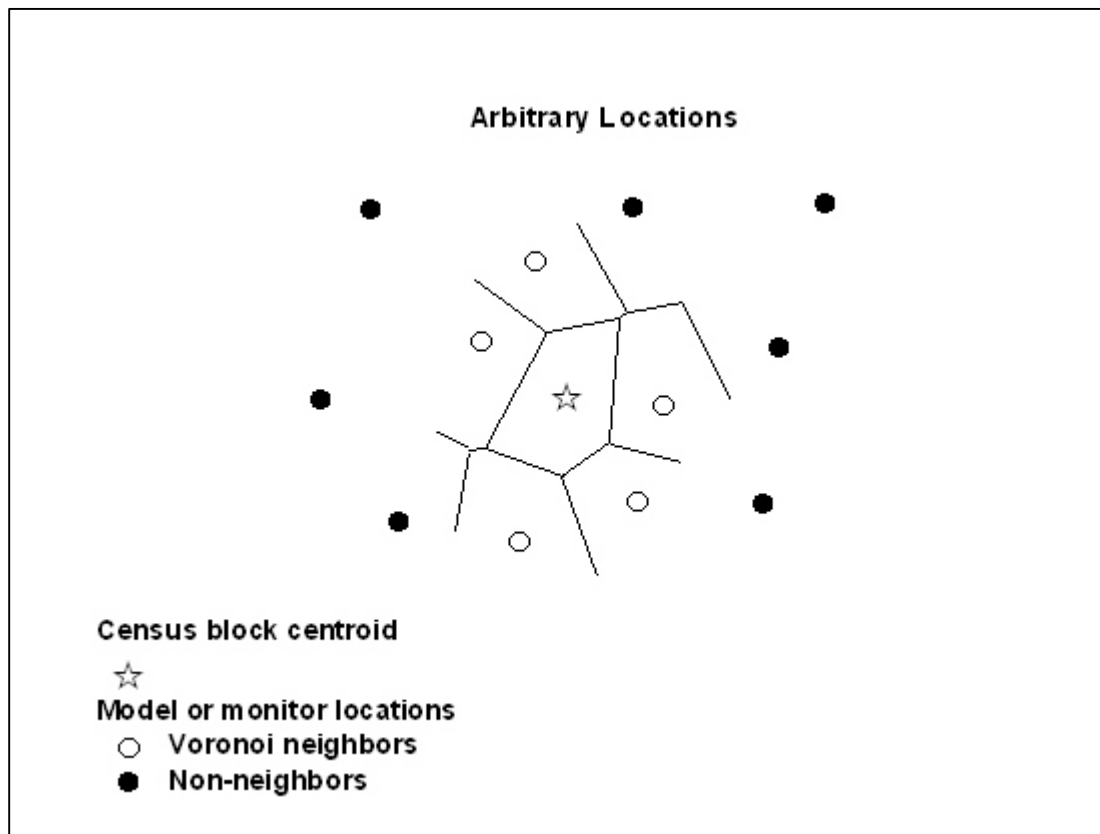


Figure 18. Sample Voronoi diagram.

5. Outputs of HEM-3

After running the AERMOD dispersion model and completing the necessary risk and exposure calculations, HEM-3 displays a series of output tables on the screen. HEM-3 also copies these screen tables to spreadsheets in Excel™ format in the output folder you specified on [Screen 1](#). (If you do not have Excel™, you can use another spreadsheet program, such as Lotus 1-2-3™ to read these files.) Finally, HEM-3 also produces a number of more detailed (dbf) database and spreadsheet files that you can use for other related analyses, such as summarizing the demographics of the populations potentially impacted by the modeled emissions. The following sections describe the output screen tables and files that HEM-3 produces.

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5.1 Maximum Individual Risk and Hazard Indices (Screen 12)

After the modeling run completes, the first output screen displayed by HEM-3 is Screen 12 (**12. Maximum Individual Risk and Hazard Indices**), shown below in Figure 19. This output screen provides the MIR for cancer and the HI for non-cancer chronic health effects, predicted for any populated receptor that does not overlap facility property.

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12. Maximum Individual Risk and Hazard Indices

The table displays the maximum risk and hazard indices (HI) impacting a receptor. The maximum impacts shown below occur at populated receptors, unless a receptor overlaps an emission source, in which case the highest offsite impacts at a polar grid receptor are displayed.

You must select one of the rows in the table before you can click on the 'Details by Pollutant' button or the 'Details by Source' button.

Parameter	Max. Risk or HI	Population	Distance (in meters)	Angle (from north)	Elevation (in meters)	Receptor Type	Notes	County FIPS code	Census Block ID	UTM east (in meters)
Cancer risk	4.2 E-5	3	431.7	252.2	90	Census block		37063	9801001074	690605
Respiratory HI	4.1 E-2	3	431.7	252.2	90	Census block		37063	9801001074	690605
Liver HI	4.4 E-3	3	431.7	252.2	90	Census block		37063	9801001074	690605
Neurological HI	2.7 E-2	3	431.7	252.2	90	Census block		37063	9801001074	690605
Developmental HI	2.6 E-1	3	431.7	252.2	90	Census block		37063	9801001074	690605
Reproductive HI	2.5 E-1	3	431.7	252.2	90	Census block		37063	9801001074	690605
Kidney HI	3.0 E-1	3	431.7	252.2	90	Census block		37063	9801001074	690605
Ocular HI	0	0				na				0
Endocrine HI	1.9 E-5	3	431.7	252.2	90	Census block		37063	9801001074	690605
Hematological HI	1.2 E-5	219	907.6	201.4	86	Census block		37063	0020272057	690684
Immunological HI	1.1 E-2	3	431.7	252.2	90	Census block		37063	9801001074	690605

Exit Help Google Earth Source Map Details by Pollutant... Details by Source... Next >

Figure 19. Screen 12 – Maximum Individual Risk and Hazard Indices

If any populated receptor is located within the [minimum overlap distance](#), then it is assumed that either the source location or the receptor location is inappropriate. (A block centroid may be inappropriate as a receptor location if the block partially encompasses an emission source, such as at a corner of the facility.) When an overlap condition occurs, the calculated results for the overlapping receptor are not used. Instead, the maximum cancer risk and HI are assumed equal

to the maximum impacts for any receptor that does not overlap facility property. This could include both populated (Census, populated user-defined) receptors and unpopulated (polar, unpopulated user-defined such as boundary and monitor) receptors, as long as they do not overlap facility property. When this occurs, a warning message displays. If so, check the coordinates in the [emissions location](#) input file, and define a set of facility boundary receptors in the [user-defined receptors](#) file.

As previously noted, HEM-3 computes cancer risks using the EPA's recommended unit risk estimates (UREs) for HAP and other toxic air pollutants. The resulting estimates reflect the risk of developing cancer for an individual breathing the ambient air at a given receptor site over a 70-year lifetime. Non-cancer health effects are quantified using hazard quotients (HQ) and hazard indices (HI) for various target organs. The HQ for a given chemical and receptor site is the ratio of the ambient concentration of the chemical to the reference concentration (RfC) level at which no adverse effects are expected. The HI for a given organ is the sum of HQs for substances that affect that organ.

In the example shown above in Figure 19, the maximum individual cancer risk or MIR for the modeled facility is $4.2 \text{ E-}5$ (or 42 in 1 million). That is, an individual's risk of developing cancer at the receptor site of maximum cancer risk impact is approximately 42 in 1 million. This is a conservative estimate, based on a resident being continually exposed to the ambient (outdoor) air over a 70-year lifetime, and is not adjusted with any attenuating exposure factors (such as daily movement out of the maximum receptor site for work and other reasons, indoor versus outdoor concentrations, the fact that people rarely live in one location for 70 years, etc.). The maximum target-organ specific hazard indices (TOSHIs) shown in Figure 19 are all less than 1. Therefore, these TOSHIs are below the level at which chronic non-cancer adverse effects would be expected as a result of lifetime exposure to the ambient air at the receptor site(s) of maximum impact for each target-organ specific hazard (e.g., the respiratory HI is 0.041, the liver HI is 0.0044, the neurological HI is 0.027, etc.). Note that the receptor location of maximum impact for each health effect—cancer, respiratory HI, neurological HI, etc.—may not be the same.

As Figure 19 shows, one health effect is listed per row. These health effects are: cancer risk; and chronic maximum TOSHIs for the respiratory system, liver, neurological system, developmental effects, reproductive system, kidney, ocular system, endocrine system, hematological system, immunological system, skeletal system, spleen, thyroid, and whole body. To view the contribution of different pollutants to the maximum cancer risk, or to any of the HI, highlight the appropriate line, then click the "Details by Pollutant" button. The pollutant contributions to the maximum cancer risk will be displayed in order of highest impact, as shown below in Figure 20.

In the example shown in Figure 20, the arsenic concentration contributed by all emission sources to the receptor location of maximum overall risk (the census block shown in the first output row in Figure 19) is $3.8 \text{ E-}3$ (or $0.0038 \mu\text{g}/\text{m}^3$). The cancer risk resulting from lifetime exposure to this concentration of arsenic is $1.6 \text{ E-}5$ (or 16 in 1 million). The sum of risk at this receptor location from all modeled pollutants listed in Figure 20 equals the overall cancer risk or MIR ($4.2 \text{ E-}5$) listed in the first row on Screen 12, shown in Figure 19.

To view the contribution of different emission sources to the maximum risk and maximum HI, highlight the row of interest on Screen 12, then click the "Details by Source" button, as shown below in Figure 21. In this example, the source identified as "SAMPLE2" contributes $2.2 \text{ E-}5$ (or 22 in 1 million) to the overall risk shown in the first output line of Figure 19. The sum of risk for

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Figure 21. Maximum Cancer Risk by Source Output Screen

To view a schematic of the locations of the maximum cancer risk and HI in comparison to the locations of the emission sources, highlight any lines on Screen 12 (Figure 19), then click the “Source Map” button.

If you requested that a map of all receptors be produced (on [Screen 1](#)), highlight any of the receptor lines on Screen 12, then click the “Google Earth™” button to view a Google Earth™ map centered on the facility, as shown in Figure 22. The map displays the emission sources in the center as pale red circles for point sources and rectangles for area sources. The map also displays all receptors within the modeled area, including both census block centroid receptors (displayed as squares) and polar grid receptors (displayed as circles). The MIR receptor is marked with a red “X”.

Click on the square census block receptors to see the total cancer risk and maximum TOSHI for that receptor, the FIPS and block ID of the receptor, as well as a listing of the top pollutants contributing to that block’s total cancer risk and maximum TOSHI. Click on the circular polar receptors to view the total cancer risk at that polar receptor, as well as the listing of the top pollutants contributing to that receptor’s risk.

The cancer risk at the census block and polar receptors are color coded on the Google Earth™ map. Red indicates a receptor with a modeled total cancer risk greater than or equal to 100 in a million. Yellow indicates risk greater than or equal to 20 but less than 100 in a million. Green indicates a risk less than 20 in 1 million.

Figure 22 shows an example in which only non-populated polar grid receptors have a risk greater than 100 in a million (shown as dark red circles). All populated census block receptors have modeled risks between 20 and 100 in a million (shown as yellow squares) or less than 20 in a million (shown as green squares).

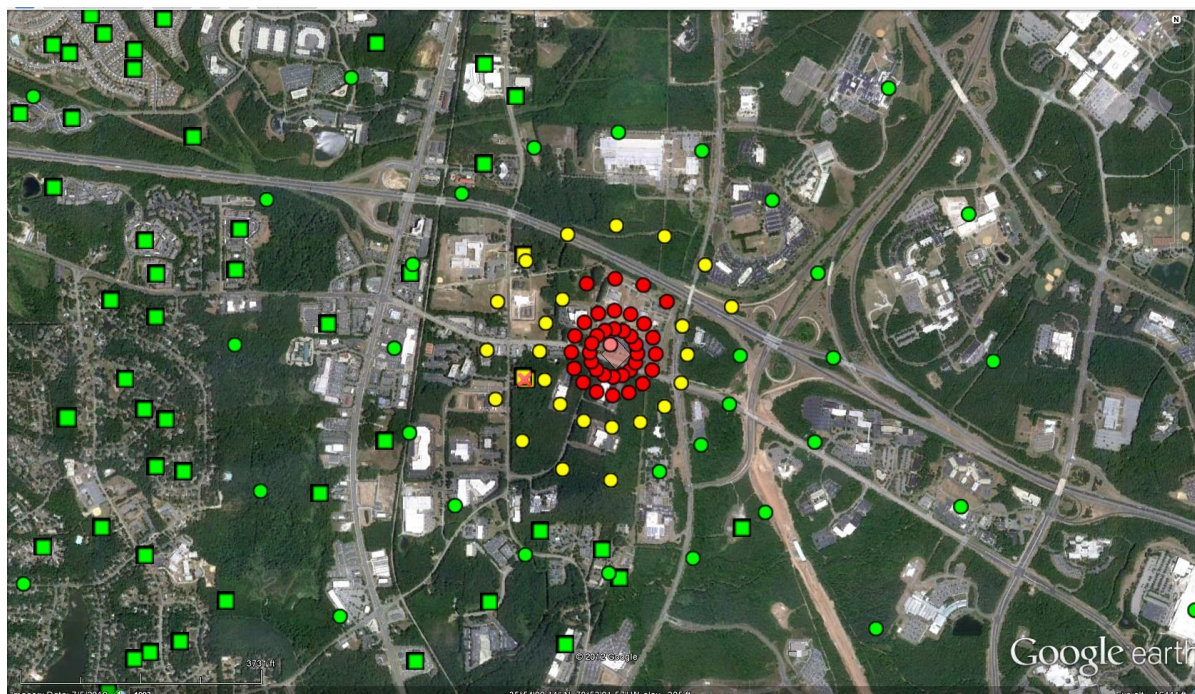


Figure 22. Sample Google Earth™ Map of Results

Note that HEM-3 does not produce a Google Earth™ results map if you answered “No” to the [Screen 1](#) question “Do you want output files and a map of results for all receptors, by pollutant and source?”

Table 27 shows the fields displayed in both Screen 12 (**12. Maximum Individual Risk and Hazard Indices**) and Screen 13 (**13. Maximum Offsite Impacts and Locations**). See [Section 5.2](#) for a discussion of Screen 13.

Table 27. Fields Included in the Maximum Individual Risk and Hazard Indices Output Screen and Maximum Offsite Impacts and Locations Output Screen

Field	Description
Parameter name	Maximum individual cancer risk (MIR), maximum respiratory HI, maximum liver HI, maximum neurological HI, etc.
Max. Risk or HI Value	MIR value or maximum TOSHI value.
Population	at the location of the MIR or maximum HI, if it is a census block.
Distance	from the center of the modeling domain, in meters.
Angle	from north.
Elevation	in meters above sea level.
Receptor type	census block receptor, polar grid receptor, user-defined receptor, boundary receptor, monitor location.
Notes	An entry in this field will generally mean that the modeling analysis should be rerun. This field will provide advice on how to change model input files or other specifications.
County FIPS code	five-digit Federal Information Processing Standard (FIPS) code which uniquely identifies the county of the receptor, if the receptor is a census block.
Census block identifier	10-digit census block ID for linking to census demographic data, if the receptor is a census block.
UTM easting coordinate	in meters.
UTM northing coordinate	in meters.
Latitude	decimal.
Longitude	decimal.
Hill Height	controlling hill height of receptor, in meters above sea level, as described in Section 2.3.1 .

As noted above, the information provided on the output screens is also automatically placed in files in HEM-3's Output directory within the folder you named on [Screen 1](#). In this directory and folder, HEM-3 automatically produces an Excel™ file entitled “maximum_indiv_risks.xls” that includes all of the data tabulated on Screen 12 (although not in the identical order as shown above in Table 27). HEM-3 also produces another file, entitled “risk_breakdown.xls” that provides the breakdown of risk and HI by pollutant and source, including a listing of pollutant concentration and URE and RfC values.

This file also shows the contributions of gaseous and particulate emissions for any chemicals that are emitted in both forms, if, on the deposition screen ([Screen 3](#)), you elected to show the

particulate/gaseous breakdown. Table 28 shows the fields included in the risk breakdown file. This file includes information about the MIR and HI, as well as the maximum offsite impacts, as discussed below in [Section 5.2](#).

Table 28. Fields Included in the Risk Breakdown File

Field	Description
Site type	MIR or maximum offsite impact
Parameter name	cancer risk, respiratory HI, liver HI, neurological HI, etc.
Source ID	Identifying name of source, or “total” for all sources combined
Pollutant	pollutant name, or “all modeled pollutants” for all pollutants combined
Emission (Pollutant) type	P = particulate, V = vapor, NA = not applicable (for output lines regarding all pollutants, or when breakdown not requested on Screen 3)
Value	cancer risk or non-cancer HQ
Value_rnd	cancer risk or non-cancer HQ rounded to two significant figures
Conc_ugm3	pollutant concentration ($\mu\text{g}/\text{m}^3$)
Conc_rnd	pollutant concentration ($\mu\text{g}/\text{m}^3$) rounded to two significant figures
Emission tpy	Modeled tons per year (tpy) emitted of pollutant
URE	unit risk estimate used to compute cancer risks for the pollutant
RfC	reference concentration used to compute HQs for the pollutant ($\mu\text{g}/\text{m}^3$)

Click “Next” on [Screen 12](#) to proceed to Screen 13, entitled *Maximum Offsite Impacts and Locations*.

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5.2 Maximum Offsite Impacts and Locations (Screen 13)

Screen 13 (**13. Maximum Offsite Impacts and Locations**), shown below in Figure 23, displays a table listing the highest cancer risks and HI predicted at any receptor that does not overlap with the emission sources, whether the receptor is populated or unpopulated. The receptors included in this calculation include all census blocks, all user-defined receptors (including boundary sites and ambient monitor sites), and all points in the polar receptor network, except for those receptors overlapping emission sources. [Note: Polar grid receptors are defined in HEM-3 as unpopulated and, therefore, 0 (zero) population is associated with polar receptor results, as can be seen in Figure 23.]

The format is the same as in Screen 12 (Maximum Individual Risk and Hazard Indices screen). Each row displays one of the following health effects: cancer risk; and maximum chronic TOSHI including respiratory HI, liver HI, neurological HI, developmental HI, reproductive HI, kidney HI, ocular HI, endocrine HI, hematological HI, immunological HI, skeletal HI, spleen HI, thyroid HI, and whole body HI. [Table 27](#) above explains the fields displayed on Screen 13.

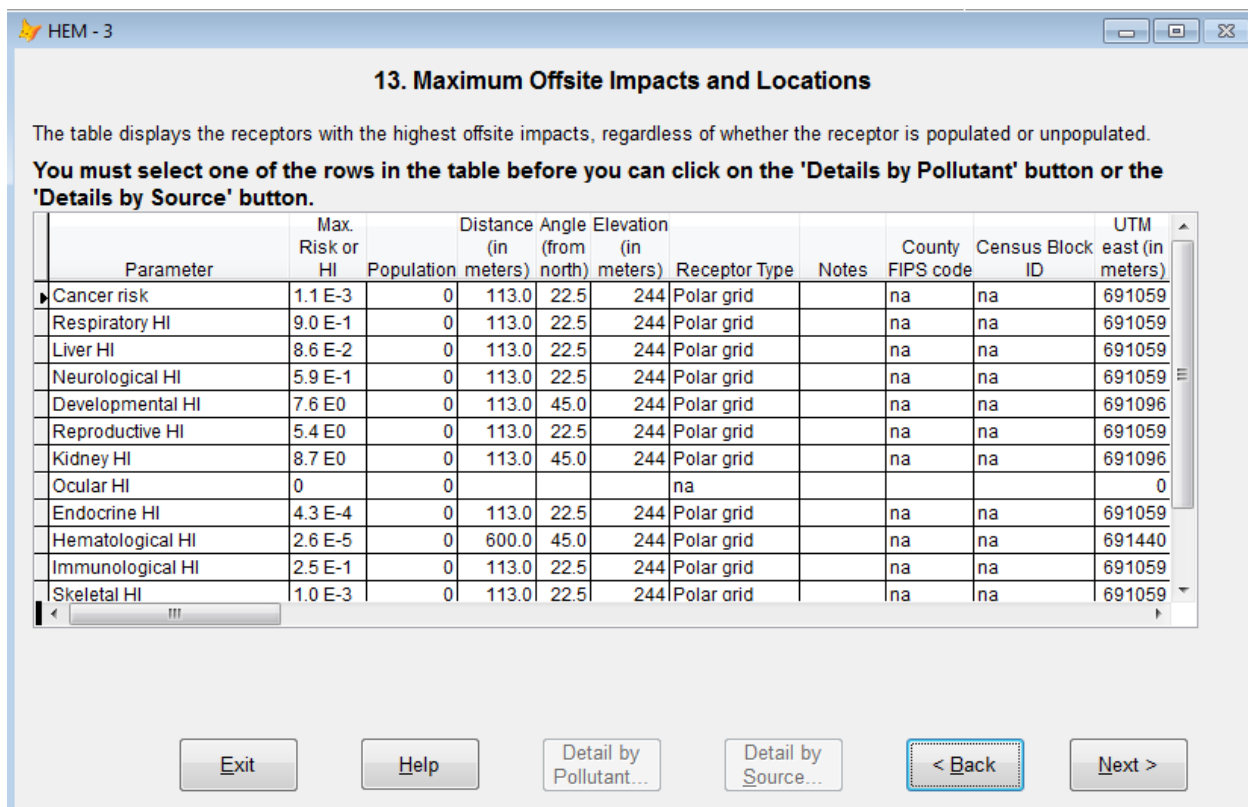


Figure 23. Screen 13 – Maximum Offsite Impacts and Locations

Similar to the MIR and HI screen ([Screen 12](#)), to view the contribution of different chemicals to the maximum offsite cancer risk, or to any of the offsite HI, highlight the desired output row, then click the “Details by Pollutant” button. Likewise, to view the contribution of different emission sources, highlight the desired row, then click the “Details by Source” button.

As noted previously, the information provided on these output screens is also placed in files in HEM-3’s Output directory within the folder you named on [Screen 1](#). HEM-3 automatically produces an Excel™ file entitled “maximum_offsite_impact.xls” that includes all of the data tabulated on this screen. In addition, the risk breakdown file (“risk_breakdown.xls”) includes the contributions of individual chemicals and emission sources to the maximum offsite impacts. [Table 28](#) above shows the fields included in the risk breakdown file.

Click “Next” button on Screen 13 to proceed to [Screen 14](#), entitled *Estimated Cancer and Non-Cancer Population Risk*.

5.3 Estimated Cancer and Non-Cancer Population Risk (Screen 14)

Screen 14 (**14. Estimated Cancer and Non-Cancer Population Risk**), shown below in Figure 24, presents two tables that estimate the populations exposed to different cancer risk levels and to different HIs for non-cancer effects. The screen also displays the potential annual cancer incidence. In the example shown in Figure 24, approximately 21,000 people are predicted to have a cancer risk greater than or equal to 1 in 1 million as a result of the facility's modeled emissions. Approximately 235 people are predicted to have a cancer risk greater than or equal to 1 in 100,000, or 10 in 1 million. Regarding chronic non-cancer HI predictions, shown in the second table of Figure 24, no people are estimated to experience an HI greater than 1. That is, no one is predicted to experience chronic non-cancer adverse effects as a result of lifetime exposure to the modeled ambient air at the receptor site(s) of maximum impact for each TOSHI. This is consistent with the maximum TOSHIs being less than 1 (as displayed in [Figure 19](#)).

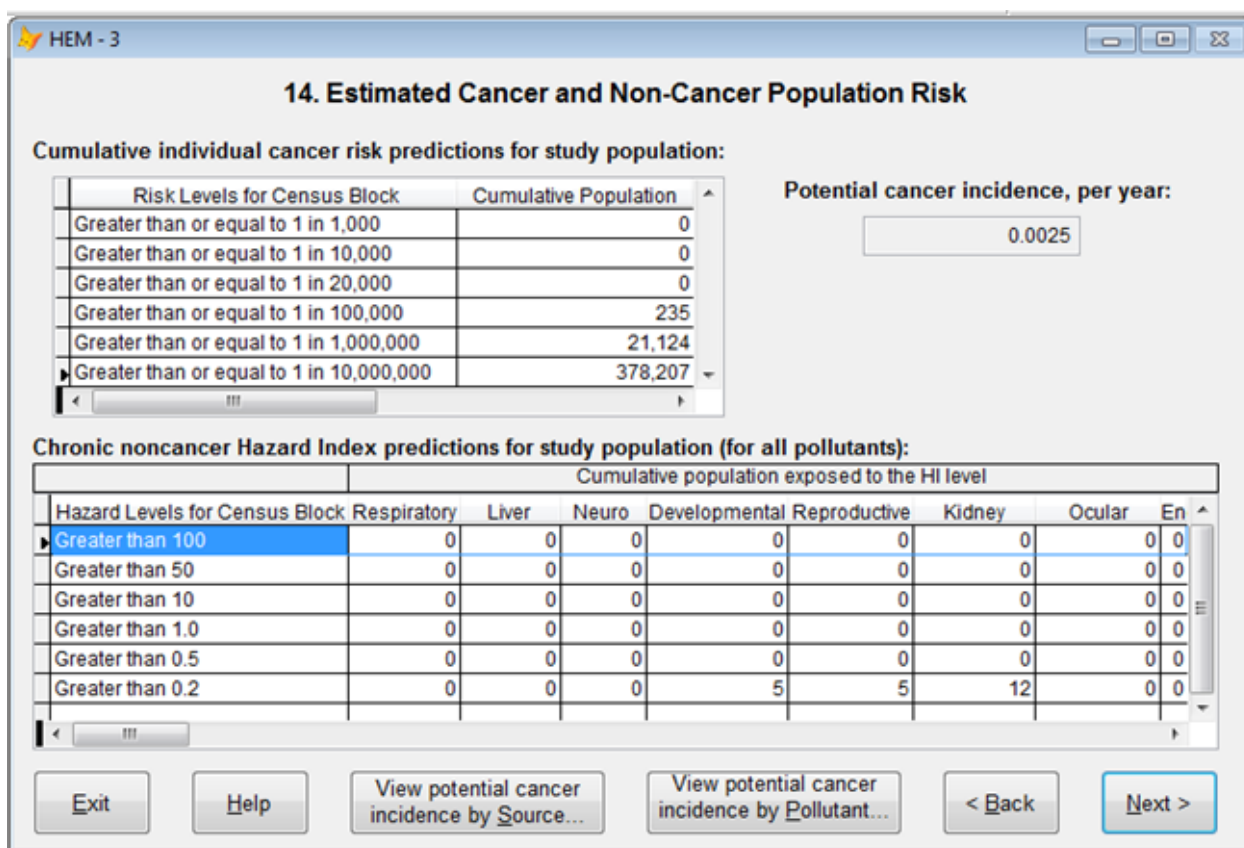


Figure 24. Screen 14 – Estimated Cancer and Non-Cancer Population Risk

The total cancer incidence (shown in Figure 24) is estimated to be considerably less than 1 excess cancer case per year. That is, 0.0025 excess cancer cases per year are predicted for the study region as a result of the facility's modeled emissions (and assuming continuous inhalation of the outdoor air for 70-year lifetimes, as well as the other conservative assumptions noted above).

Click on the “View potential cancer incidence by Source” button to see the contribution to total incidence made by each individual source (i.e., the source-specific incidence). Click on the “View potential cancer incidence by Pollutant” button to see the contribution to total incidence made by each modeled pollutant (i.e., the pollutant-specific incidence).

HEM-3 also automatically creates three Excel™ files, entitled “Cancer_risk_exposure.xls”, “Noncancer_risk_exposure.xls”, and “incidence.xls” containing the information provided in [Figure 24](#). You can find these in the user-named folder of HEM-3’s Output directory.

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5.4 Cancer Risk by Distance (Screen 15)

Screen 15 (**15. Cancer Risk by Distance**), shown below in Figure 25, displays the average cancer risk and the estimated total potential cancer incidence (or excess cancers per year) for the populations living within each of the ring distances specified for the [polar receptor network](#). This screen also displays the total population for all census blocks with geographic “centroids” inside each ring distance.

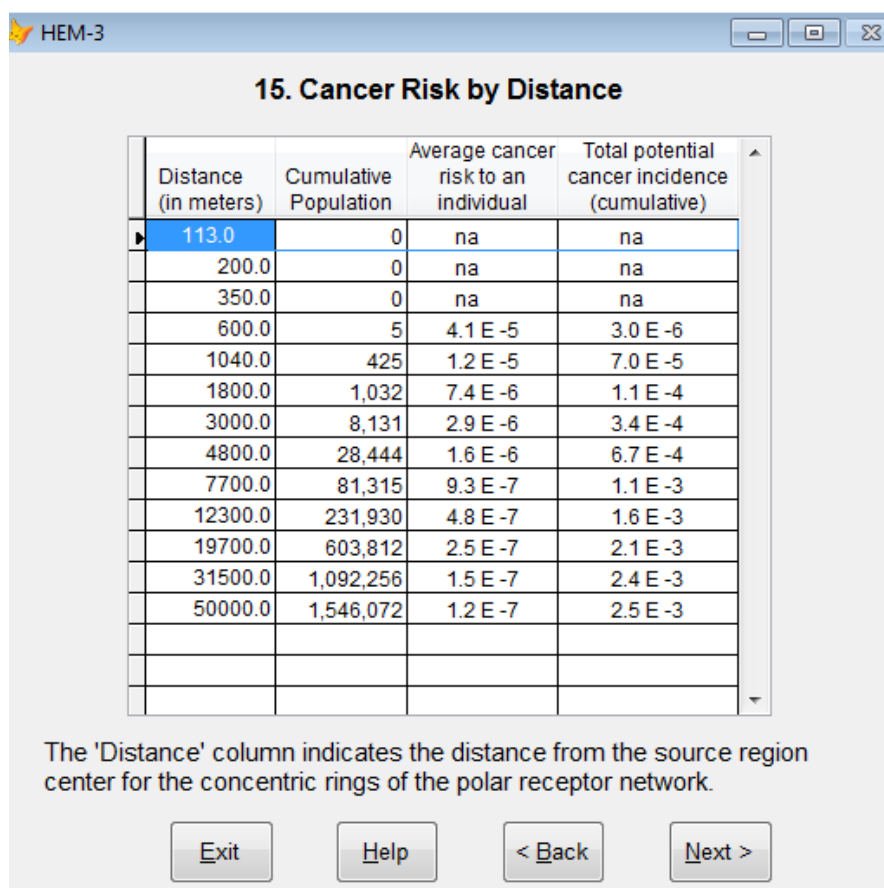


Figure 25. Screen 15 – Cancer Risk by Distance

In the example shown in Figure 25, there are 1,546,072 people living within 50,000 meters (50 km) of the modeled facility. Taking into account this total number of people living within 50 km of the center of the modeled facility, the average cancer risk to an individual in the study area is

1.2 E-7 and the total incidence is 2.5 E-3 (consistent with the incidence of 0.0025 reported in [Figure 24](#)). Figure 25 also reveals that there are 5 people living between 350 and 600 meters from the modeled facility, and that the average risk to someone at this distance is 4.1 E-5 (41 in 1 million). This risk is similar to the MIR, but not identical because the MIR is for the census block of maximum impact and these 5 people happen to reside in more than that one MIR census block. The incidence at this same distance is only 3.0 E-6, given the small population.

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5.5 Optional Maximum Short-Term Impacts (Screens 16 and 17)

If you selected the “acute” option on [Screen 1](#), the next screen HEM-3 displays is Screen 16 (**16. Maximum Offsite Short Term Acute Concentrations Compared with Reference Concentrations for Populated Receptors**), shown below in Figure 26. You can use this table to make comparisons of the maximum predicted acute pollutant concentrations with available short-term benchmark levels for populated census block and population-oriented (“P”) user-defined receptors.

Pollutant	Maximum Concentration (µg/m3)	Notes	AEGL_1 (1hr) (mg/m3)	AEGL_1 (8hr) (mg/m3)	AEGL_2 (1hr) (mg/m3)	AEGL_2 (8hr) (mg/m3)	ERPG_1 (mg/m3)
Cadmium compounds	6.7E+00						
Arsenic compounds	8.6E+00						
Benzene	2.3E+02		170.0000	29.00000	2600.000	640.0000	160.0000
1,3-Butadiene	4.9E+02		1500.000	1500.000	12000.00	6000.000	22.00000
Mercury (elemental)	2.5E-02				1.700000	.3300000	
Hydrofluoric acid	6.5E-01		.8200000	.8200000	20.00000	9.800000	1.600000
Chloroform	3.2E+00				310.0000	140.0000	
Cyanide compounds	1.8E+01						
Xylenes (mixed)	7.4E+01		560.0000	560.0000	4000.000	1700.000	
Naphthalene	1.2E+02						
Trichloroethylene	7.8E+00		700.0000	410.0000	2400.000	1300.000	540.0000
Selenium compounds	5.6E-02						
Aniline	1.6E+00		30.00000	3.800000	46.00000	5.700000	

Figure 26. Screen 16 – Maximum Offsite Short Term Acute Concentrations Compared with Reference Concentrations for Populated Receptors

Click “Next” to proceed to Screen 17, (**17. Maximum Offsite Short Term Acute Concentrations Compared with Reference Concentrations for All Receptors**), shown below in Figure 27. This second acute table is for all receptors—populated or unpopulated—including census blocks, polar grid receptors, and user-defined receptors. Thus, this table shows the maximum acute concentrations occurring anywhere offsite. If a pollutant’s maximum acute concentration occurs at a populated census block, then the results for that pollutant will be the same in both tables (Screens 16 and 17). If not, the all receptors table (Screen 17) will show the maximum, while the pollutant concentration (Screen 16) will be less than the maximum. Therefore, we recommend that you review Screen 17’s table when looking for the maximum offsite acute concentration.

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17. Maximum Offsite Short Term Acute Concentrations Compared with Reference Concentrations For All Receptors

Pollutant	Maximum Concentration (µg/m ³)	Notes	AEGL_1 (1hr) (mg/m ³)	AEGL_1 (8hr) (mg/m ³)	AEGL_2 (1hr) (mg/m ³)	AEGL_2 (8hr) (mg/m ³)
Cadmium compounds	4.9E+01					
Arsenic compounds	6.3E+01					
Benzene	1.7E+03		170.0000	29.00000	2600.000	640.0000
1,3-Butadiene	3.7E+03		1500.000	1500.000	12000.00	6000.000
Hydrofluoric acid	4.9E+00		.8200000	.8200000	20.00000	9.800000
Chloroform	2.5E+01				310.0000	140.0000
Mercury (elemental)	3.7E-02				1.700000	.3300000
Cyanide compounds	1.4E+02					
Xylenes (mixed)	5.7E+02		560.0000	560.0000	4000.000	1700.000
Naphthalene	9.4E+02					
Trichloroethylene	5.9E+01		700.0000	410.0000	2400.000	1300.000
Aniline	1.2E+01		30.00000	3.800000	46.00000	5.700000
Selenium compounds	8.1E-02					

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Figure 27. Screen 17 – Maximum Offsite Short-Term Acute Concentrations Compared with Reference Concentrations for All Receptors

[Table 29](#) shows the fields included in these tables, with a brief description for each benchmark. The EPA's Air Toxics Risk Assessment Library ([EPA 2004f](#)) provides a more detailed description of these acute benchmarks (available for download at www.epa.gov/ttn/fera/risk_atra_vol1.html). The information listed in [Table 29](#) is also output in two Excel™ files, that HEM-3 places in the user-named folder of your Output directory, entitled "Acute_chem_pop.xls" and "Acute_chem_unpop.xls". The "Acute_chem_pop.xls" output file contains the information displayed on Screen 16 ([Figure 26](#)); and the "Acute_chem_unpop.xls" output file contains the information displayed on Screen 17 ([Figure 27](#)). Note that these files specify the receptor where the maximum impact occurs for each pollutant, considering all sources.

HEM-3 also produces a third acute output file entitled "Acute_bkdn.xls" giving the contribution of each emission source to the receptor of maximum impact for each pollutant (i.e., the acute concentration of pollutant at the maximum receptor caused by each source). The acute breakdown file includes columns for: pollutant; source ID; emission type (P = particle, V = vapor, C = combined); the maximum pollutant concentration (µg/m³) at a populated receptor; the maximum pollutant concentration (µg/m³) at all receptors (both populated and unpopulated); and flag columns indicating that the pollutant's maximum concentration was interpolated. [Note: Concentration values are interpolated outside the [Distance for individual modeling of census blocks](#)—for example, between 3 km and 50 km. A breakdown by individual sources is not available for interpolated concentrations.]

Table 29. Fields Included in the Maximum Offsite Short-Term Concentration Screens

Field	Description
Pollutant	Chemical name
Maximum concentration	units = $\mu\text{g}/\text{m}^3$
Notes	An entry in this field will generally mean that the modeling analysis should be rerun. This field will provide advice on how to change model input files or other specifications.
AEGL-1, 1-hour	Acute Exposure Guideline Level 1 (AEGL-1) for a 1-hour exposure: the concentration above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects (mg/m^3).
AEGL-1, 8-hour	See AEGL-1 above, but for an 8-hour exposure.
AEGL-2, 1-hour	Concentration above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape for a 1-hour exposure (mg/m^3).
AEGL-2, 8-hour	See AEGL-2 above, but for an 8-hour exposure.
ERPG-1	Emergency Response Planning Guideline 1 (ERPG-1): concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor (mg/m^3).
ERPG-2	Concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action (mg/m^3).
IDLH/10	Immediately Dangerous to Life or Health: concentration believed likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment, divided by a factor of 10 (mg/m^3).
MRL	Acute Minimal Risk Level: daily human exposure that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure (mg/m^3).
REL	Reference Exposure Level: concentration below which no adverse health effects are anticipated, based on the most sensitive adverse health effect reported (mg/m^3).
TEEL_0	Temporary Emergency Exposure Limit 0 (TEEL) defined by the U.S. Department of Energy: the threshold concentration below which most people will experience no adverse health effects.
TEEL_1	Maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or perceiving a clearly defined objectionable odor.
Block population	if the receptor is a census block
Distance	from the center of the modeling domain (meters)
Angle	from north
Elevation	meters above sea level
County FIPS code	if the receptor is a census block
Census block identifier	for linking to demographic data (if the receptor is a census block)
UTM east coordinate	meters
UTM north coordinate	meters
Latitude	decimal
Longitude	decimal
Receptor type	C = census block, P = user-defined population receptor, PG = polar grid receptor point, B = boundary, M = monitor

5.6 Additional Output Files

In addition to the Excel™ output files discussed above, HEM-3 produces other output files that will also be located in the user-named folder of HEM-3's Output directory, once the model has completed its run. HEM-3 automatically produces some of these files; others are optional and are produced based on the modeling options you chose. These files are discussed below.

5.6.1 Block and Ring Summary Output Files

HEM-3 automatically produces two Dbase™ formatted (DBF) output files that give total cancer risks and HI for all of the modeled receptors and interpolated receptors in the modeling domain. These files are:

- Block_summary_chronic.dbf
- Ring_summary_chronic.dbf

The “block summary” file gives the total estimated cancer risk at each receptor, as well organ-specific HI for chronic non-cancer effects for the census block locations. The “ring summary” file provides these same results for points in the polar receptor network.

To facilitate detailed GIS analyses of HEM-3 results, each file gives the latitude and longitude, and the UTM coordinates of each receptor, in addition to cancer risk estimates and HI. The “block summary” file also gives the county FIPS code, block identification number, and population of each census block. This information is intended to facilitate studies linking HEM-3 results with census information, such as demographic or economic data.

5.6.2 Quality Assurance Output Files

HEM-3 also automatically provides a set of files designed to facilitate tracking and quality assurance of the model run. These files are described below:

- Input_selection_options.xls – lists the options and input file names specified by you in the user input screens.
- Overlapping_source_receptors.xls – lists receptors that were identified as located within the user-specified overlap distance of an emission source.
- Aermod.out – the dispersion model log file showing inputs data, selected options, outputs, and warning or error messages. Review Aermod.out to confirm that AERMOD completed its modeling without error; any errors internal to the AERMOD portion of HEM-3's run will be noted in this log file. [Note: Concentration results in Aermod.out and Aermod1.out should not be interpreted as predicted concentrations of any modeled pollutant; rather they reflect concentrations that result from a unit-emission rate (1 kg/s)].
- Aermod1.out – a second dispersion model log file produced in cases where both gases and particulate emissions are being modeled separately.

5.6.3 Optional Detailed Output Files

Finally, HEM-3 can produce six optional files providing more detailed results. These files are produced if you chose to produce them via the appropriate input screen (listed in parentheses next to each optional file name) below:

- All_inner_receptors.dbf ([Screen 1](#))
- All_outer_receptors.dbf ([Screen 1](#))
- All_polar_receptors.dbf ([Screen 1](#))
- Allreceptors_risk.kmz ([Screen 1](#))
- Cancer_histogram.xls ([Screen 4](#))
- Temporal.csv and Temporal.dbf ([Screen 6](#))

The four “all receptors” files provide detailed model predictions for all of the receptors in the modeling domain. Select ‘Yes’ to the all receptors question on [Screen 1](#) (“Do you want output files and a map of results for all receptors, by pollutant and source?”) and HEM-3 will produce these files. Each file gives the estimated incremental ambient concentration impact for all emission sources and for all pollutants included in the model analysis.

The “all_inner_receptors” file addresses all of the census block receptors inside the modeling [cutoff distance](#), as well as all of the [user-defined receptors](#). This file will also contain the deposition flux (in g/m²/y) if you opted to model deposition and depletion on [Screen 3](#). Columns for both wet and dry deposition flux results are provided (Wdp_g_m2_y and Ddp_g_m2_y, respectively) and will be populated with non-zero results depending on the type of deposition modeling (wet, dry or both) you selected on [Screen 3](#). [Note: If you did not choose to produce the all receptors files (Screen 1), but did choose to model deposition and depletion (Screen 3), then the deposition flux values will be located in the aermod.out output file.)

The “all_outer_receptors” file includes all of the census block receptors that have been interpolated; that is, all receptors located between the modeling [cutoff distance](#) (often specified as 3 km) and the [outer edge of the modeling domain](#) (often specified as 50 km). The all_polar_receptors file provides detailed concentration estimates for the nodes of the [polar receptor grid](#). The Allreceptors_risk.kmz is the Google Earth™ map of results at each receptor. [Figure 22](#) is an example of such a map.

The cancer histogram file gives estimates of the numbers of people exposed to different cancer risk levels, similar to the cancer risk exposure Excel™ file (Figure 25 in [Section 5.4](#)). However, the cancer histogram file includes many more risk levels than the default Excel™ file; 10 exposure bins for each factor of 10 change in estimated cancer risk. To produce this more detailed cancer histogram output file, select “Yes” for this option (“Do you want to create a detailed histogram of cancer risks?”) on [Screen 4](#).

If you selected “Yes” to output temporal or wind speed variations in emissions on [Screen 6](#), HEM-3 will create two output files named temporal.csv and temporal.dbf in your designated HEM-3 Output folder. The temporal.csv output is a comma delimited text file which may be readily imported and converted into an Excel™ spreadsheet. The Temporal output files contain annual average pollutant concentrations at different times of day for all pollutants and all receptors. This output file provides data suitable for the Hazardous Air Pollutant Exposure Model (HAPEM), which divides the day into eight 3-hour time blocks ([EPA, 2007b](#)). However,

the number of time blocks available in HEM-3's outputs is variable and depends on what output resolution you selected on [Screen 6](#).

For example, if you chose to vary emissions by the hour of day and output the concentrations diurnally, the temporal.csv and temporal.dbf output files will contain annual average pollutant concentrations at different times of day for all pollutants and all receptors. HEM-3 will compute the hour of day emissions using the resolution you selected (e.g., 1-hour through 24-hour). If you opt for 1-hour resolution and to show seasonal variations in the outputs, the temporal output files will show 96 concentrations for each receptor and pollutant. The first 24 values will represent 24-hour-day winter concentrations, the second 24 values will represent spring concentrations, the third 24 values will represent summer concentrations, and the last 24 concentrations will represent fall.

In general, we recommend that you refer to the [temporal input file guidelines](#) to help accurately interpret the order of concentration values in the Temporal output files, because the order of output concentrations is consistent with the order of the temporal factors expected by AERMOD in the inputs.

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5.7 Outputs Produced for User-Supplied Pollutant Concentration Data

In HEM-3, you can (on [Screen 1](#)) provide pollutant concentrations from an external model or from monitoring data, rather than using AERMOD in the HEM-3 run to produce ambient concentrations. When you select this option, HEM-3 will create the following output files:

- User_conc_data_maximum_risk.xls – Table of the highest pollutant-specific chronic concentrations, pollutant-specific cancer risks, total cancer risks, pollutant-specific TOSHI, total TOSHI, and (optionally) pollutant-specific acute concentrations predicted for any receptor within the modeling domain. This table also includes the FIPS code, census block ID and block population of the maximum receptor(s).
- User_conc_data_incidence.xls – Table of estimated annual cancer incidence as a result of exposure to the pollutants included in the user-supplied concentration file, including both total incidence and pollutant-specific incidence.
- User_conc_data_cancer_histogram.xls – Histogram of the numbers of people exposed to different levels of total inhalation cancer risk. This file includes population numbers binned according to risk greater than (“risk_ge”) and risk less than (“risk_lt”) levels.
- User_conc_data_HI_histogram – Histogram of the numbers of people exposed to different levels of HI for different target organs. This file includes population numbers for each TOSHI (e.g., “no_resp” for the number of people with a respiratory HI) binned according to TOSHI values greater than (“toshi_ge”) and TOSHI values less than (“toshi_lt”) levels.
- User_conc_data_block_summary.dbf – Database of total cancer risk and total TOSHI for each census block in the modeling domain.
- User_conc_data_detail_output – Database of cancer risk estimates and TOSHI for specific pollutants at each census block in the modeling domain.

6. HEM-3 Error Messages

Table 30 lists alphabetically the error messages you may encounter when running HEM-3, as well as the meaning and cause of these errors, which will allow you to remedy the error for a successful modeling run.

Table 30. HEM-3 Error Messages

Error Message	Meaning / Cause
A receptor must be close to the plant to be a candidate for removal from the list of receptors to be modeled. For this configuration, there are no receptors that meet that criteria.	There are no receptors close enough to the plant to be removed.
Aermod did not complete successfully. If you are using deposition or depletion, make sure the HAP emissions input file has the percent particle column populated for each emission. HEM-3 will end when you click on 'OK'.	Error occurred while running AERMOD. Error message is listed in the AERMOD.OUT file.
Error! Unknown temporal type: "Temporal Type" in file "VarFile" HEM-3 will end. Please correct this file before rerunning HEM-3.	An invalid temporal type is in the emissions temporal variations file. Valid entries are: SEASON, WSPEED, MONTH, HROFDAY, SEASHR, SHRDOW, or SHRDOW7.
For an urban environment, the population of the area must be at least 50,000.	Urban dispersion was chosen, but too small of an urban population was entered. It must be at least 50,000.
For facility "cFacility" the distance entered for modeling census blocks individual is greater than the maximum modeling distance. This will keep HEM-3 from modeling this facility correctly. HEM-3 will end which will allow you to fix the problem.	The radius in which individual census blocks are used as model receptors cannot be larger than the maximum modeling distance.
Google Earth is not installed on your computer. To install, go to http://pack.google.com/intl/en/integrated_eula.html?hl=en&ciint=ci_earth&ci_earth=on&utm_source=en-cdr-earth4&utm_medium=cdr&utm_campaign=e	Google Earth is required to view the map of modeling results.
No Census blocks were found in the specified domain. HEM-3 cannot continue with the input and will end when you click 'Ok'.	The modeling domain included in the input file for Voronoi modeling does not overlap any census blocks.
No emissions were input. HEM-3 will end when you click on 'OK'.	No emission sources were input.

Error Message	Meaning / Cause
Recheck the value you selected in the listbox for Particle and Vapor emissions.	On the deposition and depletion entry screen for ISC, the only valid options for particle and vapor emissions are Particle, Vapor, or Both.
Some pollutants are missing for one or more receptors. HEM-3 will end.	The input file used for Voronoi modeling must have the same set of chemicals at each receptor network.
The approximate ratio value cannot be zero. The smallest number possible for this value is 1.	
The definition of landuse filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	Invalid landuse filename.
The definition of seasons filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	Invalid seasons filename.
The emission location filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	An invalid Emission Locations input filename was entered.
The emission variations filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the folder names.	Invalid emission variations filename.
The filename you entered for the building downwash data is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	An invalid Building Downwash input filename was entered.
The folder name you have specified already exists. Do you want to overwrite the files in this folder? Select 'Yes' to overwrite the folder or select 'No' to enter a different name for the folder.	The specified output folder name already exists.
The HAP emissions filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	An invalid HAP emissions input filename was entered.
The magnitude of the maximum individual risk is too small to compute the input for Crystal Ball. No output file will be created by HEM-3.	The maximum cancer risk value is too small to generate risk level intervals.
The number of concentric circles is either less than 3 or greater than 30 for facility "Facility Name". You must end HEM-3 and correct this problem before you can run HEM-3 successfully.	The number of polar receptor rings must be between 3 and 30 inclusive.

Error Message	Meaning / Cause
The source_id, "XXXXXX", at facility, "FFFFFF ", does not exist in the emissions locations input file. HEM-3 will end so you can find and correct the error in your input file. Once the error has been fixed, run HEM-3 again.	There is a source id in the HAP emissions input file that is not in the emissions location input file. Check for consistency between the two files.
The source_id, "XXXXXX", does not exist in the HAP emissions input file. HEM-3 will end so you can find and correct the error in your input file. Once the error has been fixed, run HEM-3 again.	There is a source id in the emissions location input file that is not in the HAP emissions input file. Check for consistency between the two files.
The source_preface.txt file is not in the working directory	The file SOURCE_PREFACE.TXT is not in the HEM-3 Working folder. This may be caused by HEM-3 not processing any emission sources.
The utm east value you entered for the source region center is outside the source region. Please enter a value that is within the source region boundaries.	The modeling domain center easting coordinate that was entered is outside the emission source box.
The utm north value you entered for the source region center is outside the source region. Please enter a value that is within the source region boundaries.	The modeling domain center northing coordinate that was entered is outside the emission source box.
The Utm zone that you entered for one of your user receptors is too far from the source region center. HEM-3 cannot run correctly with this specification. Click 'Ok' to end HEM-3 to enable you to correct the user specified discrete receptor(s) file.	The UTM zones for user receptors must be within one zone of the source region.
The value you entered for the distance where source and receptor are considered to overlap is greater than 500. Change the value to a number less than or equal to 500.	Invalid entry for the distance where source and receptor are considered to overlap.
The value you entered for the distance where source and receptor are considered to overlap is greater than 500. Change the value to a number less than or equal to 500.	Invalid entry for the distance where source and receptor are considered to overlap.
The weight percentages for "XXXXXX" in your particle size input file do not total 100. HEM-3 needs to end to allow you to update your input file.	For source_id, XXXXXX, the input particle weight percents do not sum to 100.
There are duplicate source ids in your emissions locations input file. HEM-3 will end so you can fix the problem and restart HEM-3.	The emissions locations input file must contain unique source ids for each facility. A duplicate source id was found.
There are no census blocks in the area to be modeled. You may have an error in your source and location input file. Click 'Ok' to end HEM-3 and then check for errors.	No census blocks were selected to use as receptors in the modeling domain. A common cause of this is incorrect emission source locations.

Error Message	Meaning / Cause
There was a problem with running Aermod. Make sure you are able to open a DOS window on your computer and double-check your input files to make sure they are correct. HEM-3 will end when you click on 'OK'.	There was an error when HEM-3 attempted to run AERMOD and no AERMOD output file was produced.
Unable to find AERMOD Building information in specified file.	Use of building downwash was selected for HEM-3, but no building downwash parameters were found in the BPIP input file.
Unable to open user's guide.	HELP cannot open the user guide file "HEM3_users_guide.pdf" which is located in the HEM-3 root directory.
You have not specified a polar receptor network for interpolation. Make the value for the distance within which blocks are modeled the same as the maximum radius or, make the number of concentric circles or the number of radials a value other than 0.	A polar receptor network has not been defined.
You must enter a name and location of an existing file with size and deposition information for particulate matter for HEM-3 to run correctly.	A particle size filename was not entered.
You must enter a name and location of an existing file with size and deposition information for particulate matter for HEM-3 to run correctly.	A particle size filename was not entered.
You must enter a name of a pollutant in the pollutant field.	This error occurs when adding a pollutant to the HAP library file and the pollutant name was not entered.
You must enter a numeric value in the acute concentration field. If you do not have an Acute concentration value for the pollutant, enter zero (0).	This error occurs when adding a pollutant to the HAP library file and an acute concentration was not entered.
You must enter a numeric value in the RFC field. If you do not have an RFC value for the pollutant, enter zero (0).	This error occurs when adding a pollutant to the HAP library file and an RFC value was not entered.
You must enter a numeric value in the URE field. If you do not have an URE value for the pollutant, enter zero (0).	This error occurs when adding a pollutant to the HAP library file and a URE value was not entered.
You must enter a value for the distance within which blocks are modeled individually that is greater than 0.	Invalid entry for the distance in which census blocks are used as receptors.
You must enter a value for the distance within which blocks are modeled individually that is greater than 0.	A modeling distance must be entered.
You must enter a value for the maximum radius that is greater than 0.	The maximum radius of the polar receptors must be larger than 0.
You must enter a value for the maximum radius that is no greater than 50,000 meters.	The maximum radius of the polar receptors must be less than 50,000 meters.

Error Message	Meaning / Cause
You must enter a value for the number of concentric circles that is at least 4 and not greater than 30.	Invalid entry for the number of polar rings to use.
You must enter a value for the number of concentric circles that is at least 4 and not greater than 30.	Invalid number of polar receptor rings entered.
You must have DOSE_RESPONSE_LIBRARY.XLS to successfully run HEM-3. The name of the table has changed since the last version of HEM-3. Be sure you have the correct table in the REFERENCE folder. If you do not have the correct table exit HEM-3.	The file DOSE_RESPONSE_LIBRARY.XLS is not in the HEM-3 Reference folder.
You must have TARGET_ORGAN_ENDPOINTS.XLS to successfully run HEM-3. The name of the table has changed since the last version of HEM-3. Be sure you have the correct table in the REFERENCE folder. If you do not have the correct table exit HEM-3.	The file TARGET_ORGAN_ENDPOINTS.XLS is not in the HEM-3 Reference folder.

7. References

Census. 2000. *LandView® 5 on DVD*. U.S. Census Bureau, Washington, DC.

Census. 2010. Census Summary File 1 – United States:
http://www2.census.gov/census_2010/04-Summary_File_1/ prepared by the U.S. Census Bureau, Washington, DC, 2011. See also Technical Documentation for the 2010 Census Summary File 1.

EPA. 1986. *User's Manual for the Human Exposure Model (HEM)*. EPA-450/5-86-001, U.S. Environmental Protection Agency, Research Triangle Park, NC.

EPA. 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (revised) Volume II – Description of Model Algorithms. EPA-454/B-95-003b, U.S. Environmental Protection Agency, Research Triangle Park, NC.
<http://www.epa.gov/scram001/userg/regmod/isc3v2.pdf>

EPA. 1998a. *PCRAMMET User's Guide*. U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/metobsdata_procaccprogs.htm

EPA. 1998b. *Mixing Height Preprocessing Program*. U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/metobsdata_procaccprogs.htm

EPA. 1999. *PCRAMMET Preprocessing Program*. U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/metobsdata_procaccprogs.htm

EPA. 2004a. *User's Guide for the AMS/EPA Regulatory Model - AERMOD*. EPA-454/B-03-001, U.S. Environmental Protection Agency, Research Triangle Park, NC.
<http://www.epa.gov/scram001/7thconf/aermod/aermodugb.pdf>

EPA. 2004b. *AERMOD: AERMOD: Description of Model Formulation*. EPA-454/R-03-004, U.S. Environmental Protection Agency, Research Triangle Park, NC.
http://www.epa.gov/scram001/7thconf/aermod/aermod_mfd.pdf

EPA. 2004c. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-003, U.S. Environmental Protection Agency, Research Triangle Park, NC.
http://www.epa.gov/scram001/dispersion_related.htm#aermap

EPA. 2004d. User's Guide for the AERMOD Meteorological Preprocessor (AERMET), EPA-454/B-03-002, U.S. Environmental Protection Agency, Research Triangle Park, NC.
<http://www.epa.gov/scram001/7thconf/aermod/aermetugb.pdf>

EPA. 2004e. *AERMOD Deposition Algorithms - Science Document (Revised Draft)*. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.
www.epa.gov/ttn/scram/7thconf/aermod/aer_scid.pdf

EPA. 2004f. Air Toxics Risk Assessment Reference Library, EPA-453-K-04-001A, U.S. Environmental Protection Agency, Research Triangle Park, NC. April 2004.
www.epa.gov/ttn/fera/risk_atra_vol1.html

EPA. 2005. Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions. Appendix W of 40 CFR Part 51. http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

EPA. 2007a. The HEM-3 User's Guide. HEM-3 Human Exposure Model Version 1.1.0 (AERMOD version), Draft. Prepared by EC/R Inc. for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. January 2007.

EPA. 2007b. The HAPEM6 User's Guide, Hazardous Air Pollutant Exposure Model, Version 6. Prepared by ICF International for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. January 2007.
http://www.epa.gov/ttn/fera/hapem6/HAPEM6_Guide.pdf. Additional HAPEM documentation available at http://www.epa.gov/ttn/fera/human_hapem.html

EPA. 2010. Total Risk Integrated Methodology (TRIM) – TRIM.FaTE. Technology Transfer Network FERA (Fate, Exposure, and Risk Analysis). U.S. Environmental Protection Agency.
http://www.epa.gov/ttn/fera/trim_fate.html. Website last updated November 10, 2010.

EPA. 2011a. Addendum to the User's Guide for the AERMOD Terrain Preprocessor (AERMAP) (EPA-454/B-03-003, October 2004), U.S. Environmental Protection Agency, Research Triangle Park, NC. March 2011. http://www.epa.gov/scram001/dispersion_related.htm#aermap

EPA. 2011b. *Glossary of Key Terms*. Technology Transfer Network Air Toxics, 2005 National-Scale Air Toxics Assessment. U.S. Environmental Protection Agency.
<http://www.epa.gov/ttn/atw/natamain/gloss1.html>. Website last updated February 22, 2011.

EPA. 2011c. Data Dictionary (zip file). Air Toxics Data Ambient Monitoring Archive, Technology Transfer Network Ambient Monitoring Technology Information Center. U.S. Environmental Protection Agency. <http://www.epa.gov/ttn/amtic/toxdat.html#data>

EPA. 2013a. Addendum to the User's Guide for the AMS/EPA Regulatory Model – AERMOD (EPA-454/B-03-001, September 2004), U.S. Environmental Protection Agency, Research Triangle Park, NC. December 2013.
http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod

EPA, 2013b. Model Change Bulletin # 9 for AERMOD (dated 13350), U.S. Environmental Protection Agency, Research Triangle Park, NC. December 16, 2013.
http://www.epa.gov/ttn/scram/models/aermod/aermod_mcb9.txt

EPA. 2013c. Addendum to the User's Guide for the AERMOD Meteorological Preprocessor (AERMET) (EPA-454/B-03-002, November 2004), U.S. Environmental Protection Agency, Research Triangle Park, NC. December 2013.
http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet

EPA. 2014. *Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants*. U.S. Environmental Protection Agency, Research Triangle Park, NC. <http://www.epa.gov/ttn/atw/toxsource/summary.html>

Federal Register, 2012. Qualifying Urban Areas for the 2010 Census. FR 77:59 (27 March 2012). p.18652. <http://www.gpo.gov/fdsys/pkg/FR-2012-03-27/pdf/2012-6903.pdf>

Jindal, M. and D. Heinold. 1991. Development of particulate scavenging coefficients to model wet deposition from industrial combustion sources. Paper 91-59.7, *84th Annual Meeting - Exhibition of AWMA*, Vancouver, BC, June 16-21, 1991.

NCES. 2006a. *CCD Public School Data 2006-2007 school year*, Institute of Education Sciences, National Center for Education Statistics (NCES) of the U.S. Department of Education, Alexandria, VA. <http://nces.ed.gov/ccd/schoolsearch/> accessed February 2009.

NCES. 2006b. *PSS Private School Universe Survey data for the 2006-2007 school year*, Institute of Education Sciences, National Center for Education Statistics (NCES) of the U.S. Department of Education, Alexandria, VA. <http://nces.ed.gov/surveys/pss/privateschoolsearch/> accessed February 2009.

NCES. 2009a. *CCD Public School data 2009-2010 school year*, Institute of Education Sciences, National Center for Education Statistics (NCES) of the U.S. Department of Education, Alexandria, VA. <http://nces.ed.gov/ccd/schoolsearch/> accessed February 2012

NCES. 2009b. *PSS Private School Universe Survey data for the 2009-2010 school year*, Institute of Education Sciences, National Center for Education Statistics (NCES) of the U.S. Department of Education, Alexandria, VA. <http://nces.ed.gov/surveys/pss/privateschoolsearch/> accessed February 2012.

NGS. 2011. NADCON - Version 4.2. National Geodetic Survey, National Oceanic and Atmospheric Administration. http://www.ngs.noaa.gov/PC_PROD/NADCON/

Schulman, L.L., D.G. Strimaitis, and J.S. Scire. 2000. Development and Evaluation of the PRIME Plume Rise and Building Downwash Model. *Journal of the Air & Waste Management Association*, Vol. 50, pp. 378-390.

Scire, J.S., D.G. Strimaitis and R.J. Yamartino. 1990. *Model formulation and user's guide for the CALPUFF dispersion model*. Sigma Research Corp., Concord, MA.

USGS. 2006. *US GeoData Digital Elevation Models – Fact Sheet 040-00 (April 2000)*. U.S. Department of the Interior - U.S. Geological Survey, Washington, DC. <http://data.geocomm.com/sdts/fs04000.pdf>

USGS. 2010. USGS Seamless Data Warehouse. U.S. Department of the Interior - U.S. Geological Survey, Washington, DC. <http://nationalmap.gov/viewer.html>

Wesely, M.L, P.V. Doskey, and J.D. Shannon. 2002. *Deposition Parameterizations for the Industrial Source Complex (ISC3) Model*. ANL/ER/TR-01/003, Argonne National Laboratory, Argonne, Illinois 60439. See “AERMOD Deposition Parameterizations Document” pdf link under “Model Supporting Documents” section of TTN’s Preferred/Recommended Models webpage at http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod