Multi HEM-3 and RTR Summary Programs User's Guide

Instructions for using the Human Exposure Model Version 1.3.1
for Multiple Facility Modeling with
Risk & Technology Review Summary Programs

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Disclaimer

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1. Introduction

The Human Exposure Model, Version 1.3.1 (HEM-3) is a streamlined yet rigorous tool you can use to estimate ambient concentrations, human exposures and health risks that may result from air pollution emissions from complex industrial facilities. HEM-3 has been implemented in two versions: a single-facility version, and a community and sector version. This guide addresses the community and sector version, named Multi HEM-3. You can use Multi HEM-3 to model multiple facilities in a community or region, or across the entire U.S. and its territories, as in the Risk & Technology Review (RTR) assessments of entire source categories or sectors.

In RTR assessments, Multi HEM-3 is used to model emissions and the resulting ambient concentrations from hundreds of facilities located thousands of miles away from each other, and to predict the potential exposures and inhalation health risks posed by these emissions. Multi HEM-3 can accommodate facilities with overlapping zones of impact. An add-on module to Multi HEM-3 containing RTR summary programs is also available. You can use this to further summarize the cancer risk and non-cancer health effects for your modeled group of facilities as a whole.

This Multi HEM-3 User's Guide is not intended to be a stand-alone reference to Multi HEM-3. The user's guide assumes you will have some knowledge and experience with the HEM-3 developed for modeling exposure and risk from single facilities (EPA 2014b). Both single and Multi HEM-3 operate under the same general principles. Essentially, Multi HEM-3 provides a platform for running the single-facility version multiple times. In both versions, source location and emissions data are input through a set of Excel™ spreadsheets. The single-facility version includes a graphical user interface (GUI) for the selection of various dispersion modeling options. In Multi HEM-3, a control file replaces many of these GUI inputs. Therefore, you should have access to and be familiar with the more extensive user's guide for single HEM-3 entitled *The HEM-3 User's Guide, Instructions for using the Human Exposure Model Version 1.3.1 (AERMOD version) for Single Facility Modeling,* also prepared by EC/R for the EPA (EPA 2014b). The HEM-3 User's Guide provides instructions for installing and running HEM-3, in addition to more in-depth descriptions of the inputs, methodology, calculations, outputs, and limitations associated with the model than are provided here. The HEM-3 User's Guide and model are available for download from the EPA's Fate, Exposure, and Risk Analysis (FERA) Technology Transfer Network (TTN) Air Toxics Website (at http://www.epa.gov/ttn/fera/human_hem.html).

Multi HEM-3 uses the American Meteorological Society – EPA Regulatory Model (AERMOD) for dispersion modeling and runs AERMOD as a compiled executable program. It is important, therefore, that you have access to AERMOD's model documentation (available for download at www.epa.gov/scram001/dispersion_prefrec.htm#aermod).

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 2011, 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 (point) sources, area sources, volume sources, and polygon sources. This Multi HEM-3 User's Guide, as complemented by the single-facility HEM-3 User's Guide, is designed to provide all of the information you will need to run Multi HEM-3. However, some of the options for running Multi HEM-3 draw on advanced features of AERMOD. If you are unfamiliar with the AERMOD dispersion model, you may need

to refer to the AERMOD User's Guide in order to develop some of the inputs needed by Multi HEM-3. This is particularly true for some of the more complex modeling options, such as deposition and plume depletion, building downwash, and complex source configurations. Multi HEM-3 uses the most recent AERMOD version available, Version 13350 (which includes AERMOD change bulletin #9, EPA 2013b), described in the December 2013 addendum to the AERMOD User's Guide (EPA 2013a).

This manual provides an overview of the inputs and outputs of Multi HEM-3 and the RTR summary programs, along with instructions for installing and running the model and add-on module.

Section 2 describes the main features of Multi HEM-3.

Section 3 provides instructions for downloading and installing Multi HEM-3 and the RTR summary programs from the EPA's website.

Section 4 describes the facility and emission inputs required to run Multi HEM-3, as well as optional input files for more sophisticated modeling runs.

Section 5 provides step-by-step instructions for running Multi HEM-3, including a brief description of the calculations performed by Multi HEM-3 during the run.

Section 6 describes post processing procedures, and the individual facility and multiple facility risk estimate outputs produced by Multi HEM-3.

Section 7 explains what quality assurance checks should be performed on the Multi HEM-3 outputs prior to running the RTR summary programs.

Section 8 provides instructions for running the RTR summary programs.

Section 9 describes the RTR summary program outputs.

Section 10 provides step-by-step instructions for using the Multi HEM-3 and RTR summary program outputs to summarize the risk results for the modeled facilities.

Section 11 discusses source category versus facility-wide modeling runs.

Section 12 provides a brief discussion on using Multi HEM-3 to model source categories with more than 500 facilities.

Section 13 discusses potential error messages you may encounter when running Multi HEM-3, and how to respond to these messages.

Section 14 lists references used in this guide.

2. Main Features of Multi HEM-3

Multi HEM-3 performs three main operations: dispersion modeling, estimation of population exposure, and estimation of human health risks. To perform these calculations, Multi HEM-3 draws on three data libraries, which are provided with the model. The first is a library of meteorological data used for dispersion calculations collected from over 800 stations in the U.S. and its territories. The second library of census block internal point ("centroid") locations and populations provides the basis for human exposure calculations. The model includes census

data from both the 2000 and 2010 censuses, so you can base your Multi HEM-3 modeling run on either census. The census library also includes the elevation of each census block. Note that elevation is included by default in the dispersion calculations, although you have the option of excluding elevation from your run. Finally, a third library of pollutant unit risk estimates (UREs) and reference concentrations (RfCs) is used 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 2014a). The HEM-3 User's Guide provides more detailed descriptions of the data libraries provided with and used by the model (EPA 2014b).

Multi 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, years spent living elsewhere than current residential receptor site, etc.).

Cancer risks are computed using the EPA's 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. Non-cancer health effects are quantified using hazard quotients (HQs) and hazard indices for 14 "target" organs or systems and, like the risk estimates, are not adjusted for exposure factors. The HQ for a given chemical and receptor site is the ratio of the ambient concentration of the chemical to the RfC at which no adverse effects are expected. The chronic hazard index (HI) for a given target organ is the sum of HQs for substances that affect that organ. Target organ-specific hazard indices (TOSHIs) are computed for the following 14 categories: the respiratory system; the liver; the neurological system; developmental effects; the reproductive system; the kidneys; the ocular system; the endocrine system; the hematological system; the immunological system; the skeletal system; the spleen; the thyroid; and whole body effects.

Optionally, you can also use Multi HEM-3 to 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 use the RTR summary programs to compute the ratio of the maximum acute concentration to the associated benchmark to determine the maximum acute HQ for each pollutant of concern.

Multi HEM-3 identifies receptor locations at which the predicted lifetime cancer risk, chronic non-cancer hazard indices 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 hazard indices, and acute concentrations. You can also use Multi HEM-3 to estimate the numbers of people exposed to various cancer risk levels and HI levels. In addition, Multi HEM-3 provides estimates of the average cancer risks, average hazard indices, and the predicted annual cancer incidence for people living within different distances of the modeled emission sources. See the single- facility HEM-3 User's Guide (EPA 2014b) for an overview of HEM-3's methodology and calculations, and detailed descriptions of the risk and hazard outputs produced by the model.

For every modeled facility, Multi HEM-3 produces the risk and hazard results that single HEM-3 produces specific to each facility (as noted in Section 6.1). However, Multi HEM-3 also combines and summarizes these results into additional consolidated output files that include a

row of results for each modeled facility. See Section 6.2 for a discussion of these multi-facility files. Similarly, the RTR summary programs produce additional outputs of combined and summarized results that are useful in capturing the potential risks and hazards, as well as the pollutant and emission source drivers, for an entire source category modeled under the EPA's RTR program. See Section 9 for a discussion of these additional RTR outputs.

3. Installing Multi HEM-3 and the RTR Summary Programs

Download the Multi HEM-3 model and the RTR Summary Programs 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 and links to install both single HEM-3 and Multi HEM-3, including the RTR summary programs.

Installation of Multi HEM-3 consists of several steps including downloading the Multi HEM-3 model, downloading the RTR Summary Programs module, and downloading the data libraries required by Multi HEM-3. These data libraries include a chemical health effects library with toxicity value files (dose response and target organ endpoint spreadsheets); a census population and elevation library (for the 2010 and 2000 Census); and a meteorological library (characterizing typical weather patterns around the nation). The contents of each of the three data libraries are described in Section 2 of the single HEM-3 User's Guide (EPA 2014b).

Follow the steps below to download the Multi HEM-3 model, data libraries, and the RTR summary programs:

1. From the HEM Download Page, click the "Multi HEM-3" link under Section 3 *Software available for download*, and select "run" to begin the installation program for Multi HEM-3. The default location to install Multi HEM-3 is "C:\Program Files\Multi_HEM3\." You can change this location by clicking the "Change..." button and indicating an alternate location. The basic files needed to run Multi HEM-3 will be placed in the selected directory. A number of subdirectories for the data libraries will also be created, including a *Reference* folder for the chemical health effects library, *Census_2000* and *Census_2010* folders for the census libraries, and a *MetData* folder for the meteorological library. The "Installing Multi HEM3" screen is displayed while the files are being copied to the destination folder. When the installation is complete, the "InstallShield Wizard Completed" window appears. The *MetData* folder and *Census_2000* and *Census_2010* folders created as part of the installation will automatically be populated with the meteorological station data and census block files needed to run the template input files—which are provided to illustrate sample input files for a Multi HEM-3 run and which you can edit to create Multi HEM-3-ready inputs (as described further in Section 4).

2. Click the "Toxicity Value Files" link under Section 4 *Input Files for HEM-3 and Multi HEM-3* (on the HEM Download Page) to download (1) the *Dose_Response_Library.xls* reference file containing the unit cancer risk factors, the non-cancer RfCs, and the acute benchmarks for various HAP; and (2) the *Target_Organ_Endpoints.xls* reference file, which contains a listing of the non-cancer target organ endpoints impacted by various HAP. [Note: After copying these files to the Reference folder and unzipping them, check that these files are up-to-date for your modeling purposes by consulting EPA's Dose Response Assessment webpage (EPA 2014a).]

3. Click the “Nationwide 2010 Census files” link and/or the “Nationwide 2000 Census files” link under the *Census Files* heading of Section 4 *Input Files for HEM-3 and Multi HEM-3* (on the HEM Download Page) to download all state census files. [Note: Do not mix-and-match Census 2010 files with Census 2000 files.] Copy these files into the *Census_2010* and *Census_2000* folders, as appropriate, and unzip. When modeling a facility in one state, Multi HEM-3 may require census files from a neighboring state, depending on the location of the facilities and the radial distance modeled surrounding each facility. This possibility is increased when modeling multiple facilities across the U.S. Therefore, you should copy all state census files into the appropriate Census folder, not only the files for those states in which the modeled facilities are located. [Note: If you need only Census 2010 or only Census 2000 data for modeling purposes (not both), then download only the census year needed and place all census files from that year in the correct census folder.]

4. Click the “Nationwide meteorological files” link, under the *Meteorological Files* heading of Section 4 *Input Files for HEM-3 and Multi HEM-3* (on the HEM Download Page) to download all meteorological station files. Copy these files into the *MetData* folder and unzip. Similar to the census files, you should download all meteorological station files, not just a subset of the meteorological data files.

5. Finally, click the “RTR Summary Programs” link under Section 3 *Software available for download* (on the HEM Download page). Select “run” to begin the installation program for the RTR summary programs. You can use these programs to extract specific risk estimate results from the Multi HEM-3 outputs. Copy the RTR summary programs into the same directory containing Multi HEM-3, but in a different folder (e.g., named “RTR Summaries”).

4. Multi HEM-3 Inputs

Multi HEM-3 is designed to be launched from the Windows™ desktop via user-friendly input screens. These input screens primarily allow you to point Multi HEM-3 to the required and optional inputs files, and to specify certain modeling options for the run. The model accepts input files created in any version of Excel™. You can use the Excel™ input files to specify the desired modeling options and the emissions and configurations of the facilities to be modeled.

4.1 Required Input Files

A minimum of three input files are required to run Multi HEM-3: the facility list options file; the HAP emissions file; and the emissions location file. These three files contain a listing of the facilities and modeling options for the current run, a listing of the HAP emitted from each facility, and the location and configuration of emission sources at each facility to be modeled. To aid you in creating these files, templates for each (noted in the following subsections in parentheses) are provided in the Inputs directory of the installed Multi HEM-3. In addition to these three required input files, optional input files may also be used when running Multi HEM-3. See Section 4.2 for a description of these optional input files.

4.1.1 Facility List Options File

The facility list options Excel™ file is the primary driver specifying the parameters and options of the model run, and is unique to the Multi HEM-3 version. Instead of selecting all options from input screens as in the single HEM-3 version, you can enter most options in this file (e.g., parameters such as the modeling radius and overlap distance; optional modeling such as acute

concentrations and deposition flux). The facility list options file contains one row for every facility that will be run with the various modeling options listed as columns for each facility row. If you use all default modeling options, the only field requiring input is the facility ID, which can be up to 30 characters long. All other fields have defaults which are employed when the field in the facility list options file is left blank.

Table 1 shows the fields included in the facility list options file. As noted above, these fields are columns in the actual *Facility_List_Options.xls* input file that you must provide to Multi HEM-3, and each row is for a different facility as identified by the Facility ID. The rows in Table 1 are shown in the same column order required by HEM-3 in the input file. The single HEM-3 User's Guide (EPA 2014b) provides more detail on each of these options. (See *Template_Multi_Facility_List_Options.xls* in the Inputs directory.)

4.1.2 HAP Emissions File

The HAP emissions Excel™ file includes emissions in tons per year for each HAP emitted, for all facilities listed in the facility options file. The file is the same as the one used in the single HEM-3 version, with the addition of the facility ID in the first column. Figure 1 shows the Format Guidelines for the HAP emissions file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).[1] (See *Template_Multi_HAP_Emissions.xls* in the Inputs directory.)

4.1.3 Emissions Location File

The emissions location Excel™ file includes emission source locations (e.g., latitude and longitude of a stack) for all facilities listed in the facility options file. The file is the same one used in the single HEM-3 version, with the addition of the facility ID in the first column. Figure 2 shows the format guidelines for the emissions location file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).[1] If you are including polygon sources in the emissions location file, you will also need a polygon vertex file (described in Section 4.2). (See *Template_Multi_Emissions_Location.xls* in the Inputs directory.)

Note: If this is your first time running Multi HEM-3, it is highly recommended that you first run the model with the template input files provided, as practice, and to confirm that Multi HEM-3 installed properly on your computer.

[1] When preparing the HAP Emissions and Emissions Location input files of Multi HEM-3, incorporate a two-letter source type code somewhere in the source ID (e.g., EL for equipment leaks, ST for storage tanks). This two-letter source type identifier is needed if the Source Type Histogram RTR summary programs will be run after Multi HEM-3, as described below in Section 8.

Table 1. Fields in the Facility List Options Input File (Required)

Field	Default Setting (if field left blank)	Description
Facility ID		You must enter an alphanumeric string identifying the facility being modeled; up to 30 characters long.
Met Station	Met station selected by model as closest to the facility	The name of the meteorological surface station to be used by AERMOD when modeling each facility; up to 20 characters long; generally chosen by model but you have the option of specifying.
Rural/Urban	D for default	Used to set the type of dispersion environment for AERMOD. "R" indicates rural land use surrounding the facility; "U" indicates urban land use; and "D" indicates the default setting under which the model will find the nearest Census block to the facility center and determine whether that Census block is located in an urbanized area as designated by the 2010 Census. [Note: The default setting when using the 2000 Census is always rural.]
Max distance	50,000 meters	The outside max radius of the modeling domain (≤ 50 km).
Modeling distance	3,000 meters	The cutoff distance for individual modeling of ambient impacts at census blocks; beyond this distance ambient impacts are interpolated rather than explicitly modeled. [Note: For polygon source types, set the modeling distance > the largest distance across the polygon.]
Radials	16	The number of radials in the polar receptor network emanating from the facility center.
Circles	13	The number of concentric circles in the polar receptor network, centered around the facility center.
Overlap distance	30 meters	The distance – measured from each emission source at a facility – at and below which a source and receptor are considered to be overlapping. Must be ≤ 500 meters.
Acute	N	Selecting "Y" directs the model to include short-term (acute) concentration calculations and hazard predictions.
Hours	1-hour	The short-term (acute) averaging period that AERMOD should use for ambient concentrations. Four averaging period options are available:1-hr; 6-hr; 8-hr; and 24-hr.
Elevations	Y	Elevations of receptors are accounted for by default; Selecting "N" excludes elevations from the model run.
Multiplier	10	The acute multiplier applied to the average emission rate and used to approximate the short-term emission rate (e.g., 10 times the rate entered in the HAP Emissions file). Multi HEM-3 assumes that this short-term rate can occur at the same time as the worst case meteorological conditions, making the acute results conservative estimates.
First ring distance (ring1)	Calculated by model to be just outside the source locations, but not less than 100 m from facility center	The distance to the first ring (circle) of the polar network as measured from the facility center. You can override the default distance calculated by Multi HEM-3 to fit the size and shape of the facility properties to be modeled.

Field	Default Setting (if field left blank)	Description
Deposition (dep)	N	Deposition is not modeled by default; Selecting "Y" directs the model to calculate deposition in the model run (particle, vapor, or both as designated below). Note: if not modeling deposition, ignore the depletion, phase, and particle and vapor deposition fields (below).
Depletion (depl)	[depletion modeled automatically with deposition]	The current model automatically depletes the calculated deposition flux from the ambient concentrations if you opt to calculate deposition; therefore no entry necessary.
Phase	B	The default value "B" directs the model that both particles and vapor deposition will be modeled; use "P" for particle only deposition modeling; use "V" for vapor only deposition modeling. Value must be consistent with emissions (e.g., do not use "B" if emissions are 100% "P" or "V").
Particle Deposition (pdep)	WD for wet and dry particle deposition	The default value "WD" directs the model to incorporate both wet and dry deposition for particles. Use "WO" for wet only; use "DO" for dry only; use "NO" if not modeling deposition of particles.
Particle Depletion (pdepl)	[particle depletion modeled automatically with particle deposition]	The current model automatically depletes the calculated deposition flux for particles from the ambient concentrations if you opt to calculate particle deposition; therefore you need not enter anything in this column.
Vapor Deposition (vdep)	WD	The default value "'WD" directs the model to incorporate both wet and dry deposition for vapor pollutants; use "WO" for wet only; use "DO" for dry only; use "NO" if not modeling deposition of vapor pollutants.
Vapor Depletion (vdepl)	[vapor depletion modeled automatically with vapor deposition]	The current model automatically depletes the calculated deposition flux for vapor pollutants from the ambient concentrations if you opt to calculate vapor deposition; therefore you need not enter anything in this column.
All Receptors	Y	"Y" directs model to calculate results for all receptors by pollutant and source. Select "N" to receive pollutant and source contributions for the max populated and max off-site receptors only.
User receptors	N	Select "Y" to include user receptors in a separate input file.
Building Downwash (bldg_dw)	N	Selecting "Y" directs the model to include building downwash calculations in the model run. Note: if you are modeling building downwash, building dimension information is required in a separate input file.
Urban Population	None; only needed if "U" specified in Rural/Urban field	If you indicate "U" for urban land use (in Rural/Urban field above), then you must provide model with the urban population size, otherwise leave blank. Note: If you specify "U" in the Rural/Urban field but provide no urban population value in this field, the model will re-set your "U" to default.
FASTALL	N	FASTALL is not used by default. Selecting "Y" directs the model to use AERMOD's control option FASTALL, which conserves model run time by simplifying AERMOD's dispersion algorithms.

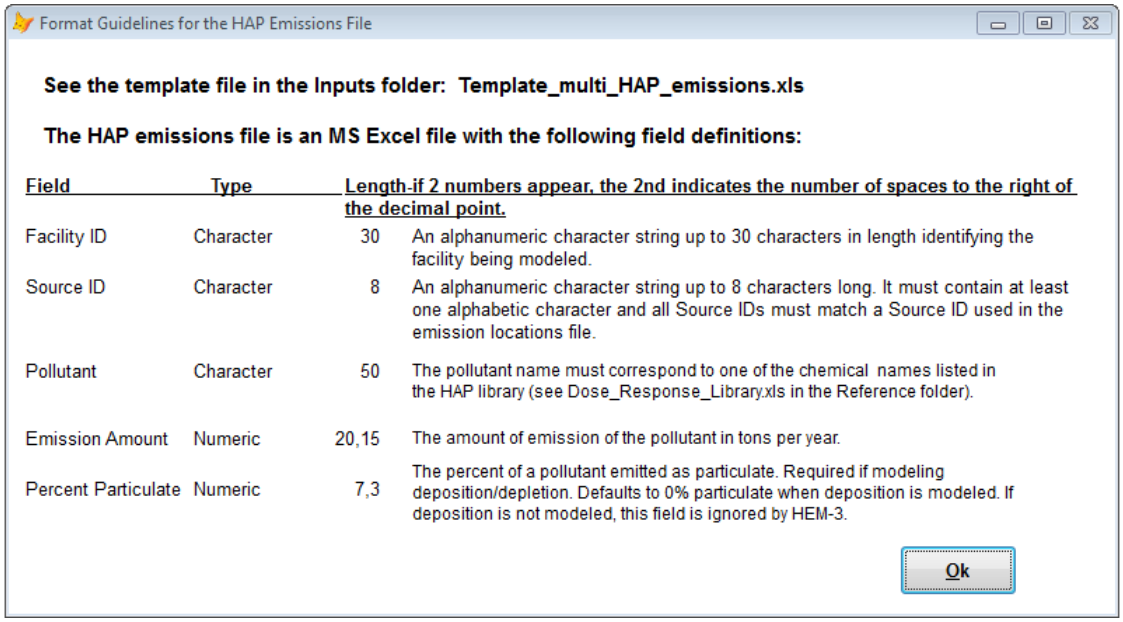


Figure 1. Format Guidelines for the HAP Emissions File (Required)

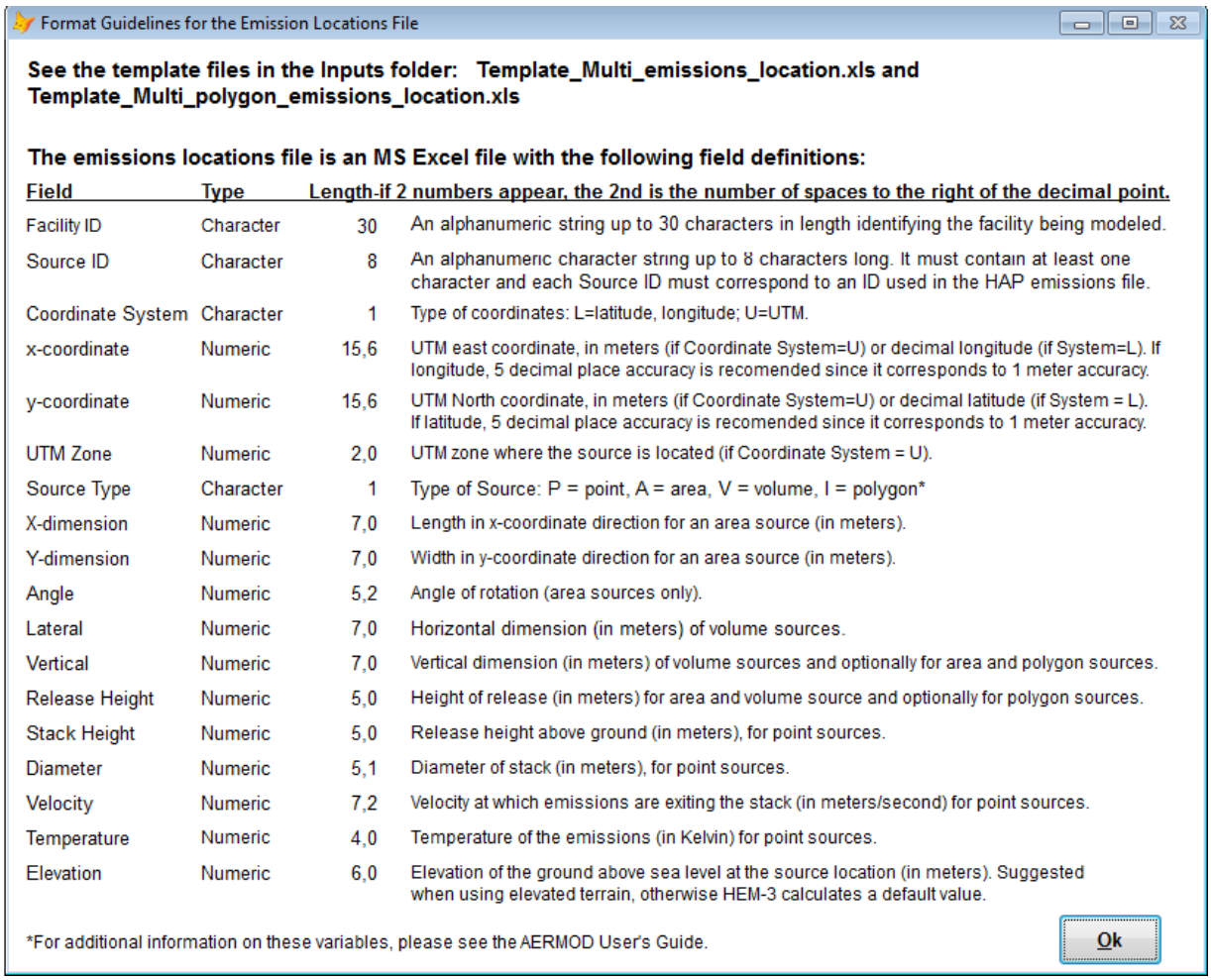


Figure 2. Format Guidelines for the Emissions Location File (Required)

4.2 Optional Input Files

In addition to the facility list options, HAP emissions, and emissions location required input files, you can use the following optional input files to further refine the Multi HEM-3 run:

- **User-defined Receptors File** (See *Template_Multi_User_Receptors.xls* in the Inputs directory) – This file is required if you want to include user-defined receptors in addition to census block and polar grid receptors for one or more facilities. The file includes the location (lat/lon or UTM) of the user-defined receptor and the type or receptor (e.g., P = populated, B = boundary) and is the same file used in the single HEM-3 version, with the addition of the facility ID in the first column. Figure 3 shows the format guidelines for the user receptors file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. Note: If you are modeling terrain effects (i.e., you left a blank or a "Y" in the elevation column of the Facility List Options file) and you choose not to provide a value for elevation in the user-defined receptors file, Multi HEM-3 will calculate the elevation of the user receptor(s) based on the surrounding elevations provided in the census database. However, if you include more than one user receptor for a given facility you should either provide an elevation for all receptors associated with that facility or leave the elevation field blank for all those receptors. See the single HEM-3 User's Guide for more detail. (EPA 2014b).

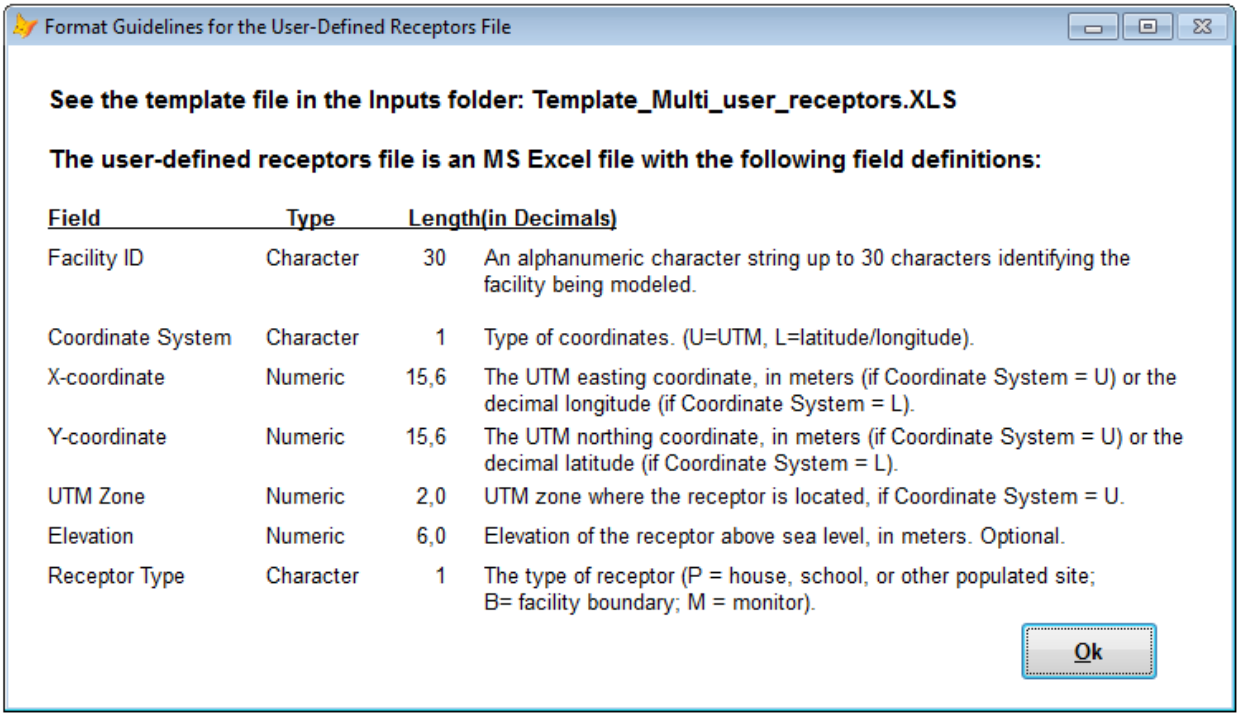


Figure 3. Format Guidelines for the User-Defined Receptors File (Optional)

- **Polygon Vertex File** (See *Template_Multi_Polygon_Vertex.xls* in the Inputs directory) – This file is required if one or more of the sources in your emissions location file is a polygon configuration (rather than a point, area, or volume configuration). Polygons are useful for complex source configurations at a facility, and when modeling census tracts

as sources (e.g., for mobile source emission estimates based on tract data). The file contains information regarding the locations of the polygon vertices and includes a separate record for each vertex of the polygon. The polygon vertex file is the same one used in the single HEM-3 version, with the addition of the facility ID in the first column. Figure 4 shows the format guidelines for the polygon vertex file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).

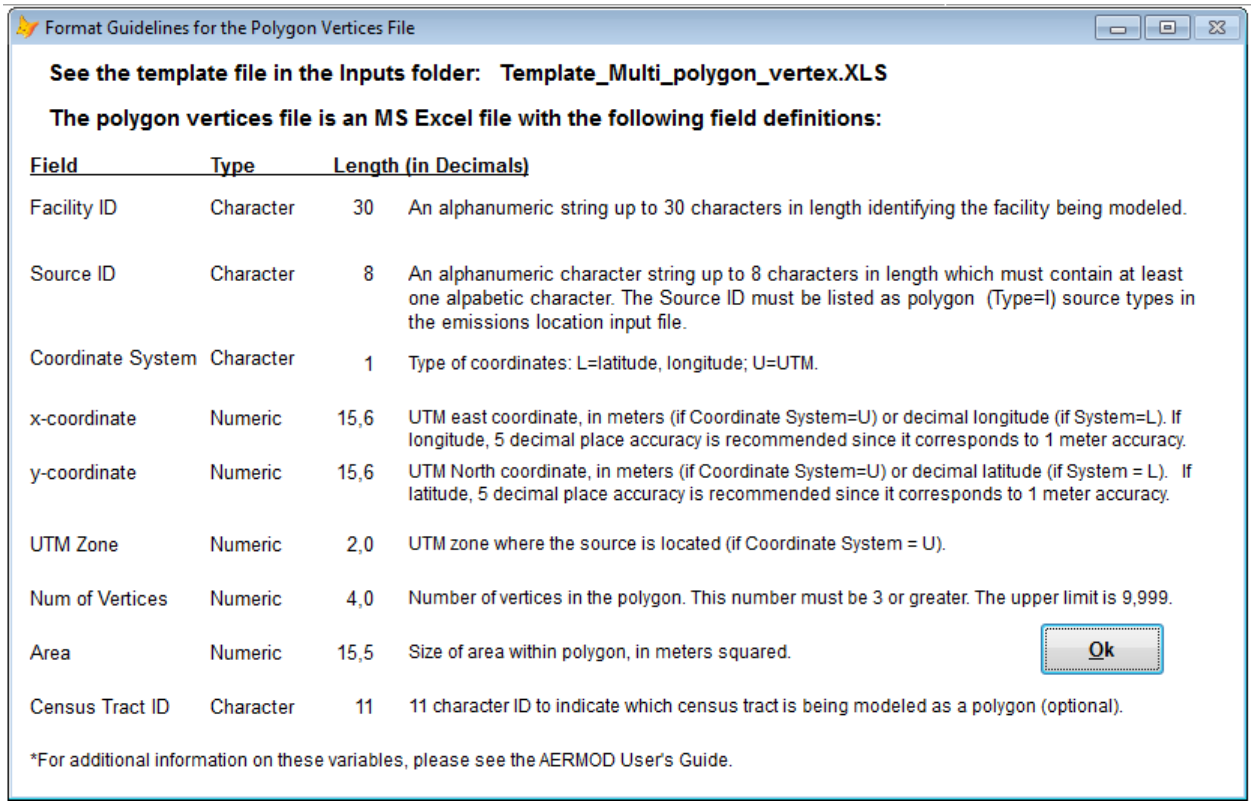


Figure 4. Format Guidelines for the Polygon Vertex File (Required for Polygon Sources)

- **Building Downwash File** (See *Template_Multi_Bldg_dimensions.xls* in the Inputs directory) – To model the effects of downwash around a building, you will need to create a file containing information on the configuration of that building. This input file contains several building dimensions including the height of the building, the projected width of the building perpendicular to the direction of air flow, the length in direction of air flow, and the distance from the source (e.g., stack) to the center of the upwind face of the building, both parallel to and perpendicular to the direction of air flow. You will need to provide these parameters for 36 wind directions at increments of 10 degrees. You can use the EPA's Building Profile Input Program (BPIP) to make these calculations. The BPIP is available for download from the www.epa.gov/ttn/scram/dispersion_related.htm webpage of EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website. Figure 5 shows the format guidelines for the building dimensions file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See also the single HEM-3 User's Guide for more detail (EPA 2014b).

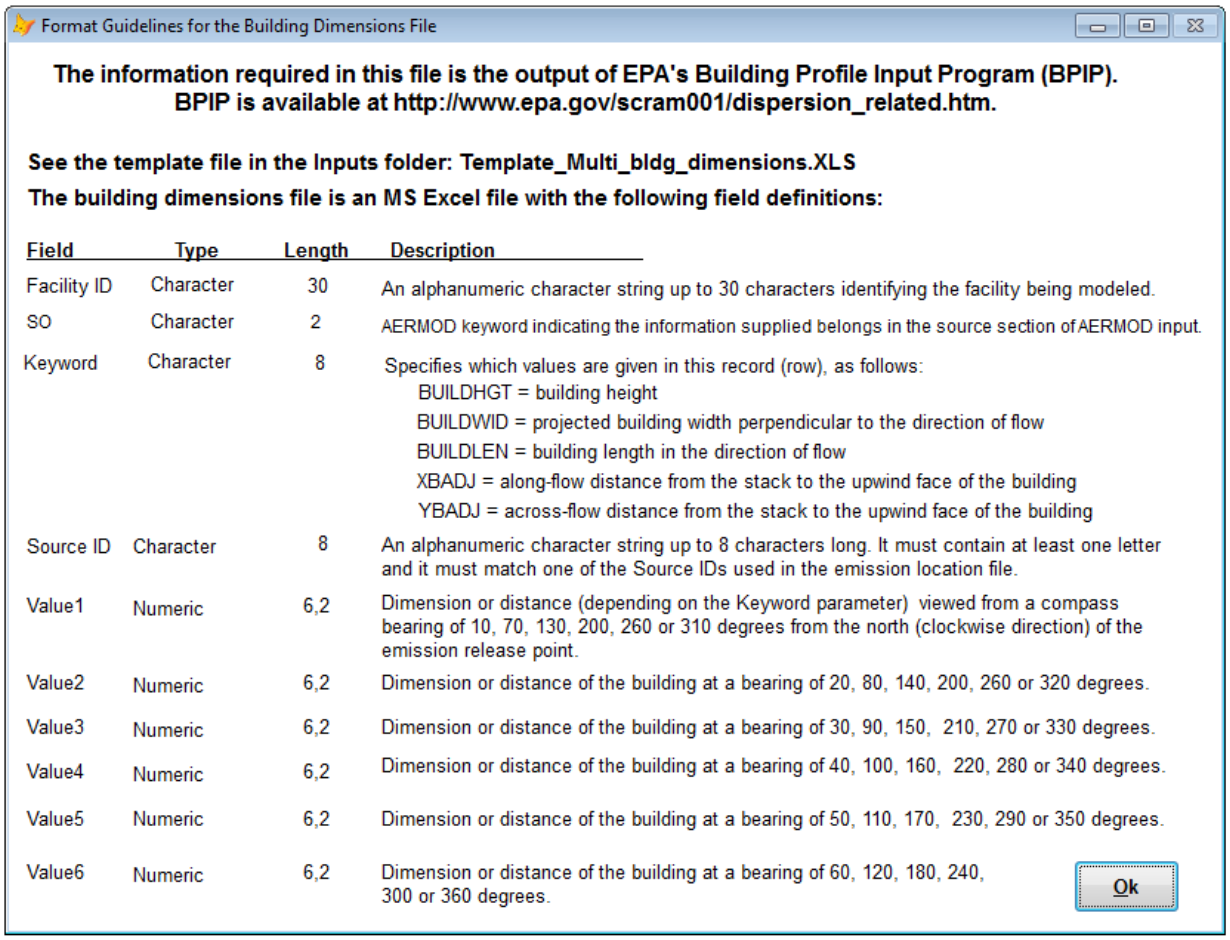


Figure 5. Format Guidelines for the Building Dimensions File (Required for Building Downwash)

- **Particle Size File** (See *Template_Multi_Particle_data.xls* in the Inputs directory) – To model deposition of particulate pollutants, you will need to create a particle size distribution file. This input file contains a separate record for each particle size range emitted by each emission source, including 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 the particles in the size range. You must specify particulate information separately for each source that emits particles. Figure 6 shows the format guidelines for the particle size file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).

- **Land Use File** (See *Template_Multi_Landuse.xls* in the Inputs directory) – To model a facility's dry deposition of vapor (gaseous) pollutants, you will need to create a file containing information on the land use and vegetation surrounding that facility. This input file includes codes characterizing the average land use and vegetation for 36 directions from the emission source(s) at increments of 10 degrees. Figure 7 shows the format guidelines for the land use file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).

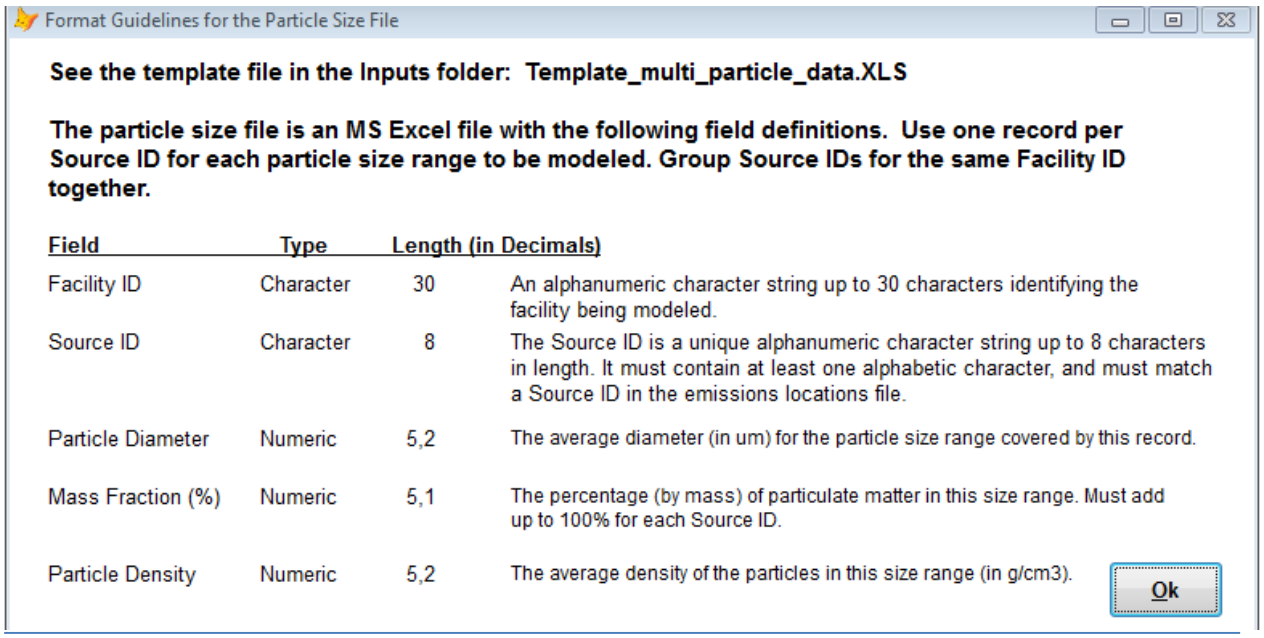


Figure 6. Format Guidelines for the Particle Size File (Required for Particle Deposition)

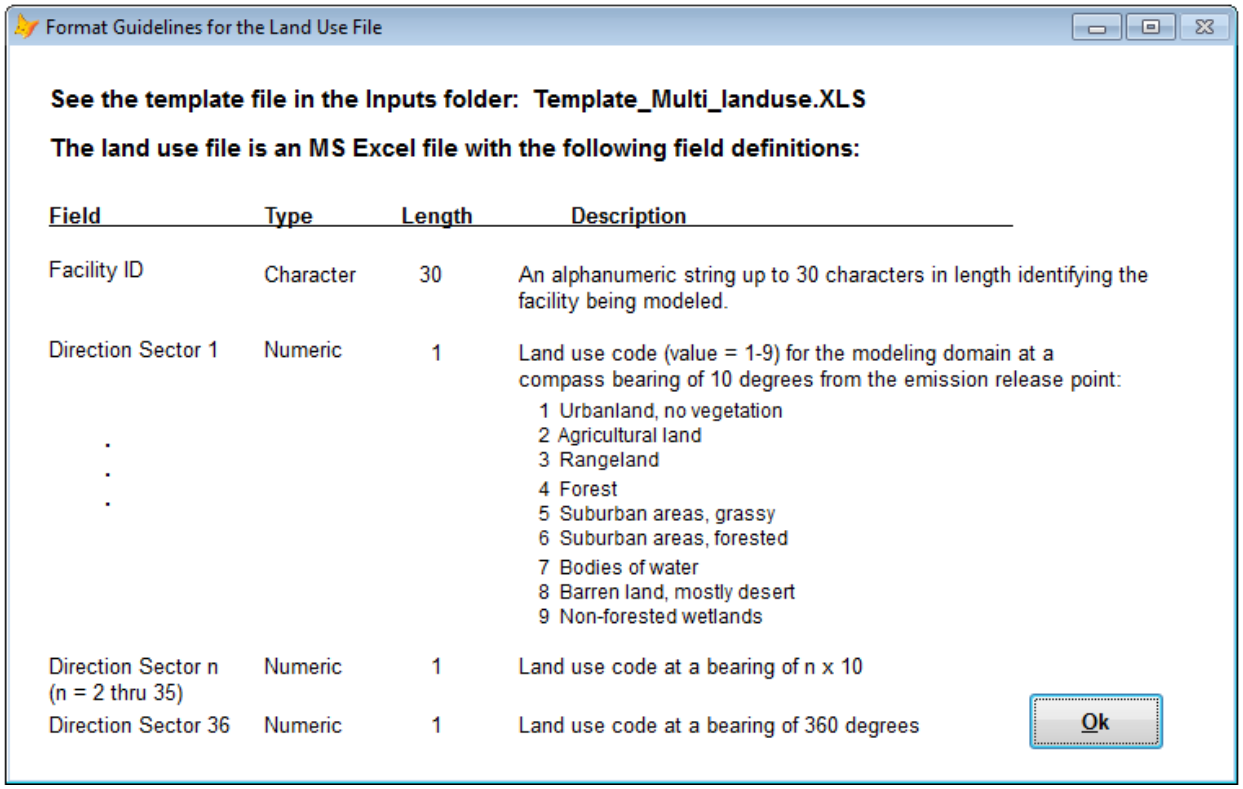


Figure 7. Format Guidelines for the Land Use File (Required for Dry Vapor Deposition)

- **Month-to-Season Assignment File** (See *Template_Multi_Seasons.xls* in the Inputs directory) – To model dry deposition of vapor (gaseous) pollutants, you will need to create a file containing information on the typical stage of vegetation in the modeled region during each month of the year (in conjunction with the land use file described above) . This input file associates each month with a season code (e.g., season code 1 = midsummer with lush vegetation; season code 2 = autumn with unharvested crop land). Figure 8 shows the format guidelines for the seasons file, provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).

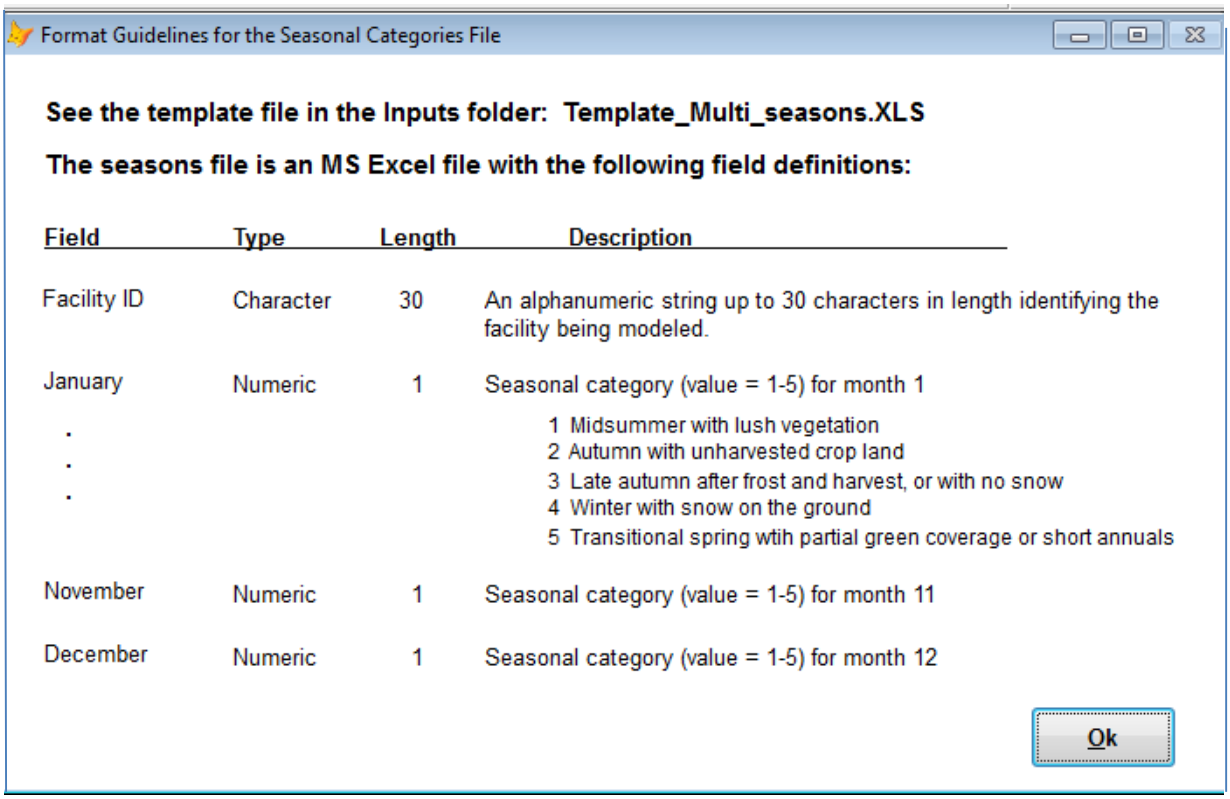


Figure 8. Format Guidelines for Seasons File (Required for Dry Vapor Deposition)

- **Temporal Variation Files** (See *Template_Multi_Temporal_hrofday.xls*, *Template_Multi_Temporal_season.xls*, *Template_Multi_Temporal_month.xls*, *Template_Multi_Temporal_seashr.xls*, and *Template_Multi_Temporal_wspeed.xls* in the Inputs directory) – These files contain a series of temporal factors that allow you to vary the emission inputs based on different time scales such as season, month, day of the week, and hour of day; or based on wind speed. Not every possible temporal variation is included in the Inputs directory as a template file, but AERMOD allows the following variations:
    - 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 of 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 meters/second of 1.54, 3.09, 5.14, 8.23, 10.8 and no upper bound), number of factors is 6.

Figure 9 shows the format guidelines for the temporal variations file(s), provided as part of Multi HEM-3's screen instructions, including a description of all fields in this input file. See the single HEM-3 User's Guide for more detail (EPA 2014b).

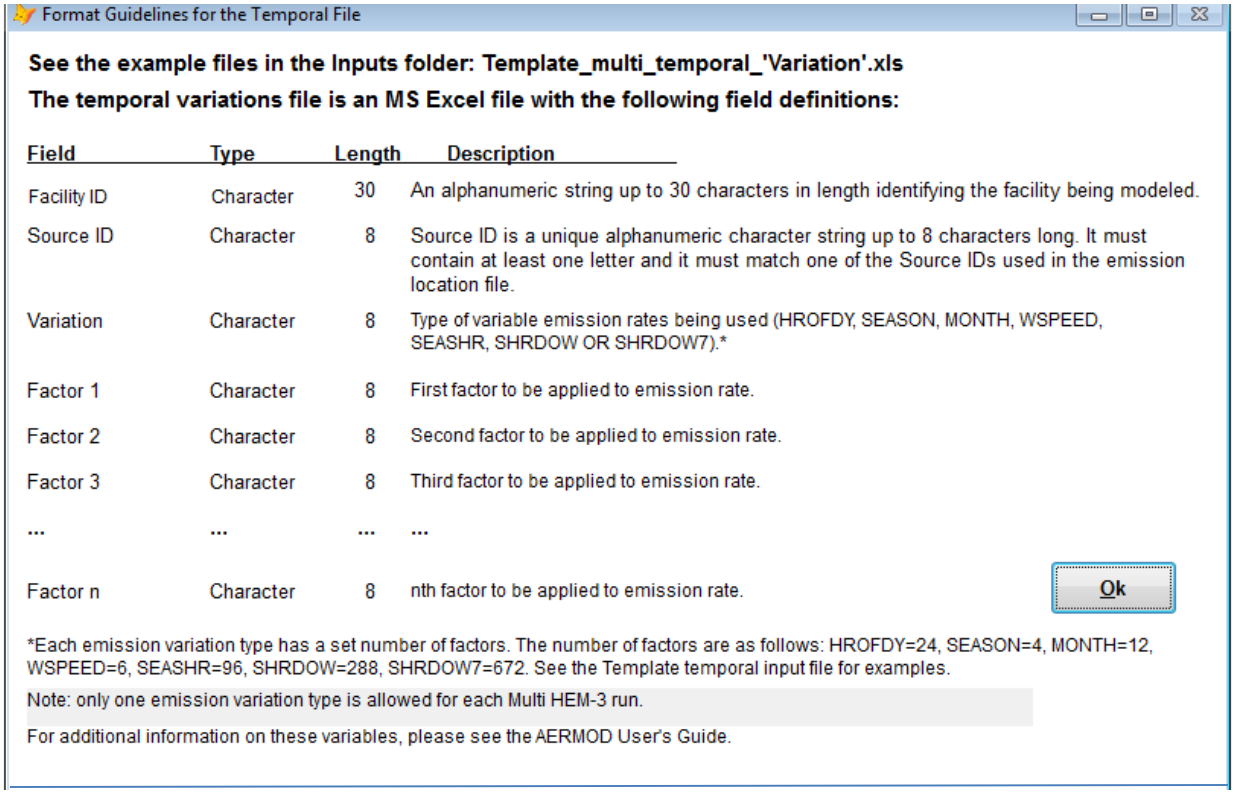


Figure 9. Format Guidelines for Temporal Variations Input File (Optional)

Section 5 *Running Multi HEM-3* provides instructions for supplying the required and optional input files to Multi HEM-3 during your modeling run.

5. Running Multi HEM-3

To launch Multi HEM-3, double-click on *Multi_Hem3.exe* or click on your desktop shortcut (if you created one) to *Multi_Hem3.exe*. Typically, Multi HEM-3 is used to run HEM-3 in the "multi" mode (i.e., for more than one facility). To model emissions from only one facility using Multi HEM-3, create the file *Facility_user_options.xls* with only the facility ID that you want to model, then run Multi HEM-3 using that file as one of the inputs. The format of the input files must remain the same as the inputs used in the Multi HEM-3 modeling runs (described in Section 4). Alternatively, use single HEM-3 (EPA 2014b) to model a single facility.

Multi HEM-3 is designed to run via user-friendly input screens that will prompt you to provide the required and optional input files. The initial title screen requires no inputs; simply click the *Next* button. The next screen displayed, shown below in Figure 10, shows the dates the dose response and target organ endpoints (toxicity value) files were last modified. If the dose response library or target organ endpoints Excel™ input files are out-of-date, click *Exit* and download newer files from EPA's Dose Response Assessment webpage (EPA 2014b) or manually modify the files in the Inputs directory, and then restart the model.

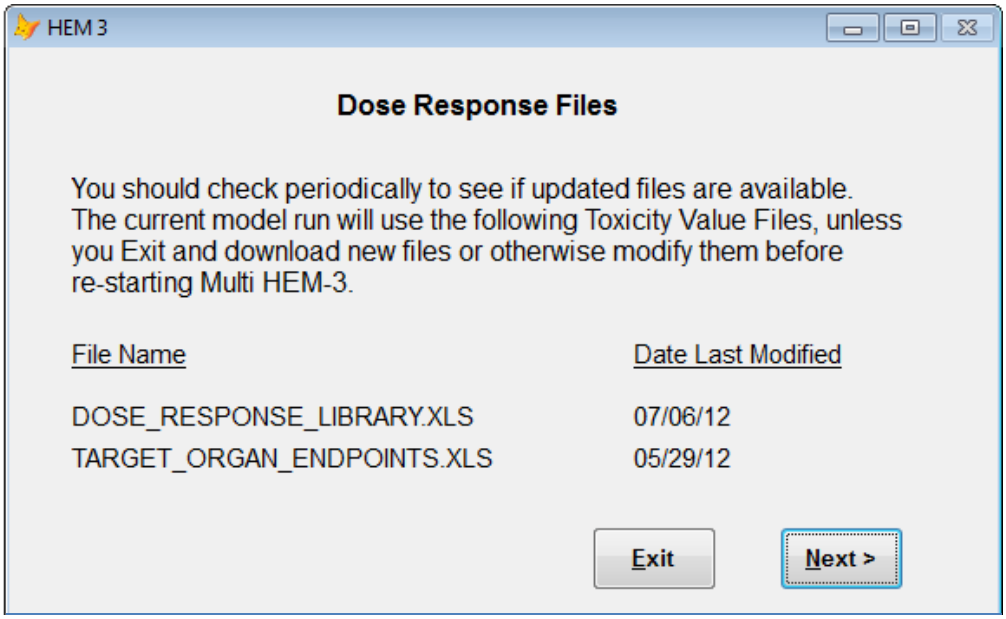


Figure 10. Dose Response Files Update Screen

You will have the option on each subsequent input screen of continuing by clicking the *Next* button, closing the program by clicking the *Exit* button, or accessing an electronic version of this Multi HEM-3 User's Guide by clicking the *Help* button. Screens requiring you to provide input files contain instructions on the required formats for the files. To access these instructions, click on the *View Format Guidelines* button above each input box. These format guidelines are also provided in Section 4. Click on the *Browse* button next to the input box to select the file path and name from the computer's directory rather than entering the information manually. Multi HEM-3 contains three input screens requiring Yes/No answers as well as pathnames to input files. If modeling deposition, an additional screen will appear requiring input file pathnames. These screens are discussed below.

5.1 Providing Required Input Files

On screen *1. Required Input Files*, shown below in Figure 11, provide the required input files by entering the path and file name or browsing and selecting the appropriate files. As described in Section 4.1, three files are required, beginning with the model's driver file listing the facilities and options to be modeled (*Facility_List_Options.xls*), followed by the pollutant emission rate file (*Hap_Emissions.xls*), and the emission source location file (*Emissions_Location.xls*). A fourth file is required via this screen only if any sources are configured as polygons and designated as polygons (source type upper case I or 'I') in the *Emissions_Location.xls* file. Note that when modeling large sources configured as polygons (e.g., census tracts), the modeling distance you enter in the *Facility_List_Options.xls* file should be set greater than the largest distance across the polygon, to ensure discrete modeling of all census blocks within the polygon.[2]

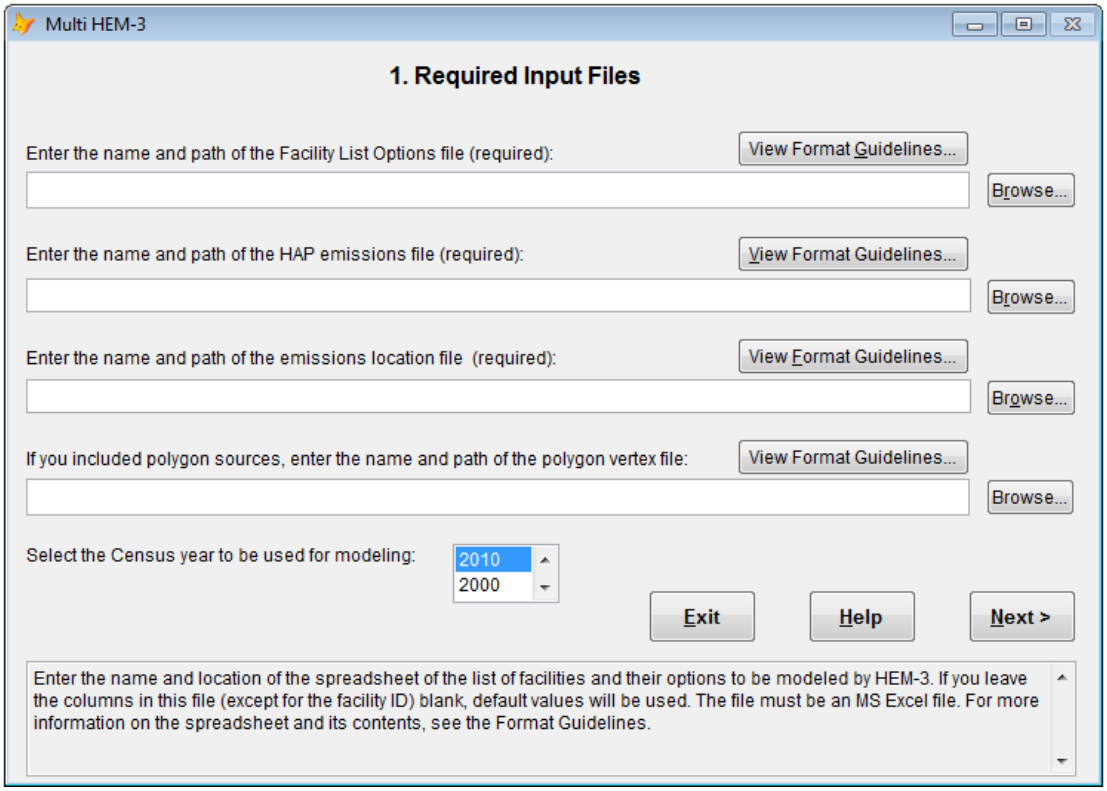


Figure 11. Required Input Files Screen

Here you can select the census year to be used in the modeling run (2010 or 2000). The census data set you select will affect where impacts such as risk are estimated (at the block "centroids"), the population used for calculating impacts such as cancer incidence, and the population exposed to various risk and hazard levels. Additional instructions are displayed at the bottom of the required input files screen when each of the four input boxes is clicked. More details about each of these files are provided in Section 4, and in the single HEM-3 User's Guide (EPA 2014b).

[2] Unlike other sources, when polygons are modeled by Multi HEM-3, the overlap function—which typically ensures that impacts (e.g., risk) are not calculated as overlapping with a source—is disabled. This allows the impacts for a polygon source (e.g., mobile source emissions modeled uniformly across a census tract) to be calculated within the polygon being modeled.

5.2 Providing Optional Input Files

On screen *2. Optional Input Files*, shown below in Figure 12, you can provide optional input files for a more refined modeling run, as indicated in your *Facility_List_Options.xls* file. These modeling options—including user receptors, building downwash, and deposition—will be included in the model run *only* if you entered a **Y** (for Yes) in the *Facility_List_Options.xls* file column under each respective field. If you have not entered a **Y** in each field, answering 'Yes' on the optional input files screen will not suffice to include the option in the model run.

If you have entered **Y** in the *Facility_List_Options.xls* file field(s), you must provide the respective optional input file(s) using this screen, or change the *Facility_List_Options.xls* field(s) to **N** for Multi HEM-3 to successfully run.

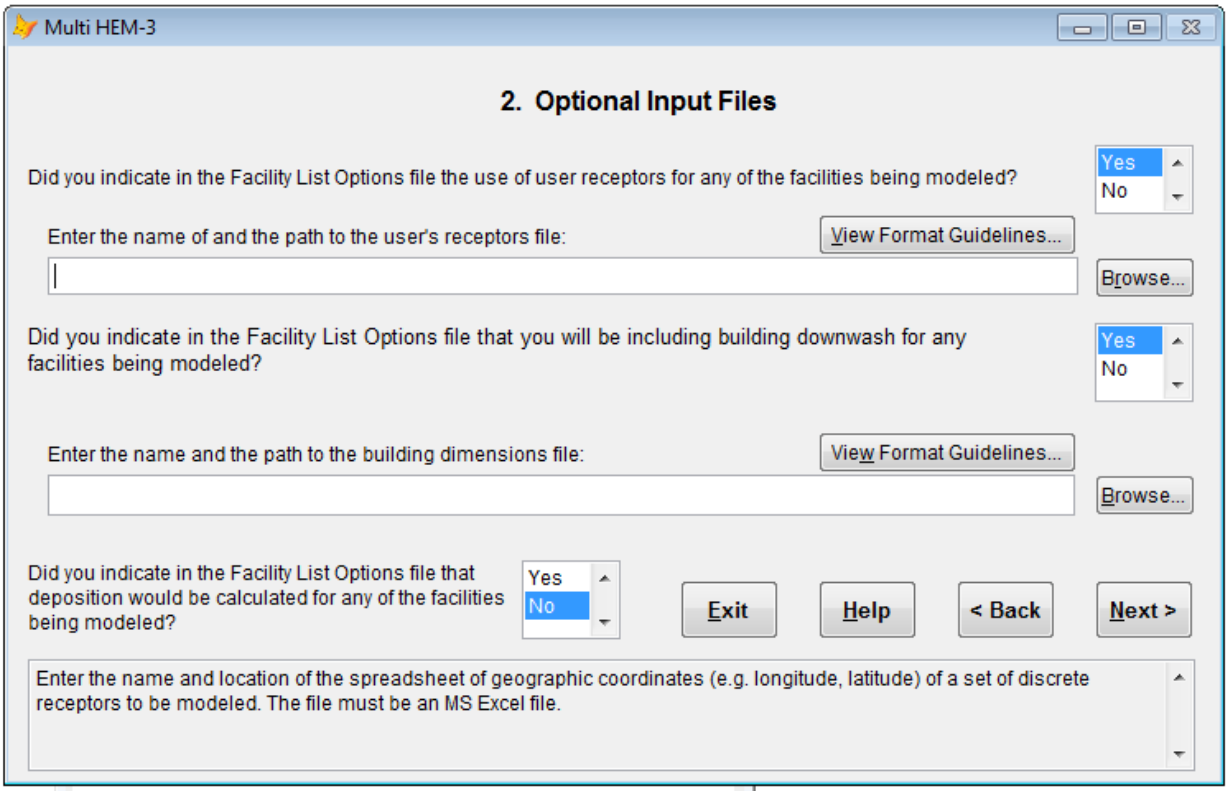


Figure 12. Optional Input Files Screen

5.2.1 Providing User Receptor and Building Dimensions Input Files

If you indicated user receptor modeling in the *Facility_List_Options.xls* file for any facility, select **Yes** in the first Yes/No toggle on the Optional Input Files screen (Figure 12) to specify the path and file name of the user receptor input file. If you are not modeling user-defined receptors, no input is required.

If you indicated building downwash modeling in the *Facility_List_Options.xls* file for any facility, select **Yes** at the second Yes/No toggle to enter a building dimensions file for the modeling of building downwash (by AERMOD). Click on the *View Format Guidelines* next to each input file request box for more information about these files. Further information is also available in Section 4 of this guide and in in the single HEM-3 User's Guide (EPA 2014b).

5.2.2 Providing Deposition Input Files

Use the third Yes/No toggle (Figure 12) to specify whether or not you indicated that deposition and depletion in your *Facility_List_Options.xls* file are to be modeled in the run for any facility.

Select **No** on the third Yes/No toggle of screen 2 if you have not indicated deposition and depletion in the *Facility_List_Options.xls* file for any facility, then click *Next*. This will take you to screen *3. Specify Temporal Variations (Optional)* screen where you can specify temporal variations in the emission inputs and concentration outputs, as described in Section 5.3.

Select **Yes** on screen 2 to indicate that deposition and depletion are to be modeled. Deposition and depletion 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. (Once the run completes, you can use this modeled deposition flux as an input to a separate multi-pathway model such as the Total Risk Integrated Methodology (TRIM) (EPA 2010).)

Selecting **Yes** will take you to screen *2a. Specify Files for Deposition and Depletion*, shown below in Figure 13. Here you will enter the names of the additional input files needed for deposition modeling. Multi HEM-3 uses AERMOD to calculate deposition and depletion effects for particulate matter, gaseous (vapor) pollutants, or both, as indicated in the *Facility_List_Options.xls* fields. You have the option of modeling dry-only, wet-only, or wet and dry deposition and depletion. (See Table 1 in Section 4.1 for the default deposition and depletion values assumed by the model in the *Facility_List_Options.xls* file.)

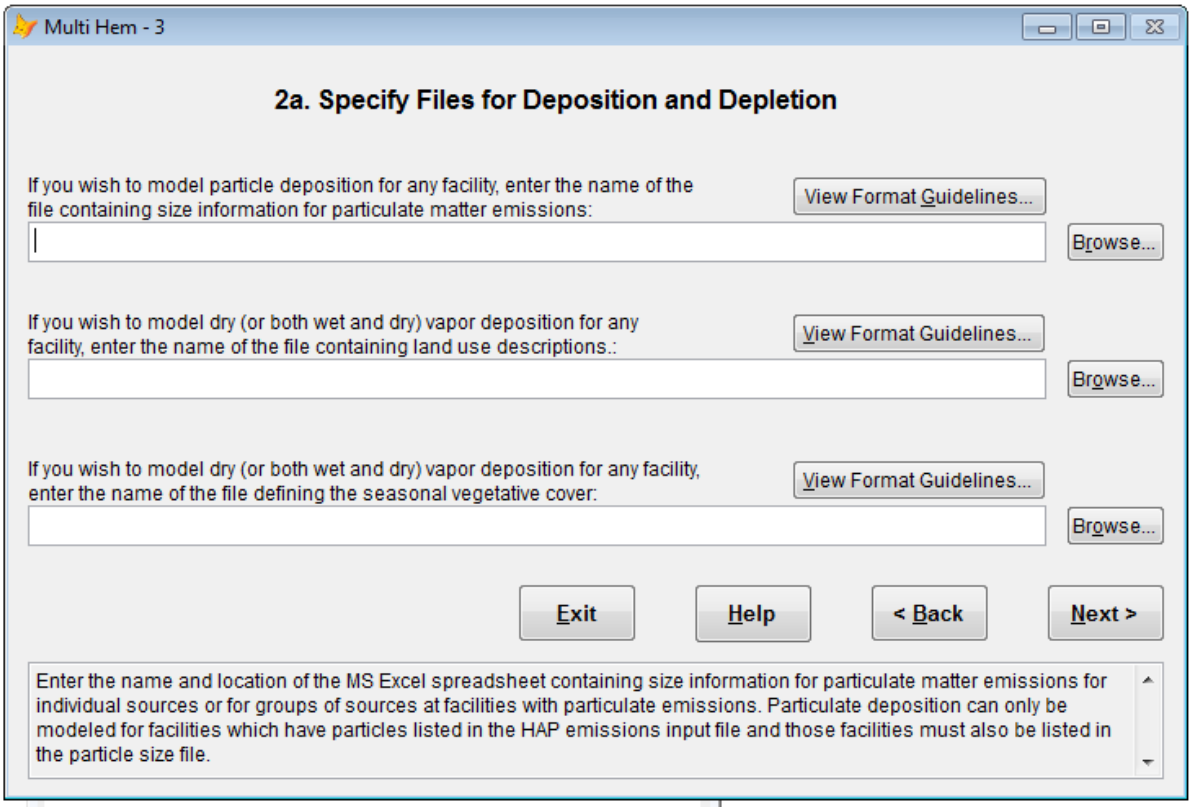


Figure 13. Optional Deposition and Depletion Input Screen

Enter deposition input files on the *Specify Files for Deposition and Depletion* screen (Figure 13). The input files you provide should be consistent with the type of deposition you indicated in the

Facility_List_Options.xls fields. For particulate deposition and depletion, a particle size distribution input file is needed. For vapor (gaseous) dry deposition and depletion, land use and month-to-season input files are needed. Click on the *View Format Guidelines* next to each input file request, for more information about these files. Further information is also available in Section 4 of this guide and in in the single HEM-3 User's Guide (EPA 2014b). After providing the appropriate input files, click *Next* at the bottom of the screen to be taken to the *3. Specify Temporal Variations (Optional)* screen, described in Section 5.3.

5.3 Specifying Optional Temporal Variations

Use screen *3. Specify Temporal Variations (Optional)* to include temporal variations in the emission inputs AERMOD uses. You can also use this screen (Figure 14) to show hourly and seasonal resolution in the ambient concentration outputs AERMOD produces. [Note: Unlike other options in Multi HEM-3, the temporal option does not have a controlling field value in the *Facility_List_Options.xls* file, but rather is controlled by the answers you provide on the 3. *Specify Temporal Variations (Optional)* screen.] From this screen, you can:

- Choose to include a temporal variations input file that varies the emissions AERMOD uses from specific sources and facilities 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).

- Direct Multi HEM-3 to provide an output file from AERMOD displaying diurnal and/or seasonal variations (based on meteorological fluctuations and/or the user-supplied temporal variations specified above) in the ambient concentration results.

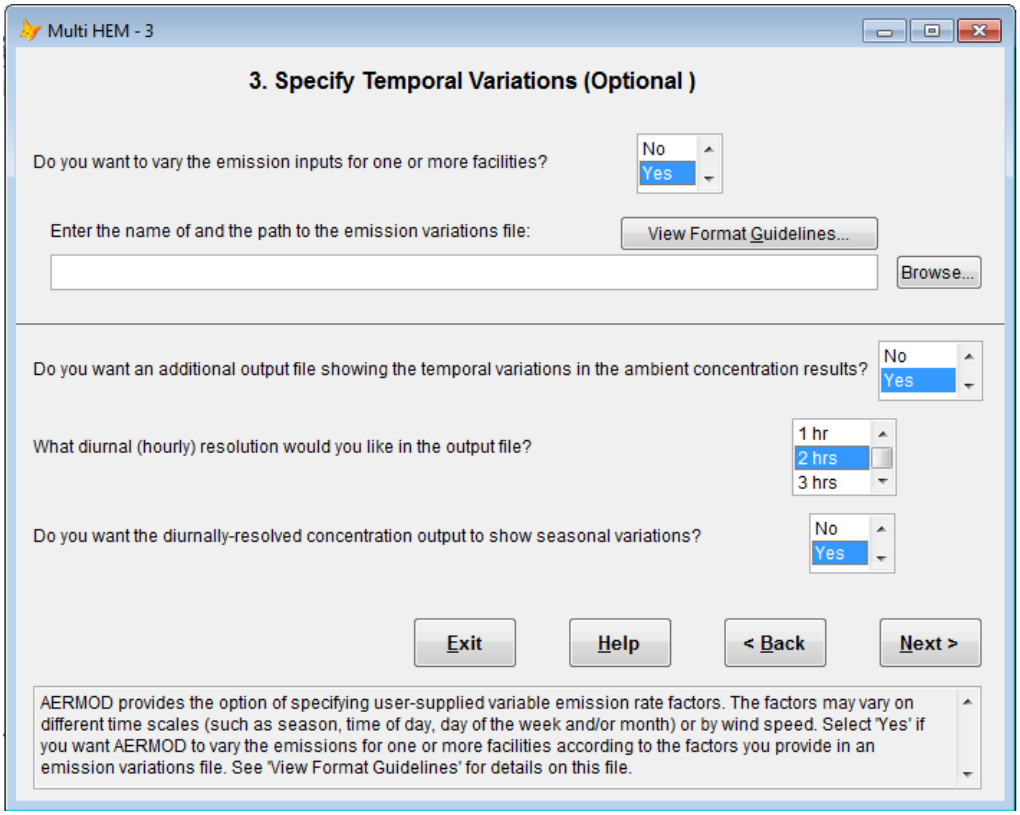


Figure 14. Optional Temporal Variations Input Screen

To vary the emission inputs, select **Yes** on the first Yes/No toggle on this screen (Figure 14), then enter the path and file name of the temporal variation file. This file contains factors that Multi HEM-3 (via AERMOD) will apply to vary the emissions based on different time scales or wind speeds. Click on the *View Format Guidelines* button next to the input file request for more information about this file. Further information on this file is also provided in Section 4 of this guide and in the single HEM-3 User's Guide (EPA 2014b).

Note that for short-term emission rates, the temporal factors applied by the emission variations input file will compound the acute multiplier specified in the facility list options file. For example, the factors you supply in the temporal variations 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 you apply hour of day temporal factors for example, you may want to set the acute multiplier to 1 (by editing the facility list options file), unless it is reasonable to assume that the short-term rate may still exceed the hour of day factors by an additional multiple.

To produce additional output files (*temporal.csv* and *temporal.dbf*) showing temporal variations based on the supplied emission variation factors above and/or meteorological variations, select **Yes** on the second Yes/No toggle on this screen (Figure 14). Then choose the diurnal (hourly) resolution 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).

To show seasonal variations in the diurnally-resolved concentration outputs, select **Yes** on the third Yes/No toggle. [Note: If you direct Multi HEM-3 to show seasonal resolution in the outputs, then the number of concentrations which will be output in the *temporal.xlsx* and *temporal.dbf* files will equal 4 (seasons) times the number of concentrations that the selected resolution produces (e.g., 4 x 24 or 96 concentrations if you select a 1-hour resolution with seasonal variations)].

You can select the second output option on the *Specify Temporal Variations* screen (Figure 14) alone or in combination with the first input option. If you select only the second output option—not in combination with a temporal variation file—then the temporal variations in the ambient concentration outputs will result from the effects of meteorological fluctuations calculated by AERMOD (e.g., based on meteorological parameters provided by the nearest met station). If you select the second output option in combination with your temporal variation input file, then the temporal variations in the ambient concentration outputs will result from applying to the emissions both meteorological fluctuations and the time or wind speed factors you provided in the temporal variation input file.

Click *Next* at the bottom of the *Specify Temporal Variations* screen to initiate the Multi HEM-3 run, which is described further in Section 5.4.

5.4 Multi HEM-3 Calculations

Multi HEM-3 begins by calculating certain modeling parameters based on the inputs, such as the facility center, the population density, and the placement of the polar grid network. Multi HEM-3 also uses the defined modeling domain to retrieve the relevant census block data from the census database (either 2000 or 2010). After Multi HEM-3 creates an input file for AERMOD based on the calculated modeling parameters, Multi HEM-3 initiates AERMOD. Once AERMOD is running, Multi HEM-3 closes. On the task bar, you will see that a disk operating system (DOS)

window is active. [Note: this open DOS window indicates that AERMOD is running. Do not close this window unless you want to abort the current run.]

To gauge how long AERMOD will run for a given facility, open the DOS window to view the output messages from AERMOD. These show what day of the year AERMOD is currently processing. Modeling run times can vary significantly from one facility to another based on the size and complexity of the facility/sources, the specific modeling options chosen for each facility, and the population density of each facility's modeling domain.

After AERMOD finishes modeling a facility, the DOS window will close, Multi HEM-3 will restart, and processing of the AERMOD output files for that facility begins. Once Multi HEM-3 has processed the AERMOD output files for the given facility, the files which Multi HEM-3 has created will be copied to that facility's output folder.

Multi HEM-3 will then start processing inputs for the next facility. During the AERMOD and Multi HEM-3 processing, your computer will intermittently display the DOS window on the task bar or a Microsoft Visual FoxPro® pop-up window. Processing will require minutes to hours depending on the modeling parameters noted above, though during the run you can use your computer for other purposes.

When Multi HEM-3 has processed all facilities the following message appears: "Multi HEM-3 has completed successfully. Click 'OK' to end the program." Click **OK** to end Multi HEM-3. All output files are automatically placed in the generic 'output' folder created by Multi HEM-3, located in the Multi HEM-3 directory.

At the beginning of the model run, the complete HAP Emissions file contents and the complete Emissions Location file contents are read into a DBF file and compared to ensure the Source IDs match. If there are any Source IDs in one file that are not in the other, your computer will display an error message showing which source IDs from which facility are not matched. Multi HEM-3 will then end. Correct the omission or discrepancy in the input file(s) before re-running the model.

The calculations section of the single HEM-3 User's Guide (EPA 2014b) provides more detail regarding the dispersion modeling calculations that Multi HEM-3 implements using AERMOD, as well as the post-dispersion modeling cancer risk and non-cancer hazard calculations performed by Multi HEM-3 to generate its outputs. These outputs are discussed in Section 6.

6. Post Processing Procedures and Multi HEM-3 Outputs

Implement one of the two following options once Multi-HEM-3 has completed processing all facilities listed in the *Facility_List_Options.xls* file:

1) Copy all of the files in the Multi HEM-3 'output' folder to another folder; or

2) Rename the Multi HEM-3 'output' folder more specifically by incorporating a short identifier relevant to the run (e.g. *output_Petro* or *Petro_output* if the run modeled petroleum manufacturing facilities).

If you want to keep the outputs somewhere other than under the Multi HEM-3 folder, choose option 1. If you want to keep all Multi HEM-3 outputs with the Multi HEM-3 program, choose option 2. If you choose option 2, Multi HEM-3 will create a new 'output' folder the next time it is run. [Note that you should never rename any of the individual Multi HEM-3 output files. The RTR

summary programs expect the files to adhere to the naming convention used by Multi HEM-3. Running of the RTR summary programs is discussed in Section 8.]

6.1 Individual Facility Outputs

Multi HEM-3 uses each facility ID to automatically create facility subfolders under the "output" folder in the HEM-3 directory. All output files associated with an individual facility are placed in the subfolder with its corresponding facility ID as each subfolder's name. The facility-specific outputs provide modeled results relevant to location-specific risk (including the maximum individual risk (MIR) for each facility), target-organ specific hazard indices (TOSHI), and concentration, as well as modeled incidence and the population exposed to various risk and TOSHI levels. These outputs are described in some detail in the outputs section of the single HEM-3 User's Guide (EPA 2014b) and include the following default files:

- maximum_indiv_risks.xls
- maximum_offsite_impacts.xls
- cancer_risk_exposure.xls
- noncancer_risk_exposure.xls
- risk_breakdown.xls
- incidence.xls
- input_selection_options.xls
- overlapping_source_receptors.xls
- block_summary_chronic.dbf
- ring_summary_chronic.dbf
- all_inner_receptors.dbf
- all_outer_receptors.dbf
- all_polar_receptors.dbf
- allreceptors_risk.kmz
- source_locations.kml
- aermod.out

If you optionally chose to model acute impacts for any facility by entering **Y** in the Acute column of the *Facility_List_Options.xls* input file, the individual facility output folder will also include the following files:

- acute_bkdn.xls
- acute_chem_pop.xls
- acute_chem_unpop.xls

Finally, if you opted for additional output files showing temporal variations (when prompted on the bottom half of the *Specify Temporal Variations* screen, Figure 14), temporal.csv and temporal.dbf output files will also be provided in each facility folder. The temporal.csv output is a comma delimited text file which may be readily imported and converted into an Excel™ spreadsheet.

All of the above listed output files are specific to an individual facility, and do not summarize the entire group (or source category/sector) of modeled facilities. Review the single HEM-3 User's Guide (EPA 2014b), if necessary, for a greater understanding of the values presented in each of the facility files. The *input_selection_options.xls* output file in each facility folder is also helpful to review regarding the input parameters upon which each facility's outputs are based.

6.2 Multiple Facility Outputs

In addition to the individual facility outputs listed above, Multi HEM-3 produces four summary output files, based on the results for the entire group (or source category/sector) of modeled facilities. These multi-facility outputs are updated after the output files for the individual facilities have been created and essentially concatenate the individual facility results into group-wide summary files. In each of these four XLS files, Multi HEM-3 writes one row of information for each facility upon completion of that facility's individual modeling run. The four summary XLS output files created by Multi HEM-3 are described below, including a listing of the fields (columns) in each file, and an abbreviated screenshot of each file.

- ***Facility_max_risk_and_HI.xls*** – This Multi HEM-3 output file provides the maximum modeled risk and hazard index results for every facility as well as additional facility-specific modeling results, including:

    - a listing of all facility IDs modeled;
    - the cancer risk at the receptor which experiences the highest risk in the modeled radius around each facility (i.e., facility-specific MIR);
    - whether or not the MIR is interpolated from nearby receptors[3];
    - the type of receptor where the MIR occurs (e.g., census block, polar grid, user-defined receptor);
    - the latitude and longitude of the MIR receptor;
    - the 14 TOSHIs at the receptors that experience the maximum TOSHI for each facility including: whether or not the TOSHI value is interpolated, the receptor type(s) where the max TOSHIs occur, and the latitude and longitude for certain max TOSHI receptors (e.g., respiratory, neurological);
    - the population, if any, excluded from the modeling run because of any census block centroid(s) located within the overlap distance around each emission source (and therefore considered on facility property)[4]
    - the cancer incidence (predicted excess cancers per year due to modeled emissions) at each facility;
    - the file name of the meteorological station used in the modeling of each facility;
    - the distance (in miles) from the facility center to the meteorological station used in the modeling run; and
    - the latitude and longitude location of the facility center calculated by Multi HEM-3.

    Figure 15 shows a sample *Facility_max_risk_and_HI.xls*, which has been abbreviated to fit on the page by excluding 13 of the 14 TOSHI values and associated columns. The TOSHIs modeled by Multi HEM-3 impact the following organs and organ systems: respiratory; liver; neurological; developmental; reproductive; kidney; ocular; endocrine; hematological; immunological; skeletal; spleen; thyroid; and whole body. In the example shown in Figure 15, only respiratory HI is shown, which is commonly the highest TOSHI level based on the dispersion and inhalation modeling performed by AERMOD and Multi HEM-3. Regarding modeled risk in this example, two facilities show a cancer risk in the second column greater than 1 in a million (that is, greater than 10^{-6}).

[3] An interpolated MIR generally suggests that the modeling distance should be increased and the facility remodeled.

[4] A value in the population overlap field generally indicates that the facility should be remodeled (e.g., with a smaller overlap distance specified) to ensure that the population associated with the census block centroid(s) is accounted for.

- ***Facility_cancer_risk_exp.xls*** – This Multi HEM-3 output file lists the facilities by ID, their corresponding latitudes and longitudes (of the calculated facility centers), and the population exposed to different cancer risk levels, including:

    - the number of people from all facilities exposed to a cancer risk level greater than or equal to 1 x 10^{-3}, designated as "pop_ge_eneg3" in the column header (which may also be expressed as a risk of 1 in 1,000 or 1,000 in a million);
    - the number of people from all facilities exposed to a cancer risk level greater than or equal to 1 x 10^{-4}, designated as "pop_ge_eneg4" in the header (which may also be expressed as a risk of 1 in 10,000 or 100 in a million);
    - the number of people from all facilities exposed to a cancer risk level greater than or equal to 1 x 10^{-5}, designated as "pop_ge_eneg5" in the header (which may also be expressed as a risk of 1 in 100,000 or 10 in a million);
    - the number of people from all facilities exposed to a cancer risk level greater than or equal to 1 x 10^{-6}, designated as "pop_ge_eneg6" in the header (which may also be expressed as a risk of 1 in 1,000,000 or 1 in a million);
    - the number of people from all facilities exposed to a cancer risk level greater than or equal to 1 x 10^{-7}, designated as "pop_ge_eneg7" in the header (which may also be expressed as a risk of 1 in 10,000,000 or 0.1 in a million).

    Figure 16 shows a sample *Facility_cancer_risk_exp.xls* for the same run that produced the *Facility_max_risk_and_HI.xls* shown in Figure 15. In this example, 1,468 people residing near one facility and 142 people residing near another facility experience a modeled risk greater than or equal to 1 in a million. The other three facilities modeled do not result in any surrounding populations experiencing a risk greater than or equal to 1 in a million; consistent with the risk (MIR) results shown in the second column of the *Facility_max_risk_and_HI.xls* output shown in Figure 15.

- ***Facility_toshi_exp.xls*** – This Multi HEM-3 output file lists the facilities by ID and the number of people with a TOSHI greater than 1 for each facility and for each of the 14 TOSHIs currently modeled by Multi HEM-3. Figure 17 shows a sample *Facility_toshi_exp.xls* for the same run that produced the Multi HEM-3 outputs shown in Figures 15 and 16. In this example, no people surrounding any of the modeled facilities are predicted to experience a TOSHI greater than 1. [Note: Because the convention of one significant figure is employed, an HI greater than 1 equates mathematically to an HI greater than or equal to 1.5.]

- ***Facility_tox_weighted_emissions.xls*** – This Multi HEM-3 output file lists the toxicity-weighted emissions for each facility. Toxicity weightings for cancer risk are expressed in terms of the product of the URE in lifetime cancer risk per µg/m^3 and emissions in tons/year, and are computed by summing this product for every chemical emitted at a facility. Toxicity-weighted emissions for non-cancer risk are expressed in terms of the ratio of emissions in tons/year to the RfC in mg/m^3, and are computed separately for each target organ by summing these ratios for each chemical. Figure 18 shows a sample *Facility_tox_weighted_emissions.xls* for the same run that produced the Multi HEM-3 outputs shown in Figures 15, 16, and 17.

Multi HEM-3 will create two Excel™ files listing the dose response values and target organ endpoints for the modeled pollutants; these output files are named *Dose_response_library.xls* and *Target_organ_endpoints.xls*. Two additional DBF output files are also created when the Multi HEM-3 run has completed successfully: *Faclist.dbf* and *Hap_library.dbf*. *Faclist.dbf* is a list of all facility IDs that were run for the current source category. *Hap_library.dbf* is the DBF

version of the Dose Response Library XLS file from the HEM-3 “Reference” folder. [Note: Do not change the names of the Multi HEM-3 output files, as these files are referenced by their names when running the RTR summary programs described in Section 8.]

1	facil_id	mx_can_rsk	can_rsk_interpltd	can_rcpt_type	can_lat	can_lon	respiratory_hi	resp_hi_interpltd	resp_rcpt_type	[43 other TOSHI columns]	pop_overlp	incidence	metname	miles	fac_center_lat	fac_center_lon
2	48005NEI12810	9.0286E-07		Census block	31.342	-94.706	0.007086817		Census block	...		4.95422E-05	LA13957_UstarMod.sfc	148	31.338	-94.713
3	05003NEIART$10736	3.0319E-06		Census block	33.145	-91.972	0.203390104		Census block	...		0.000105232	AR13963_UstarMod.sfc	176	33.139	-91.966
4	13093NEI46838	4.0436E-06		Census block	32.091	-83.82	0.033039428		Census block	...		1.64535E-05	GA13874_UstarMod.sfc	181	32.079	-83.79
5	17161NEI56034	0		na	41.754	-90.29	0.000564176		Census block	...		0	IL14923_UstarMod.sfc	37	41.754	-90.29
6	21111NEI32872	4.4105E-07		Census block	38.181	-85.753	0.003461951		Census block	...		9.96017E-05	KY13810_UstarMod.sfc	2	38.181	-85.753

Facility_max_risk_and_HI

Figure 15. Sample Facility_max_risk_and_HI Multi HEM-3 Output (abbreviated)

1	facility_id	lat	lon	level3	pop_ge_eneg3	level4	pop_ge_eneg4	level5	pop_ge_eneg5	level6	pop_ge_eneg6	level7	pop_ge_eneg7
2	48005NEI12810	31.338	-94.713	0.001	0	0.0001	0	0.00001	0	0.000001	0	0.0000001	8075
3	05003NEIART$10736	33.139	-91.966	0.001	0	0.0001	0	0.00001	0	0.000001	1468	0.0000001	11925
4	13093NEI46838	32.079	-83.79	0.001	0	0.0001	0	0.00001	0	0.000001	142	0.0000001	1642
5	17161NEI56034	41.754	-90.29	0.001	0	0.0001	0	0.00001	0	0.000001	0	0.0000001	0
6	21111NEI32872	38.181	-85.753	0.001	0	0.0001	0	0.00001	0	0.000001	0	0.0000001	6688

Facility_cancer_risk_exp

Figure 16. Sample Facility_cancer_risk_exp Multi HEM-3 Output

1	facility_id	level1	resp_hi	liver_hi	neuro_hi	develop_hi	repro_hi	kidney_hi	ocular_hi	endo_hi	hema_hi	immune_hi	skel_hi	spleen_hi	thyroid_hi	wholeb_hi
2	48005NEI12810	Greater than 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	05003NEIART$10736	Greater than 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	13093NEI46838	Greater than 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	17161NEI56034	Greater than 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	21111NEI32872	Greater than 1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Facility_toshi_exp

Figure 17. Sample Facility_toshi_exp Multi HEM-3 Output

1	facility_id	cancer_risk	respiratory	liver	neuro	developmental	reproductive	kidney	ocular	endoc	hemato	immunological	skeletal	spleen	thyroid	wholebody
2	48005NEI12810	0.000026754	0.21	0.001075	0	0.00414875	0	0	0	0	0	0	0	0	0	0
3	05003NEIART$10736	0.00021437	5.254081633	0.02625	0	0.0035925	0	0	0	0	0	0	0	0	0	0
4	13093NEI46838	0.000016074	0.149160998	0.00305	0.00009	0.0006775	0	0	0	0	0	0	0	0	0	0
5	17161NEI56034	0	0.092928571	0	0	0.0024875	0	0	0	0	0	0	0	0	0	0
6	21111NEI32872	0.00000819	0.064285714	0	0	0.00004	0	0	0	0	0	0	0	0	0	0

Facility_tox_weighted_emissions

Figure 18. Sample Facility_tox_weighted_emissions Multi HEM-3 Output

7. Quality Assurance Checks and Multi HEM-3 Reruns

Before initiating the quality assurance (QA) checks and possible remodeling runs described in this section, rename the Multi HEM-3 'output' folder, as instructed in Section 6. Remember, the name you choose should be relevant to the run (e.g., *Petro_output* if the run modeled petroleum manufacturing facilities). If you do not rename the output folder, any Multi HEM-3 facility reruns, which may be necessary, as described below, will cause your original outputs to be overwritten.

There are several QA checks that you should perform after Multi HEM-3 has completed running and before you run the RTR summary programs, to determine if any of the facilities need to be remodeled. Open and check the *Facility_max_risk_and_HI.xls* file to:

- ensure that the number of facilities modeled in column A equals the number of facilities in the input files (e.g., *Facility_List_Options.xls*);
- ensure that the maximum cancer risk values in column B occur at census block or populated user-defined receptors rather than at unpopulated polar grid (or boundary or monitor) receptors, as noted in column D; and
- ensure that the TOSHI values in the various HI columns occur at census block or populated user-defined receptors rather than at unpopulated polar grid (or boundary or monitor) receptors.

The cancer risk and non-cancer TOSHI checks described above are especially important for facilities of interest, such as those facilities with the highest relative risk or relative TOSHI values in the modeled set. If these QA checks fail, rerun Multi HEM-3 (as described below) for the facilities that failed one or more of the QA checks, before running the RTR summary programs. Rerunning Multi HEM-3 for such facilities will ensure that all facilities in the group or source category are modeled, and that the modeled maximum risk and TOSHI values occur at populated receptors (i.e., where people reside).

Follow these steps to rerun a facility to force the MIR or the maximum TOSHIs to occur at census block or populated user receptors to correct situations when the MIR or the maximum TOSHIs occur at a polar grid receptor[5]. First, look at the *facilityname_allreceptors_risk.kmz* file located in the individual facility subfolder. Opening this file will start Google Earth™, if it is installed on your computer. Figure 19 shows a sample Google Earth™ KMZ output file.

Zoom in on the facility center and turn on the polar grid (by checking the box next to "Polar receptors" in the Places key) so the polar grid receptor at which the MIR or TOSHI value occurs is also visible.

Next, find the census block centroid closest to the MIR polar receptor. Use the 'ruler' tool to measure the distance (in meters) from the census block centroid to the facility center. Round this distance up enough to ensure that a census block centroid near the current polar MIR receptor will be closer to the facility center than this revised first polar ring when the facility is

[5] The MIR or maximum TOSHIs can occur at a polar grid receptor if there is a census block receptor located within the overlap distance of the plant boundary. In this case, Multi HEM-3 will select the closest receptor to the plant boundary (i.e., census block, user-defined, or polar) to estimate the MIR at a location nearest to the population inside the overlap distance that has been excluded.

rerun, as explained further below. Follow these steps for all facilities of interest requiring remodeling.

To rerun the facility or facilities, create a copy of the input file *Facility_list_options.xls*. Be careful to name the new file so that it is obvious it is not the original *Facility_list_options.xls* file (e.g., *QA1_Facility_list_options.xls*, to indicate it as the first QA run). Delete the rows for the facilities that do NOT have to be rerun.

Next, under the column heading 'ring1', enter the value determined from the above instructions (i.e., the distance in meters between the facility center and the census block centroid closest to the MIR polar receptor, rounded up). Save these changes and close the file.

Start Multi HEM-3. When prompted for the required input files, use the new *QA1_Facility_list_options.xls* file. Multi HEM-3 will then run only the facilities with revised first ring distances. This "bumping out" of the first polar ring will ultimately allow Multi HEM-3 to choose a populated census block receptor as the MIR or TOSHI receptor, because the first polar ring of polar receptors will be more distant from the facility center than the closest census block centroid. When the new 'output' folder has been generated by the rerun, rename the Facility_max_risk_and_HI.xls output as *QA1_Facility_max_risk_and_HI.xls*. You should also change the 'output' folder name generated by this run to 'output_QA1' or 'QA1_output' in case additional QA runs are necessary.

Once you have rerun the facility or facilities, check the outputs to determine if the relevant MIR or TOSHI is now at a census block receptor by opening the *QA1_Facility_max_risk_and_HI.xls* file. If the MIR or TOSHI is still at a polar grid receptor, repeat the above steps (starting with opening the *facilityname_allreceptors_risk.kmz* file, and this time using the identifier *QA2* for the naming convention). Make the first ring of the polar grid even farther from the plant center than in the first adjustment.

Once you have successfully adjusted the distance so that the MIR and maximum TOSHIs occur at census block receptors, copy the most recent facility rows from all *QA_Facility_max_risk_and_HI.xls* files (e.g., *QA1…*, *QA2…*, *QA3…*) into the original *Facility_max_risk_and_HI.xls* file. Open both files and replace the row for the adjusted facility in the original *Facility_max_risk_and_HI.xls* file with the new row from the *QA_Facility_max_risk_and_HI.xls* file.

Perform this row replacement for each remodeled facility, using the most recent QA run applicable to that facility. Copy the most recent facility output subfolder (including all its revised contents) to the location of the original facility output and overwrite the original subfolder for each remodeled facility.

Finally, a facility may require remodeling (using the steps described above) if the maximum risk and/or TOSHI values of that facility are interpolated, rather than explicitly modeled. The *Facility_max_risk_and_HI.xls* output indicates interpolated maximum risk values in column C (if blank, the value is not interpolated) and maximum TOSHI values in the columns to the right of each TOSHI value (e.g., column F for respiratory HI). Generally, a value is interpolated if the maximum receptor is located outside of the modeling distance within which receptors are explicitly modeled (e.g., at a default value of 3,000 m or 3 km). This can occur if a modeled facility is located in a sparsely populated area, where there are no census block centroids within the modeling distance (e.g., 3 km) of the facility center.

Open the *facilityname_allreceptors_risk.kmz* file located in the individual facility subfolder to determine if a facility with an interpolated maximum risk and/or TOSHI should be remodeled with an increased modeling distance. The KMZ file will show where the closest census block centroids are located. If the facility is one of interest or concern (for example, if its relative risk or TOSHI is high), the modeling distance should be increased to include the census block centroid(s). Use Google Earth's™ ruler tool to determine the new modeling distance. Remember to round up this distance slightly before remodeling the facility in a QA run, as previously described. If the relative risk and/or TOSHI is low—and if the reason for the low value(s) is that the facility is located in a sparsely populated area—you may decide that remodeling is not necessary.

An interpolated maximum risk or TOSHI value may also occur if one or more of the emission sources is mislocated – for example, with an incorrect latitude or longitude that places a source too far from the actual facility location. This interpolated situation requires remodeling to correct the location inaccuracy. If one or more source is mislocated (as determined by opening and viewing the *facilityname_allreceptors_risk.kmz* file), perform a QA rerun for that facility using a corrected emissions location file (and a corrected polygon vertex file, if the misplaced source is configured as a polygon).

In general, the image of each facility's emission sources and receptors overlaid on a Google Earth™ satellite map (i.e., the *facilityname_allreceptors_risk.kmz* file) is a powerful tool for QA checks of the inputs and modeling parameters that Multi HEM-3 uses. Figure 19 below shows a sample Google Earth™ output map of emission sources and receptors with both census block and polar grid receptors turned on. Emission sources are evident in the center of the polar grid network, and the red "X" denotes the MIR receptor that occurs at a census block centroid. 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.

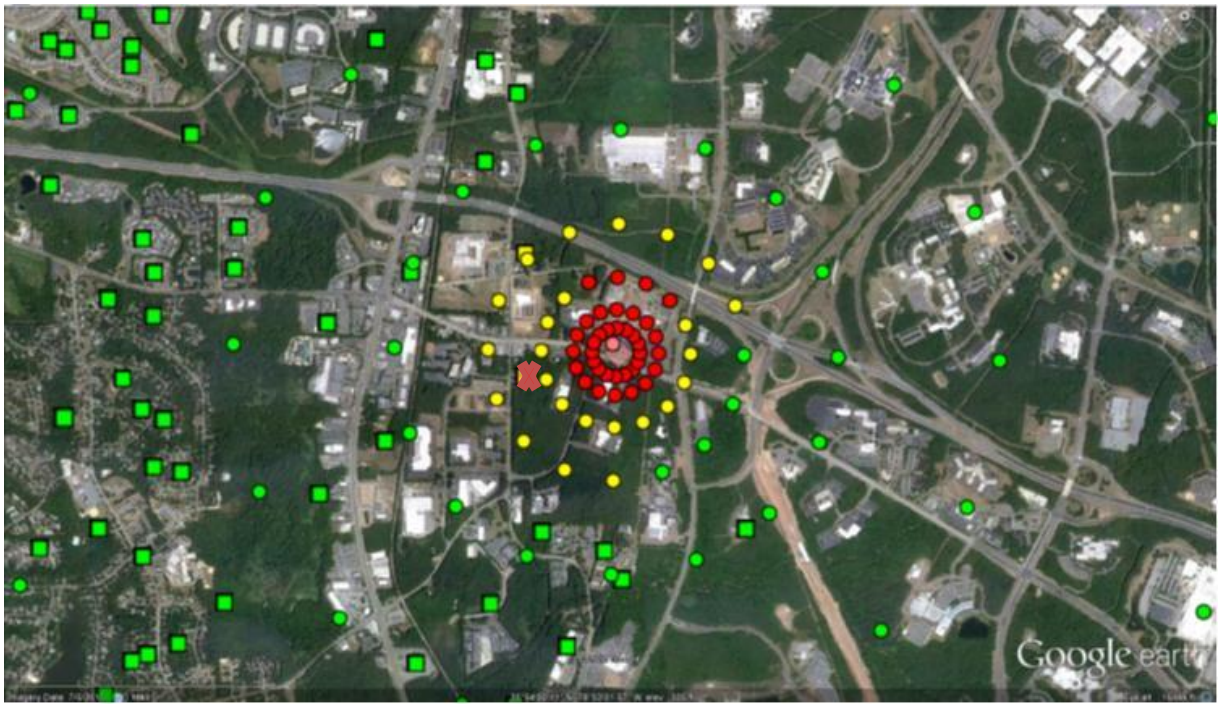


Figure 19. Sample Allreceptors_Risk.kmz Multi HEM-3 Output

Open and view each KMZ file, even if all maximum risk and TOSHI values listed in the *Facility_max_risk_and_HI.xls* output occur at census block centroids and no values are interpolated, to perform a QA check of each image. Determine if sources are mislocated or misaligned enough to require remodeling, and if the surrounding populations are represented well enough by the census block centroids (if not, you may need to remodel using user-defined receptors).

This QA check of each KMZ image is highly recommended. Even a QA check of a KMZ image that shows nothing amiss may prove useful. That is, if nothing looks amiss in the KMZ image but the maximum risk and TOSHI values seem too high to be reasonable, this may indicate an error in the emission amounts or pollutants provided in the HAP emissions input file.

Once you have performed all QA checks and runs, you are ready to run the RTR summary programs, as described in Section 8. Remember, the RTR summary programs need the 'final' *Facility_max_risk_and_HI.xls* and the *faclist.dbf* outputs to run and these two files should not be renamed.

8. Running RTR Summary Programs

After Multi HEM-3 has run and created the facility and summary output files described in Section 6, and after you perform the QA checks and adjustments on the Multi HEM-3 outputs described in Section 7, you can use the RTR summary programs to extract and further summarize results from the Multi HEM-3 outputs.

The RTR summary programs produce outputs that report the maximum cancer risk and the overall incidence considering emissions from all modeled facilities. These programs also identify the category-wide pollutant and source type drivers of cancer risk, incidence, and non-cancer hazard indices, and estimate the category-wide population exposed to various risk and TOSHI levels. The category-wide histograms showing population exposed to various risk levels is provided both overall (considering all sources) and broken down by source type. The RTR summary programs identify the locations of maximum risk and maximum TOSHI for the entire group of modeled facilities.

Furthermore, if you chose the option to model acute concentrations and impacts as part of the Multi HEM-3 run, you can use the RTR summary programs to report category-wide acute concentrations and hazard quotients based on various acute benchmarks. Section 9 includes more details regarding each of the RTR summary program outputs.

Double-click on the file *rtr.exe* or click on your desktop short-cut (if you created one) to start the RTR summary programs. The summary programs module consists of two main screens. The initial title screen requires no inputs; simply click the *Next* button to proceed to the *RTR Summary Programs* screen.

On the *RTR Summary Programs* screen, shown below in Figure 20, you can create an identifier for the group of modeled facilities or source category that will be used in the naming of the RTR summary program outputs, and to indicate which Multi HEM-3 outputs will be used as inputs for the RTR summary programs. From this screen, you can launch the specific RTR summary programs to be applied to the Multi HEM-3 outputs.

- The first input box on the screen prompts you to enter an RTR source category identifier. This identifier can be a string of up to 20 characters (e.g., Petro for petroleum refineries,

ONG for oil and natural gas, MIN for mineral wool, SLS for secondary lead smelting). This identifier will be applied in the naming of the RTR outputs.

- The second input box on the screen prompts you to designate the location of the Multi HEM-3 output files to be used as inputs in the RTR summary program runs. Click on the *Browse* button next to the box to select the file path from a directory of choice rather than manually entering the information. [Note: This path and the identifier entered in the first input box above will be saved and appear as the defaults the next time you start the RTR Summary Programs module.]

- The third input box lists the summary programs available to be run. You can select from seven programs, which summarize different aspects of the Multi HEM-3 outputs. These are:
    - Acute Impacts
    - Cancer Drivers
    - Hazard Index Drivers
    - Incidence Drivers
    - Cancer and Non-cancer Histogram
    - Maximum Risk by Category
    - Source Type Risk Histogram (additional input needed, as described below)

  Choose the program you want to run by clicking on it. As Figure 20 shows, your selection will be highlighted. Next, click on the *Run Program* button. You can select only one program at a time.

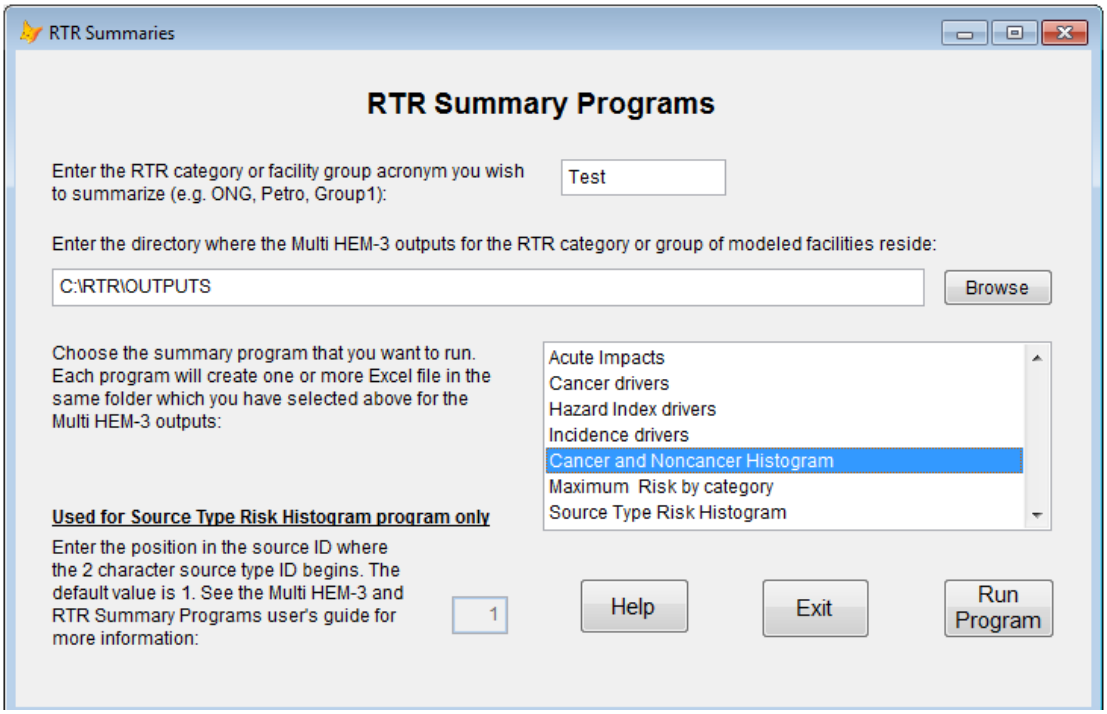


Figure 20. RTR Summary Programs Screen

When running the *Source Type Risk Histogram* program, an additional input is required indicating where in the source identification (source ID) naming scheme the emission type is indicated. The source ID should include two characters that indicate the type of the particular

source, as noted in the footnote to the HAP emissions and emissions location input files in Section 4.1. For example, you might indicate fugitive emissions in the source ID as FG, while you might indicate process stack emissions by the characters PS in the same location of the source ID. Thus, for the *Source Type Risk Histogram* program, you must enter a number from 1 to 7 in the fourth input box on the *RTR Summary Programs* screen indicating where in the source ID the two-character designation for the emission source type begins. The default position is 1. (However, in the sample source IDs listed in the *Template_Multi* input files provided with the Multi HEM-3 installation, the two-letter source type code begins in position 3; e.g., 'EL' in MEEL0014 and 'ST' in MEST0009).

The output files of the RTR summary programs will be stored in the Multi HEM-3 Output directory with the naming scheme *SourceCategoryAcronym_program output name.xls*. For instance, the output of the Cancer Drivers program for the oil and natural gas (ONG) example would be named *ONG_cancer_drivers.xls*.

Note that to use the Acute Impacts RTR summary program, there must be acute results in the Multi HEM-3 outputs. This means that you must have entered a **Y** in the acute column of the facility list options input file, before running Multi HEM-3, for one or more of the modeled facilities. As noted in Section 4.1, a blank in the acute column of the facility list options is interpreted by Multi HEM-3 as a default of **N** (for no modeling of acute effects), so you will need to manually change this default setting if acute modeling is desired.

Note also that the Acute Impacts summary program and the Source Type Risk Histogram summary program require that the *All Receptors* files be generated by Multi HEM-3. The generation of the *All Receptors* output files is the default in the facility list options input file, so even if this column is left blank, the *All Receptors* files will be generated. However, if you entered **N** in the All Receptors column of the facility list options prior to running Multi HEM-3, the Acute Impacts and Source Type Risk Histogram RTR summary programs cannot be run.

9. RTR Summary Program Outputs

The seven RTR summary programs described above create nine summary Excel™ output files, which are listed and briefly described below. Following the listing, Figures 21 through 29 provide sample screenshots for these RTR summary program output files.

- ***SourceCategoryAcronym_sector_mir_incidence.xls***

  Provides the sector incidence for the source category/sector as a whole, and the maximum risk ("sector MIR") occurring at a populated census block receptor taking into account multiple facility impacts on census block receptors located near more than one modeled facility. See Figure 21.

- ***SourceCategoryAcronym_category_maxrisk.xls***

  Provides the Federal Information Processing Standards (FIPS) code; census block ID; and census block population for the census block with the maximum modeled risk in the source category/sector. [Note: This category max risk will equal the highest facility-specific risk listed in the *Facility_max_risk_and_HI.xls* Multi HEM-3 output file except when (1) the highest facility-specific risk does not occur at a census block, or (2) multi-facility impacts on the same receptor cause the max risk for the entire source category/sector to be greater than the highest facility-specific risk.] See Figure 22.

- ***SourceCategoryAcronym_histogram_risk.xls***

  Lists the number of people and facilities in the source category at different cancer risk levels (e.g., < 10^{-6} or 1 in 1 million, >= 10^{-6} or 1 in 1 million, >=10^{-5} or 10 in 1 million, >=10^{-4} or 100 in 1 million). [Note: This program produces population estimates with the one significant figure rounding convention that the EPA has adopted for risk levels. Multiple impacts on the same receptor (from facilities located close to one another) may cause the population numbers from this file to differ from the population numbers provided by the *Facility_cancer_risk_exp.xls* Multi HEM-3 output file.] See Figure 23.

- ***SourceCategoryAcronym_histogram_hi_part.xls***

  Lists the number of people (p) and facilities (f) in the source category at different HI levels (e.g., <= 1, >1, > 10) for a partial list of HI types of interest (respiratory, neurological, reproductive). [Note: this program produces population estimates with the one significant figure rounding convention that the EPA has adopted for HI levels. Multiple impacts on the same receptor (from facilities located close to one another) may cause the population numbers from this file to differ from the population numbers provided by the *Facility_toshi_exp.xls* Multi HEM-3 output file.] See Figure 24.

- ***SourceCategoryAcronym_incidence_drivers.xls***

  Lists the pollutants emitted and the incidence associated with each individual pollutant for the source category as a whole. See Figure 25.

- ***SourceCategoryAcronym_cancer_drivers.xls***

  Lists the facilities by ID; the MIR modeled at each facility from all pollutants and emission sources acting on the receptor; the predominant pollutant(s) and emission source(s) contributing to at least 90% of that facility's MIR; and the cancer risk associated with each of those pollutant-emission source combinations. See Figure 26.

- ***SourceCategoryAcronym_hi_drivers.xls***

  Lists the facilities by ID; the HI type or TOSHI (respiratory, neurological, liver, etc.); the maximum TOSHI value at each facility from all pollutants and emission sources, the predominant emission source and pollutant combinations contributing to the maximum TOSHI; the pollutant- and source-specific TOSHI value for the maximum receptor; and the percentage each emission source-pollutant combination contributes to the maximum TOSHI. See Figure 27.

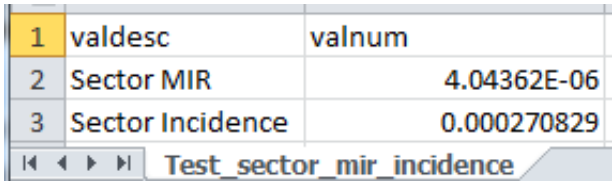
- ***SourceCategoryAcronym_sourcetype_histogram.xls***

  Provides a table showing the maximum cancer risk by emission source type for the category; the number of people estimated at various risk levels (e.g., >= 1 in 1 million, >= 10 in 1 million, >= 100 in 1 million) attributable to each emission source type; and the incidence attributable to each emission source type. See Figure 28.

- ***SourceCategoryAcronym_acute_impact_flags_all.xls***

  Lists the facilities by ID; every modeled pollutant emitted and that pollutant's maximum modeled acute concentration at each facility; the 1-hour dose-response values for each pollutant based on six acute benchmarks (REL, AEGL1, AEGL2, ERPG1, ERPG2 and

IDLH); and the hazard quotient (HQ) based on the pollutant concentration and dose-response values for the six benchmarks. These benchmarks are defined in the Outputs section of the single HEM-3 User's Guide (EPA 2013). [Note: This summary file is available only if you entered **Y** in the acute column of the facility list options input file prior to modeling.] See Figure 29.



1	valdesc	valnum
2	Sector MIR	4.04362E-06
3	Sector Incidence	0.000270829

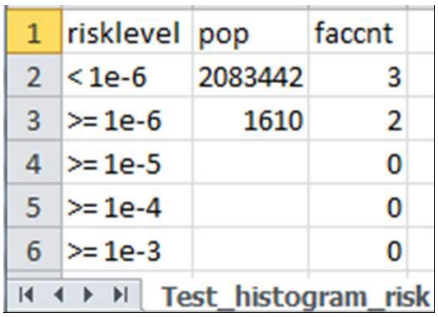
Test_sector_mir_incidence

Figure 21. Sample Sector_MIR_Incidence RTR Summary Output

1	fips	block	population	mir
2	13093	9703001135	76	4.04362E-06

Test_category_maxrisk

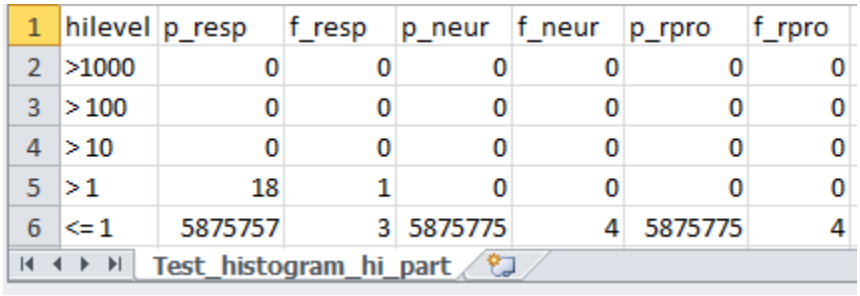
Figure 22. Sample Category_Maxrisk RTR Summary Output



1	risklevel	pop	faccnt
2	< 1e-6	2083442	3
3	>= 1e-6	1610	2
4	>= 1e-5		0
5	>= 1e-4		0
6	>= 1e-3		0

Test_histogram_risk

Figure 23. Sample Histogram_Risk RTR Summary Output



1	hilevel	p_resp	f_resp	p_neur	f_neur	p_rpro	f_rpro
2	>1000	0	0	0	0	0	0
3	> 100	0	0	0	0	0	0
4	> 10	0	0	0	0	0	0
5	> 1	18	1	0	0	0	0
6	<= 1	5875757	3	5875775	4	5875775	4

Test_histogram_hi_part

Figure 24. Sample Histogram_HI_Part RTR Summary Output

1	pollutant	incidence
2	Acetaldehyde	3.072E-07
3	Formaldehyde	0.000270522
4	Lead compounds	0
5	Maleic anhydride	0
6	Methanol	0
7	Phenol	0
8	Triethylamine	0

Test_incidence_drivers

Figure 25. Sample Incidence_Drivers RTR Summary Output

1	facname	mir	pollname	cancer_rsk	rsk_contrb	source_id
2	05003NEIART$10736	3.03186E-06	Formaldehyde	6.2103E-07	20.48	MEWW0032
3	05003NEIART$10736	3.03186E-06	Formaldehyde	4.1801E-07	13.79	MERP0001
4	05003NEIART$10736	3.03186E-06	Formaldehyde	1.40941E-07	4.65	MESH0027
5	05003NEIART$10736	3.03186E-06	Formaldehyde	1.40941E-07	4.65	MESH0028
6	05003NEIART$10736	3.03186E-06	Formaldehyde	1.40941E-07	4.65	MESH0029
7	05003NEIART$10736	3.03186E-06	Formaldehyde	1.40941E-07	4.65	MESH0030
8	05003NEIART$10736	3.03186E-06	Formaldehyde	1.25683E-07	4.15	MERP0004
9	05003NEIART$10736	3.03186E-06	Formaldehyde	1.13245E-07	3.74	MESH0007
10	05003NEIART$10736	3.03186E-06	Formaldehyde	1.11866E-07	3.69	MESH0008
11	05003NEIART$10736	3.03186E-06	Formaldehyde	7.97531E-08	2.63	MESH0011
12	05003NEIART$10736	3.03186E-06	Formaldehyde	7.97531E-08	2.63	MESH0013
13	05003NEIART$10736	3.03186E-06	Formaldehyde	7.97531E-08	2.63	MESH0015
14	05003NEIART$10736	3.03186E-06	Formaldehyde	7.72161E-08	2.55	MESH0012
15	05003NEIART$10736	3.03186E-06	Formaldehyde	7.3679E-08	2.43	MESH0016
16	05003NEIART$10736	3.03186E-06	Formaldehyde	7.3679E-08	2.43	MESH0017
17	05003NEIART$10736	3.03186E-06	Formaldehyde	7.3679E-08	2.43	MESH0018
18	05003NEIART$10736	3.03186E-06	Formaldehyde	6.19336E-08	2.04	MESH0024
19	05003NEIART$10736	3.03186E-06	Formaldehyde	6.19336E-08	2.04	MESH0025
20	05003NEIART$10736	3.03186E-06	Formaldehyde	6.19336E-08	2.04	MESH0026
21	05003NEIART$10736	3.03186E-06	Formaldehyde	6.03462E-08	1.99	MEEL0014
22	13093NEI46838	4.04362E-06	Formaldehyde	3.68609E-06	91.16	MEEL0001
23	17161NEI56034	0	None	0	0	None
24	21111NEI32872	4.41053E-07	Formaldehyde	3.26975E-07	74.14	MESH0003
25	21111NEI32872	4.41053E-07	Formaldehyde	1.14077E-07	25.86	MESH0004
26	48005NEI12810	9.0286E-07	Formaldehyde	7.98194E-07	88.41	MEST0002
27	48005NEI12810	9.0286E-07	Formaldehyde	9.01073E-08	9.98	MESH0003

Test_cancer_drivers

Figure 26. Sample Cancer_Drivers RTR Summary Output

	facname	hi_type	hi_total	srcid	pollname	poll_hi	poll_hipct
2	FACILITY1	Respiratory HI	1.926522489	MESH0002	Maleic anhydride	1.662206507	86.28
3	FACILITY1	Respiratory HI	1.926522489	MESH0002	Maleic anhydride	0.106214178	5.51
4	FACILITY1	Liver HI	0.007369729	MESH0011	Phenol	0.005095489	69.14
5	FACILITY1	Liver HI	0.007369729	MEST0009	Phenol	0.000860618	11.68
6	FACILITY1	Liver HI	0.007369729	MESH0007	Phenol	0.000229859	3.12
7	FACILITY1	Liver HI	0.007369729	MEST0010	Phenol	0.000214285	2.91
8	FACILITY1	Liver HI	0.007369729	MESH0013	Phenol	0.000172113	2.34
9	FACILITY1	Liver HI	0.007369729	MEST0009	Phenol	0.00016079	2.18
10	FACILITY1	Developmental HI	0.000104187	MERP0004	Methanol	5.17805E-05	49.7
11	FACILITY1	Developmental HI	0.000104187	MERP0001	Methanol	4.68289E-05	44.95
12	FACILITY2	Respiratory HI	0.010661982	MEST0002	Formaldehyde	0.009308649	87.31
13	FACILITY2	Respiratory HI	0.010661982	MESH0003	Formaldehyde	0.001097888	10.3
14	FACILITY2	Liver HI	6.72457E-05	MESH0003	Phenol	6.72457E-05	100
15	FACILITY2	Developmental HI	0.001355088	MEST0008	Methanol	0.001312178	96.83
16	FACILITY3	Respiratory HI	0.398959369	MESP0003	2,4-Toluene diisocyanate	0.356122467	89.26
17	FACILITY3	Respiratory HI	0.398959369	MESK0004	2,4-Toluene diisocyanate	0.039177306	9.82
18	FACILITY3	Neurological HI	0.000122443	METR0001	p-Xylene	5.12074E-05	41.82
19	FACILITY3	Neurological HI	0.000122443	METR0005	p-Xylene	3.39627E-05	27.74
20	FACILITY3	Neurological HI	0.000122443	METR0001	n-Hexane	1.14191E-05	9.33
21	FACILITY3	Neurological HI	0.000122443	METR0005	n-Hexane	7.57357E-06	6.19
22	FACILITY3	Neurological HI	0.000122443	METR0001	Styrene	5.87012E-06	4.79
23	FACILITY3	Neurological HI	0.000122443	METR0001	Toluene	5.12074E-06	4.18
24	FACILITY3	Developmental HI	1.05943E-05	METR0001	Ethyl benzene	6.36971E-06	60.12
25	FACILITY3	Developmental HI	1.05943E-05	METR0005	Ethyl benzene	4.22463E-06	39.88
26	FACILITY3	Immunological HI	0.028306959	METR0001	Benzene	0.01701919	60.12
27	FACILITY3	Immunological HI	0.028306959	METR0005	Benzene	0.011287769	39.88
28	FACILITY3	Whole body HI	0.000474322	METR0001	Acetonitrile	0.00028518	60.12
29	FACILITY3	Whole body HI	0.000474322	METR0005	Acetonitrile	0.000189142	39.88
30	FACILITY4	Respiratory HI	0.052479908	MESP0003	2,4-Toluene diisocyanate	0.047627047	90.75

Test_hi_drivers

Figure 27. Sample HI_Drivers RTR Summary Output

1	Created on Wednesday, September 12, 2012 @ 1:09pm					
2	Prepared by EC/R Inc.					
3						
4	Sector MIR = 4 (in a million)					
5	**Test Maximum Risk by Emission Source Type**					
6		**EL**	**SH**	**ST**	**WW**	**RP**
7	**Cancer Risk**					
8	***Maximum (in 1 million)***	4	2	0.8	0.6	0.5
9	***Number of people***					
10	>= 100 in 1 million	0	0	0	0	0
11	>= 10 in 1 million	0	0	0	0	0
12	>= 1 in 1 million	142	360	0	0	0
13						
14	**Incidence**	1.87608E-05	0.000166312	4.49854E-05	1.42884E-05	2.64554E-05
15						
16						
17						
18						
19						
20						

Risk Sheet2 Sheet3

Figure 28. Sample Sourcetype_Histogram RTR Summary Output

1	facid	pollutant	conc_mg	rel	aegl_1_1h	[4 other benchmark columns]	hq_rel	hq_aegl1	[4 other HQ columns based on 4 other benchmarks]
2	05003NEIART$10736	Formaldehyde	2.14972726	.055000000	1.10000000	…	39.08595018	1.954297509	…
3	05003NEIART$10736	Maleic anhydride	3.859246233	.000000000	.000000000	…	0	0	…
4	05003NEIART$10736	Methanol	0.266241437	28.0000000	690.000000	…	0.009508623	0.000385857	…
5	05003NEIART$10736	Phenol	1.323073382	5.80000000	58.0000000	…	0.2281161	0.02281161	…
6	13093NEI46838	Acetaldehyde	0.004339166	.470000000	81.0000000	…	0.009232268	5.357E-05	…
7	13093NEI46838	Formaldehyde	0.967457753	.055000000	1.10000000	…	17.59014097	0.879507048	…
8	13093NEI46838	Lead compounds	2.39097E-07	.000000000	.000000000	…	0	0	…
9	13093NEI46838	Methanol	2.312921054	28.0000000	690.000000	…	0.082604323	0.003352059	…
10	13093NEI46838	Phenol	0.288286189	5.80000000	58.0000000	…	0.049704515	0.004970452	…
11	17161NEI56034	Methanol	0.507239005	28.0000000	690.000000	…	0.018115679	0.000735129	…
12	17161NEI56034	Triethylamine	0.033161706	2.80000000	.000000000	…	0.011843466	0	…
13	21111NEI32872	Formaldehyde	0.046264793	.055000000	1.10000000	…	0.841178053	0.042058903	…
14	21111NEI32872	Methanol	0.030153883	28.0000000	690.000000	…	0.001076924	4.37013E-05	…
15	48005NEI12810	Formaldehyde	0.032116041	.055000000	1.10000000	…	0.583928013	0.029196401	…
16	48005NEI12810	Methanol	24.62154026	28.0000000	690.000000	…	0.879340724	0.035683392	…
17	48005NEI12810	Phenol	0.003094717	5.80000000	58.0000000	…	0.000533572	5.33572E-05	…

Test_acute_impact_flags_all

Figure 29. Sample Acute_Impact_Flags_All RTR Summary Output (abbreviated)

10. Using the Outputs to Summarize Risk Results

This section contains an overview on using the Multi HEM-3 and RTR summary program outputs to report the cancer risks, non-cancer hazards and acute impacts posed by a group or source category of modeled facilities.

Step 1: Open the *Facility_max_risk_and_HI.xls* output to obtain the facility-specific MIR in column B (mx_can_rsk), as well as the facility-specific maximum TOSHI values in each of their respective columns. [Note: the highest facility-specific maximum is not necessarily the overall source category/sector maximum based on concurrent emissions from the entire group of modeled facilities. Multi-facility impacts on the same receptor (from facilities located close to one another) are not accounted for in the *Facility_max_risk_and_HI.xls* output file, as an output specific to each individual facility.]

Step 2: Open the *SourceCategoryAcronym_sector_mir_incidence.xls* output to obtain the sector MIR in row 2 (based on concurrent emissions from the entire source category/sector of facilities), and the sector incidence in row 3. Open the *SourceCategoryAcronym_category_maxrisk.xls* to identify the census block experiencing the sector MIR, including the block's population. [Note: These two output files report the source category/sector MIR occurring at a populated census block receptor; these outputs will therefore not report the highest risk if it does not occur at a census block (e.g., at a user-defined receptor). Thus the sector MIR will be equal to or greater than the highest facility MIR found in Step 1, except when the highest facility-specific MIR does not occur at a census block receptor. The sector MIR will equal the highest facility-specific census block risk listed in the *Facility_max_risk_and_HI.xls* file if there are not multiple impacts from more than one facility on the maximum receptor for the sector as a whole. As noted above, emissions from nearby facilities may impact the same receptor, which sometimes happens when modeling large source categories/sectors. In these cases, the sector MIR will be higher than the highest facility-specific census block risk.]

Step 3: Open *SourceCategoryAcronym_cancer_drivers.xls* to obtain the pollutant and emission source type driving the modeled risk. To report the cancer drivers, use the HAP from column C (pollname) and the source type from column F (source_id) for *all* rows associated with the facility showing the highest risk. The MIR value from this highest facility will equal that listed in the *Facilty_max_risk_and_HI.xls* file from Step 1. [Note: This output does not account for 100% of the modeled risk, but rather provides those pollutant-emission source combinations that contribute at least 90% to the facility's MIR (from one or more pollutant-emission source combinations, depending on how many combinations are needed to describe 90% of the modeled risk at each facility).]

Step 4: Open *SourceCategoryAcronym_histogram_risk.xls* to obtain the number of people and facilities at various risk levels. The total population within the modeling domain (by default a 50-kilometer radius around each facility or your user-specified radius) equals the sum of cells B2 + B3. This histogram output counts facilities based on modeled risk at populated census block receptors. Consequently, this file's facility count numbers will be in accord with the manual counting of facilities at each risk level from the *Facility_max_risk_and_HI.xls* file, except when facilities rise into a certain risk level due solely to the modeled risk at a receptor which is not a census block receptor (e.g., a user receptor). Therefore, when using user-defined receptors, you should manually count facilities in the *Facility_max_risk_and_HI.xls* file to determine the number of facilities with

potential for surrounding population to be at or above each risk level, if the placement of the user receptor accurately represents where people reside. [Note: This output is based on the one significant figure rounding convention adopted by the EPA.]

Step 5: Open *SourceCategoryAcronym_hi_drivers.xls* to obtain the pollutant and emission source driving the TOSHI. To report the HI drivers, use the HAP from column E (pollname) and the source from column D (src_id) for all rows associated with the facility showing the highest total TOSHI in column C. The TOSHI value from this highest facility should equal the TOSHI value listed in the *Facilty_max_risk_and_HI.xls* file from Step 1. [Note: This output does not account for 100% of the modeled TOSHI, but rather provides those pollutant-emission source combinations that contribute at least 90% to the facility's total TOSHI.]

Step 6: Open *SourceCategoryAcronym_histogram_hi_part.xls* to obtain the number of people (p) and facilities (f) with TOSHI > 1. These numbers are based on the one significant figure rounding convention. [Note: Check this file's facility count against a manual count of the *Facility_max_risk_and_HI.xls* file if using user-defined receptors, as explained with the *histogram_risk* output file in Step 4 above.]

Step 7: Open *SourceCategoryAcronym_incidence_drivers.xls* to obtain the sector-wide incidence attributable to each pollutant. You can also use this file to calculate the percentage each HAP contributes to the sector-wide incidence by determining the ratio of the pollutant-specific incidence to the total incidence. (Calculate the total incidence by summing all pollutant-specific incidences in this file; this total will equal the sector incidence reported above in Step 2.)

Step 8: Open *SourceCategoryAcronym_sourcetype_histogram.xls* to obtain the number of people at various risk levels for each emission source type, and the incidence attributable to each source type. This output also shows the sector MIR (which will equal the sector MIR provided in the *SourceCategoryAcronym_sector_mir_incidence.xls* file in Step 2).

Step 9: Open *SourceCategoryAcronym_acute_impact_flags_all.xls*, if you modeled acute impacts, to obtain the hazard quotients (HQs) based on various benchmarks for each pollutant of interest, as well as the highest acute concentration for each HAP. You can perform a manual count using this output file to determine the number of facilities with an HQ >= 1.5 for any benchmark. [Note: An HQ >=1.5 is the mathematical definition of "greater than 1" when using the one significant figure rounding convention.]

For additional details regarding the modeling results for each of the facilities in the group or source category, open the individual facility folders in the output directory. Section 6.1 contains a list of these facility-specific output files. These files are described in more detail in the outputs section of the single HEM-3 User's Guide (EPA 2014b).

11. Source Category versus Facility-wide Modeling Runs

The instructions provided in this guide for running Multi HEM-3 and the RTR summary programs to estimate the cancer risks, non-cancer hazards and acute impacts posed by source category emissions can also be used for modeling on a facility-wide basis. “Facility-wide” denotes all emission processes at an individual facility, not only those emission processes at the facility that are regulated by the EPA under a specific source category or sector.

In some cases, the facility-wide emissions are identical to the source category or sector emissions (i.e., all facility processes are regulated under the same source category or sector). Generally, however, there are differences between the source category and facility-wide emission inputs (and therefore outputs), because more than one source category or sector is regulated by the EPA at a given facility. Thus, the facility-wide inputs will have more emission sources and often more pollutants for some of the facilities. With more emission sources, the facility center location may be different from that in the source category run. This different facility center location may result in different census blocks being included or excluded in the modeling. The census blocks affected will be ones that are near the maximum radius of the modeling domain (e.g. at a default radius of 50 km, or at the user-specified radius).

To compare the facility-wide results to the source category results using Excel™ spreadsheets, copy and paste the facility-specific MIRs (or HIs), provided in the *Facility_max_risk_and_HI.xls* file for both the source category run and facility-wide run, into the same Excel™ spreadsheet. To be certain that each MIR is correctly paired, sort both output files by Facility ID first, to ensure that the rows in the source category file are in precisely the same order as in the facility-wide file. Alternatively, to avoid human error, you may wish to use Access™ to combine the Excel™ outputs by performing a query on facility ID.

Once the source category results and facility-wide results are paired correctly in the spreadsheet, you can make comparisons, including calculating the percentage that the source category MIR (or HI) contributes to the facility-wide MIR (or HI) for every facility modeled. You can display these comparison calculations in a matrix similar to the one shown in Table 2 below.

Table 2. Sample Matrix Comparing Source Category to Facility-Wide MIR Results

Name of Source Category	Number of Facilities binned by Facility-Wide MIR (in 1 million)				
Source Category MIR is X% of Facility-Wide MIR	All	MIR < 1	1≤MIR<10	10≤MIR<100	100≤MIR
>90%					
50-90%					
10-50%					
< 10%					
Total					

12. Using Multi HEM-3 for Modeling Numerous Facilities

The ability of Multi HEM-3 to read Microsoft Excel™ 2007/2010 formatted spreadsheets means that large source categories (many facilities) can be processed. Excel™ 2007/2010 spreadsheets are capable of accommodating up to 1,048,576 rows. This large row capacity would allow for the entry of over 1,000 facilities into Multi HEM-3, depending upon the complexity of each facility.

In practice, however, large source category runs are limited by the amount of disk space and memory available to Multi HEM-3, and the amount of time you may be willing to wait for a model run to complete. In addition, FoxPro™ table file sizes are limited to 2 GB. Therefore, Excel™ formatted inputs that are approaching maximum row capacities may cause Multi HEM-3 to attempt to generate FoxPro™ tables that exceed the 2 GB limit. For example, the *all_outer_receptors.dbf* output file may exceed the 2 GB limit (using the default values in the facility list options input file). In this case, Multi HEM-3 will automatically generate multiple *all_outer_receptors.dbf* output files to avoid exceeding the 2 GB limit. However, if non-default modeling values are used (e.g., a modeling distance approaching the maximum domain distance), other output files may become large and exceed the 2 GB limit.

For these reasons, you should limit the number of facilities in one modeling run to less than 500. If you need to model more than 500 facilities for a source category, break up the input files (to <= 500 facilities per run), then combine output files after all modeling runs are complete. This is a recommended and approximate guideline, rather than a strict modeling rule.

13. Multi HEM-3 Errors

This section first discusses three common error messages you may encounter while running Multi HEM-3 and explains how to respond to these messages. Following this discussion is a more complete list of error messages provided by Multi HEM-3, including a description of each. See the single *HEM-3 User's Guide* for a discussion of the general limitations and uncertainties associated with the model (EPA 2014b).

1. If running Multi HEM-3 on a dual-core or quad-core computer, you may get two types of random error messages. The first type of message is "The file *filename* already exists. Do you want to overwrite it?" You will have the option of choosing either 'Yes' or 'No'. The correct action is to respond 'Yes'; and Multi HEM-3 will continue processing as if the error never occurred. [Note: This Windows™ issue happens only rarely and occurs because the computer mistakenly executes the "Create File" command in the code before the "Erase File" command.]

2. The second type of message is "The file *filename* is read only." You will have the option of choosing 'Cancel', 'Ignore' or 'Help'. The correct action is to respond 'Cancel'; this will end Multi HEM-3. (If you select 'Ignore', another error will occur and the file specified will not contain the correct data.) Once Multi HEM-3 has stopped, restart the model and Multi HEM-3 will begin processing the facility that was being evaluated when the error occurred. [Note: the errors described here are most likely to occur on machines running Windows® XP (32-bit version).]

3. Another type of error message may occasionally occur when a facility is located in a sparsely populated region. If no census blocks are found in the modeling domain, Multi

HEM-3 will fail with the message “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 Multi HEM-3.” Click ‘OK’ to end Multi HEM-3.

Once Multi HEM-3 ends, check the locations of the source IDs for the facility in the *Emissions_locations.xls* input file. If there is one or more source ID with a location far from the rest of the source IDs, skip that facility until you have determined the correct coordinates of the source(s). To make this determination, open the *facility_list_options.xls* file. Next, cut and paste the row with this facility ID to a separate *facility_list_options.xls* file with a different name (e.g., *Rerun_facility_list_options.xls*). Then, close both files and restart Multi HEM-3. Be sure to keep all of the current inputs (including any of the rows for facilities already modeled in the *facility_list_options.xls* file). Click the ‘Next’ button on each screen and Multi HEM-3 will begin modeling the next facility in the *facility_list_options.xls* file.

If you need to determine new coordinates for any of these sources, first make a copy of the *Emissions_locations.xls* input file. Rename the new file as necessary to indicate that you have revised this file (e.g., *Emissions_locations_revised.xls*). Make any necessary changes to the new file. Do not delete any entries in the new *Emissions_locations.xls* file unless also deleting these entries in the *Hap_emissions.xls* input file. Remember, any changes you make should be to a *copy* of the *Emissions_locations.xls* and/or the *Hap_emissions.xls* input, not the original files. When you are ready to rerun the facilities with the revised input files, start Multi HEM-3. On the first input screen, enter the name of the revised *Facility_List_Options.xls* file and the name of the revised version of the *Emission_location.xls* and/or the *Hap_emissions.xls*.

If all the source ID locations look correct, but you are still encountering an error, it is possible that the facility cannot be modeled (e.g., it is located in an unpopulated area). This has occurred, for example, when facilities are located in unpopulated areas of Alaska and unpopulated islands off the coast of California. Using Google Earth™, look at the area where the facility is located to verify that there are no people living in the modeling domain. If this is the case, make a note of why that facility was not modeled and delete the entry for the facility in the *facility_list_options.xls* file. Once you have deleted the facility from the file, restart Multi HEM-3 to begin modeling the next facility in the *facility_list_options.xls* file. [Note: Remember that when restarting Multi HEM-3, no rows from the *facility_list_options.xls* should be deleted except the facility row in question.]

Note: In some instances, restarting Multi HEM-3 will cause multiple rows for the same facility to be generated in Multi HEM-3’s four outputs (described in Section 6.2). This may occur, for example, if you ended Multi HEM-3 to correct an input for a facility that does not need to be removed from the *facility_list_options.xls* file, and then restarted Multi HEM-3. If the values are different for any of these redundant rows, determine which row contains the correct updated (rerun) values. To make this determination, open the respective updated facility folder and then delete the Multi HEM-3 rows (e.g., in *Facility_max_risk_and_HI.xls*) which have different risk, HI, and population values than those shown in the updated facility folder’s outputs.

Table 3 lists alphabetically a more complete list of error messages you may encounter when running Multi 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 3. Multi HEM-3 Error Messages

Error Message	Meaning / Cause
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 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.
No Aermod.out produced.	There was an error when HEM-3 attempted to run AERMOD and no AERMOD output file was produced.
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.
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 building downwash filename you entered is not in the location you specified. Click 'Ok' to end HEM-3, then either provide the building downwash file or choose not to model building downwash when you restart HEM-3.	Invalid building downwash filename.
The building downwash filename you entered 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 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 facility list filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	Incorrect facility list input filename was entered.
The file containing landuse information cannot be found. Click 'Ok' to end HEM-3, then either provide the landuse file or choose not to model dry vapor deposition when you restart HEM-3.	Invalid landuse filename.
The file containing particle size data cannot be found. Click 'Ok' to end Multi HEM-3, then either provide the particle size file or choose not to model particle deposition when you restart HEM-3.	A particle size filename was not entered.

Error Message	Meaning / Cause
The file containing seasonal vegetative cover cannot be found. Click 'Ok' to end HEM-3, then either provide the seasons file or choose not to model dry vapor deposition when you restart HEM-3.	Invalid filename for the seasonal vegetative cover file.
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 met station "filename" could not be found in the AERMOD met station library. Check your Facility_List_Options input file to change the name.	The meteorological surface filename included in the Facility_List_Options input file cannot be located in the HEM-3 AERMOD meteorological file library. Check that the filename entered is correct.
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.
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 user receptor filename you entered is not in the location you specified. Click 'Ok' to end Multi HEM-3, then either provide the user receptor file or choose not to model with user receptors when you restart HEM-3.	Invalid user receptor filename.
The user receptor filename you entered is not in the location you specified. Click 'Ok' to re-enter the filename or change the directory.	An invalid User Receptor input filename was entered.
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
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 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.

14. References

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