1.0 Introduction

In 1997, the U.S. Environmental Protection Agency's (EPA) Office of Solid Waste (OSW) and Office of Research and Development (ORD) began working together on the development of the Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) modeling system. The 3MRA modeling system is intended to be one of EPA's next generation of multimedia exposure and risk models to support regulatory decisions. EPA designed the modeling system specifically to meet the needs of OSW programs, but the 3MRA modeling system has the flexibility to be used for many EPA applications. In particular, it was designed to provide risk managers with information, at a national level, on exposure and risk to human and ecological receptors due to the release of hazardous constituents from the management of solid and hazardous wastes.

This document is the second volume of a four-volume set that describes the 3MRA modeling system.

- Volume I provides an overview of the system, including the reasons for its development, its conceptual design, the modeling approach, and the underlying science of each of the 3MRA modeling system component modules;
- Volume II (this volume) describes a representative national data set collected to develop and test the 3MRA modeling system;
- Volume III describes the verification and validation activities and peer reviews undertaken to support the model development process;
- Volume IV provides a discussion of uncertainty and sensitivity.
- Volume V describes the 3MRA modeling system technology design and provides a users' guide.

The data collection effort for the 3MRA modeling system representative national data set was designed to cover the range of environmental conditions across the United States and implemented to demonstrate how to collect the data needed to run the 3MRA modeling system. To document this data collection effort, this volume describes

- What data were collected for use in the 3MRA modeling system;
- Where data were obtained (data sources);
- How data were compiled and processed (methodology);

- Quality assurance and quality control (QA/QC) measures to ensure that data quality objectives (DQOs) were met; and
- Issues and uncertainties associated with data availability (data gaps) and accuracy.

The rest of this section includes a description of the 3MRA modeling system development process; an overview of the 3MRA modeling system; a summary of the approach to data collection; a discussion of sites, settings, and areas of interest; a summary of data quality objectives (DQOs); a description of the data collection methodology; and the organization of the rest of this volume.

1.1 3MRA Modeling System Development

Program office scientists and risk managers in OSW collaborated with EPA scientists in ORD to develop the 3MRA modeling system. A core team put together EPA's science plan for developing the system (U.S. EPA, 1999a). The science plan identified OSW needs and the scientific approach to be taken. These needs were then described in terms of goals and objectives. One overriding theme was to use existing regulatory models where appropriate, thus relying on the science behind them and the level of acceptance associated with their use. The following regulatory models have been incorporated into Version 1 of the 3MRA modeling system: Industrial Source Complex Short-Term Model, Version 3 (ISCST3), for air dispersion and deposition (U.S. EPA, 1995); EPA's Composite Model for Leachate Migration with Transformations Products (EPACMTP) (U.S. EPA, 1996a,b,c, 1997) for subsurface transport; and EPA's Exposure Analysis Modeling System II (EXAMS II) (Burns et al., 1982; Burns, 1997) for surface water transport. Each of these legacy models was modified somewhat to provide needed functionality within the 3MRA modeling system. All other source, fate and transport, food web, exposure, and risk modules were developed specifically for the 3MRA modeling system based on sound science and established principles.

The 3MRA modeling system represents the integration of more than 25 independent software components developed by 5 different software development groups located across the country. Core teams were formed to oversee the development of each set of modules. These core teams consisted of OSW and ORD staff working together to design each module; see that adequate test plans were developed; and oversee the testing, verification, and documentation of the modules.

1.2 Overview of the 3MRA Modeling System

The 3MRA modeling system was developed as a tool to provide risk assessment support for the types of risk management decisions that are made within EPA's OSW. OSW applies risk assessment modeling tools in a variety of situations; one application is the use of tools to conduct site-based national-level risk assessments to support rule making for the identification of hazardous wastes. Consequently, EPA needed the 3MRA modeling system to model environmental settings that are representative of the range of environmental settings found in the United States, and within this broad range of settings, to simulate the release, fate, and transport of many chemicals in waste undergoing a range of physical and biochemical processes. More than 400 chemicals are regulated under the RCRA programs. EPA needs to consider the impacts of these released chemicals on humans and the environment within the broad range of environmental settings. This requires a modeling tool that encompasses releases to all media, transport within those media, uptake in terrestrial and aquatic food webs, and exposure of specific receptors to contaminated media and food items.

The 3MRA modeling system was designed to estimate national distributions of human and ecological risks resulting from long-term (chronic) chemical release from land-based and wastewater waste management units (WMUs) using a site-based approach. The national distribution is constructed by performing "site-based" assessments at a statistically significant number of randomly sampled industrial waste site locations across the United States. The 3MRA framework describes a tiered approach for populating data files for each site characterization and evaluation. The approach is referred to as "site-based" because the assignment of data values for the site being simulated occurs according to a tiered protocol. Data values are filled first with data at a site level. When site data are not available, a statistically sampled value from a geographically relevant regional distribution of values is used. When a representative regional distribution for the variable is not available, a value from a national distribution is assigned.

The 3MRA modeling system simulates contaminant releases from a WMU to the various media (air, water, soil) based on the chemical/physical properties of the constituent, the characteristics of the WMU that is modeled, and the environmental setting (e.g., meteorological region) in which the facility is located. Once released from the WMU, the contaminant is transported through environmental media and into biological compartments such as produce, beef, and fish. Human and ecological receptors included in the simulation may be exposed concurrently to contaminated media and food through multiple pathways and routes of exposure. For each receptor that is included in the simulation, the 3MRA modeling system performs risk/hazard calculations based on aggregate exposures modeled through space and time.

Figure 1-1 provides an overview of the 3MRA modeling system design. As suggested in this figure, the system performs three major functions: (1) the site definition, (2) the multimedia, multipathway simulation, and (3) the exit level processing. The site definition in the figure includes both the selection of site characteristics from three levels of data, as well as the estimation and selection of chemical properties. The multimedia, multipathway simulation includes all of the science modules linked together to predict behavior of chemicals from source release through exposure and risk. The linkages among the science modules are depicted in Figure 1-2. The exit level processing occurs after the simulation is completed and consists of two-stage processing of the risk outputs followed by the risk visualization of exit level distributions. At the top of Figure 1-1, the looping structure used to conduct national scale analyses is summarized, including the site location loop, the WMU loop, the number of iterations, and the number of chemicals (which are simulated individually).

The 3MRA modeling system was designed specifically to include Monte Carlo simulation methods to address both uncertainty and variability in the risk outputs. Statistical distributions were developed for many modeling parameters and provide a statistical measure of variability and uncertainty, i.e., the range and distribution of potential exposures and risks

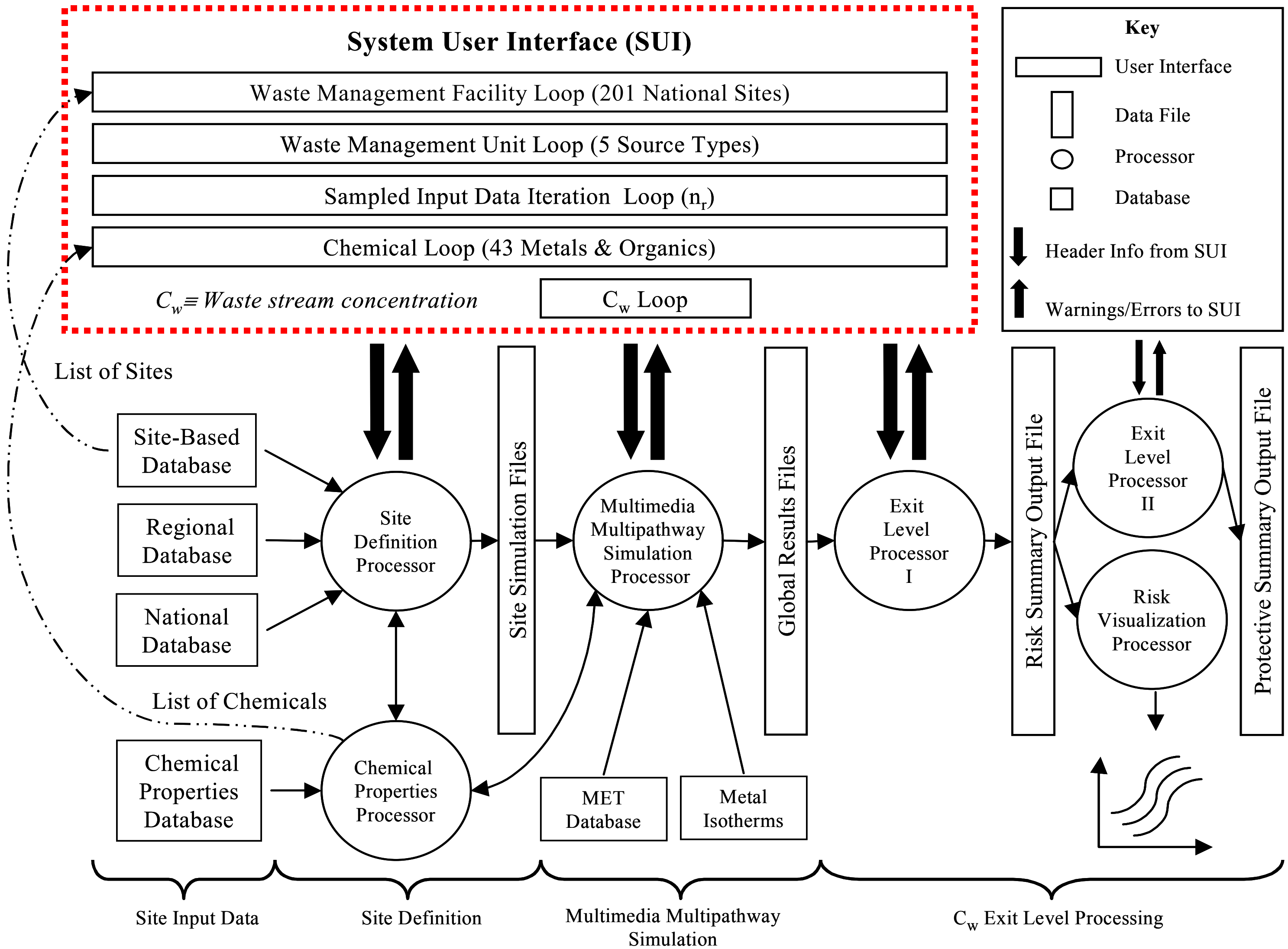
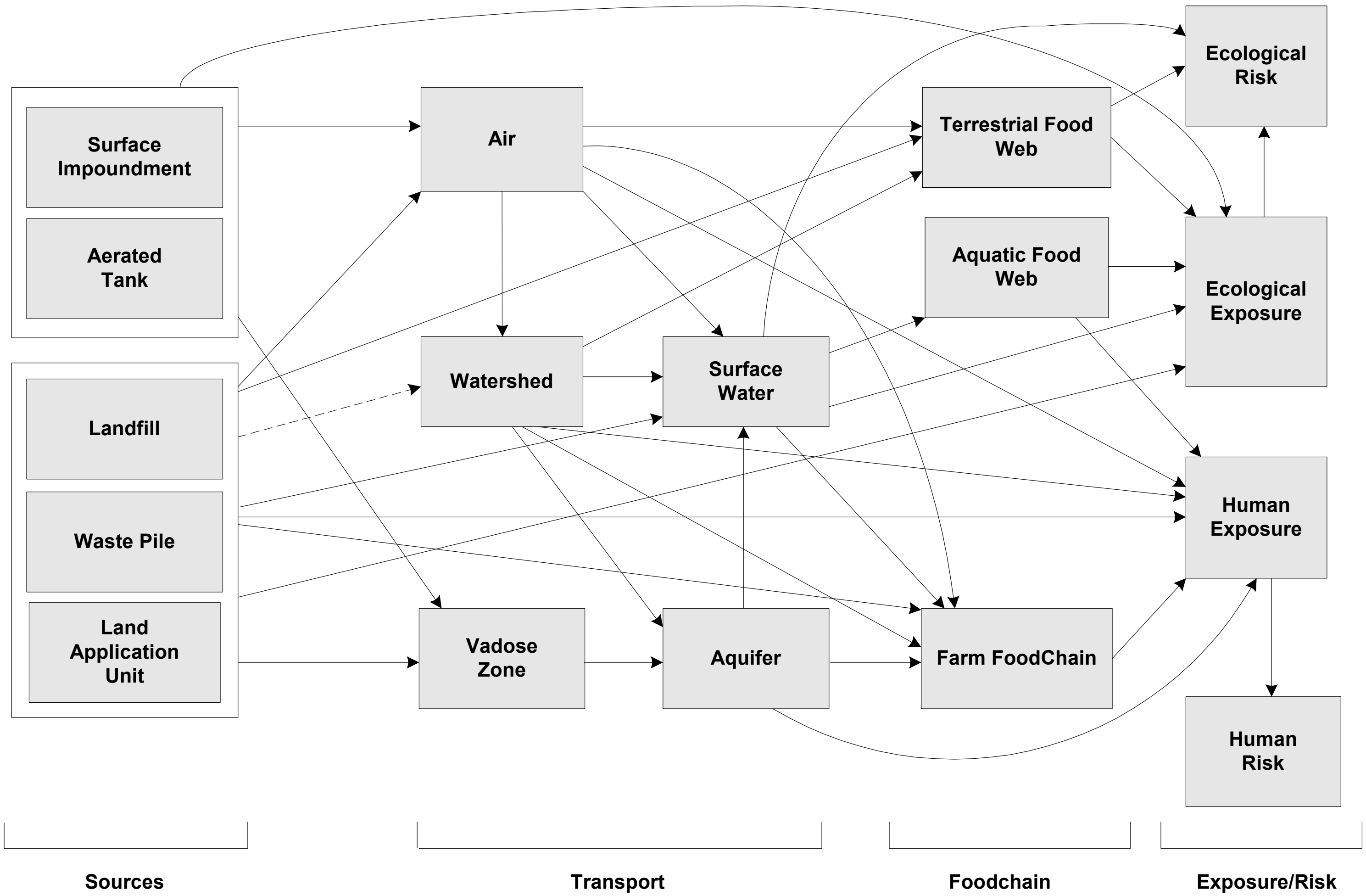


Figure 1-1. 3MRA modeling system design.



The dashed line indicates that soil concentrations for the local (land-based source) and regional watersheds may be added together to estimate total soil concentrations for areas (e.g., habitats) that include both regional and local watershed components.

Figure 1-2. Linkages among the source, fate, transport, exposure, and risk modules of the 3MRA modeling system.

occurring at a site. When applied to the sites in a national assessment, the result is a national distribution of risks with a statistical measure of variability and uncertainty. The sites currently in the database were randomly selected from solid waste management sites across the United States to represent the national variability in waste management scenarios and locations. The methodology for selecting the sites allows for measures of protection to be calculated at the site level and aggregated over all the sites to develop the national distribution of risks.

1.3 Approach to Data Collection

As described in Volume I, the 3MRA modeling system contains 17 media-specific pollutant release, fate, transport, exposure, and risk modules. The modules have varying data requirements covering a wide range of general data categories: WMU characteristics; waste properties, meteorological data; surface water and watershed layout and characteristics; soil (vadose zone) properties; aquifer (saturated zone) properties; food chain or food web characteristics; human and ecological exposure factors; and the types and locations of human receptors and ecological receptors and habitats surrounding a WMU. In addition, for each chemical to be assessed by the 3MRA modeling system, the modules require the following chemical-specific data: chemical properties, bio-uptake and bioaccumulation factors, and human and ecological health benchmarks. Table 1-1 lists the 46 chemicals included in the representative national data set.

Table 1-1. Chemicals Included in the Representative National Data Set

Constituent	CAS	Chem Type
TCDD, 2,3,7,8-	1746-01-6	D
Mercury	7439-97-6	Hg
Mercury (elemental)	7439-97-6e	Hg
Methyl mercury	7439-97-6m	Hg
Antimony	7440-36-0	M
Arsenic	7440-38-2	M
Barium	7440-39-3	M
Beryllium	7440-41-7	M
Cadmium	7440-43-9	M
Chromium (total)	7440-47-3	M
Chromium III (insoluble salts)	16065-83-1	M
Chromium VI	18540-29-9	M
Lead	7439-92-1	M
Nickel	7440-02-0	M
Selenium	7783-79-1	M
Silver	7440-22-4	M
Thallium	7446-18-6	M

(continued)

Table 1-1. (continued)

Constituent	CAS	Chem Type
Vanadium	7440-62-2	M
Zinc	7440-66-6	M
Acetonitrile	75-05-8	O
Acrylonitrile	107-13-1	O
Aniline	62-53-3	O
Benzene	71-43-2	O
Carbon disulfide	75-15-0	O
Chlorobenzene	108-90-7	O
Chloroform	67-66-3	O
Dichlorophenoxyacetic acid, 2,4- (2,4-D)	94-75-7	O
Ethylene dibromide	106-93-4	O
Hexachloro-1,3-butadiene	87-68-3	O
Methoxychlor	72-43-5	O
Methyl ethyl ketone	78-93-3	O
Methyl methacrylate	80-62-6	O
Methylene chloride	75-09-2	O
Nitrobenzene	98-95-3	O
Pentachlorophenol	87-86-5	O
Phenol	108-95-2	O
Pyridine	110-86-1	O
Tetrachloroethylene	127-18-4	O
Thiram	137-26-8	O
Toluene	108-88-3	O
Trichloroethane, 1,1,1-	71-55-6	O
Trichloroethylene	79-01-6	O
Vinyl chloride	75-01-4	O
Benzo(a)pyrene	50-32-8	S
Bis(2-ethylhexyl) phthalate	117-81-7	S
Dibenz(a,h)anthracene	53-70-3	S

The representative national data set described in this volume was compiled to enable development and comprehensive testing of the 3MRA modeling system. Although the 3MRA modeling system is intended for national-scale assessments, its analyses are based on a regional, site-based approach, in which risks are evaluated at a number of representative individual nonhazardous industrial waste management sites across the country. To collect data for model testing and development, EPA employed three data collection approaches consistent with this modeling approach. In order of preference, they are

- *Site-based*–Input data are collected and passed to the model for each site.

- *Regional*–The nation is divided into regions of similar characteristics; data are collected to characterize the variability within each region; and each site is assigned to a region.

- *National*–Distributions or fixed values are collected for inputs that characterize the nation as a whole.

For each variable, EPA selected one of these data collection approaches by considering the preference for site-based data, data availability, and the level of effort for data collection. EPA collected regional data (e.g., meteorological and aquifer data) and national data (e.g., exposure factors, waste properties, chemical-specific data) only when site-based data were not readily available. Table 1-2 shows the data collection approach by data type and gives the section number for the section of the document that describes the data collection approach in detail.

Although this analysis is based primarily on site-based data that are collected by site location, the 3MRA modeling system is not intended for a site-specific analysis. The site-based data are intended to provide a representative data set for a national assessment. Thus, although a large effort went into identifying, to the greatest extent possible, the locations of each site and collecting accurate data to characterize each site, the data are not meant to be used for site-specific risk assessments. Instead, the site-based data and analysis are intended to develop nationwide chemical-specific distributions of risks.

EPA limited this data collection effort to information that could be obtained from readily available data sources. The intent of the data set is to reasonably represent the nationwide variability of environmental conditions that influence the fate and transport of chemicals from industrial waste management units (WMUs). This was accomplished by collecting data from extant data sources, such as published literature; existing geographic information system (GIS) coverages; other EPA data collection efforts, such as the Exposure Factors Handbook (EFH); and meteorological data sets. As such, the data collection effort was limited to secondary data sources. Each source represented a proven and well-documented data set, with adequate documentation to ensure consistent and known quality. Data sources that would require extensive effort to document in terms of sources and data quality, such as permit records from state or local governments, were not included.

1.4 Sites, Settings, and Area of Interest

The data collection effort centered around the collection of site-based data for representative industrial nonhazardous waste management sites across the United States using data from EPA's 1985 *Screening Survey of Industrial Subtitle D Establishments* (Westat, 1987). This survey was designed to represent a total population of nearly 150,000 establishments generating nonhazardous industrial wastes. Although it is more than 10 years old, the survey represents the largest consistent set of data available on Industrial D facility location and WMU

Table 1-2. Data Collection Approach, by Data Type

Data Type (Report Section)	Data Collection Approach		
	Site-Based	Regional	National
WMU (Section 3)	●		●
Waste properties (Section 16)			●
Air Model (Section 16)			●
Meteorological (Section 4)		●	
Watershed and waterbody layout (Section 5)	●		
Surface water (Section 6)		●	●
Soil/vadose zone (Section 7)	●		●
Aquifer (Section 16)		●	●
Farm food chain/terrestrial food web (Section 10)			●
Aquatic food web (Section 11)		●	●
Human exposure factors (Section 8)			●
Ecological exposure factors (Section 12)		●	●
Chemical properties[a] (Section 17)			●
Bio-uptake/bioaccumulation factors[a] (Sections 8, 10, 11)			●
Human health benchmarks[a] (Section 15)			●
Human receptor type and location (Section 9)	●		●
Ecological benchmarks[a] (Section 14)			●
Ecological receptor and habitat type and location (Section 13)	●	●	
Risk and control variables (Section 16)			●

[a]Chemical-specific variables.

dimensions. EPA selected a total of 201 sites from the 2,850 facilities (out of a total of 15,844 surveyed facilities) that had one or more of four types of WMUs onsite (landfill, waste pile, land application unit [LAU], and surface impoundment).

EPA selected the sample of 201 facilities to represent the types, sizes, and geographic locations of WMUs at which exempt waste could be currently disposed. In the representative national data set, the locations of these facilities determine the sites where the 3MRA modeling system is implemented and the screening survey data determine the type and size of WMUs that are present at a particular site. The area of interest (AOI) is the spatial area within which data are collected and risks are estimated. At each site, the AOI for testing and developing the 3MRA modeling system is the WMU area plus the area encompassed by a 2 km radius extending from the corner of the square WMU.

Because of difficulties in modeling multiple units at a single site, the data collection effort assigned multiple AOIs and multiple settings for Industrial D sites with multiple WMU types. The 3MRA modeling system defines a setting as a unique WMU type/site combination. Thus, a site with a landfill and a waste pile would constitute two settings. Settings are the basic spatial modeling unit for the 3MRA modeling system, with each model realization being run at a single WMU/site setting. There are 419 unique WMU/site settings across the 201 sites selected for the example data set. Table 1-3 shows the breakout of WMU types across theses 419 settings and compares these statistics with the overall survey data (for the 2,850 facilities in the screening survey with onsite WMUs). The 419 settings include all the 282 unique Industrial D WMU/site combinations plus 137 aerated tank settings.[1]

Table 1-3. Settings/WMU Type Distribution for the 201-Facility Sample.

WMU Type	Settings - 201 Sample Facilities[a]	Settings - 2,850 Industrial D Facilities[b]
	Number	Number
Landfill	56	827
Land application unit (LAU)	28	354
Waste pile	61	853
Surface impoundment	137	1,930
Aerated tank	137[c]	–[c]
TOTAL	419	3,964

[a] Random sample, proportional by industry sector, from the 2,850 Industrial D facilities reporting onsite waste management. A setting is a unique WMU type/site combination.
[b] Facilities in 1985 *Screening Survey of Industrial Subtitle D Establishments* (Westat, 1987) reporting onsite hazardous waste management (out of 15,844 establishments surveyed).
[c] The representative national data set places an aerated tank at every surface impoundment facility (there are no tank data in the Industrial D Screening Survey data).

To estimate human and ecological risk for each of the 419 settings, the 3MRA modeling system uses the Industrial D data on WMU dimensions along with site-based data on waterbodies, watersheds, soils, and human and ecological receptor types and locations collected within the 2 km AOI. To supplement these site-based data, EPA collected regional data (e.g., meteorological, water quality, and aquifer data) and national data (e.g., exposure factors, waste properties, chemical-specific data) to satisfy the data requirements of all 17 modules (i.e., five source, five fate and transport, three food chain/food web, two exposure, and two risk modules).

[1]The Industrial D screening survey data do not include data for aerated tanks. EPA placed a tank at each surface impoundment site from the 201 sites because the presence of the impoundment indicates that the facility manages liquid wastes and therefore could have a treatment tank (see Section 3).

1.5 Data Quality Objectives

Data collection for the 3MRA modeling system involved extracting data from secondary sources, which are compilations of data that are well documented in terms of how the primary data were obtained (e.g., through direct measurement of meteorological conditions or by observation, characterization, and mapping of soil types). For such secondary data collection efforts, DQOs can be described as clear specifications of the type, amount, and quality of data in terms of their end use, which, in this case, is an example data set for 3MRA modeling system testing.

Establishing DQOs for the 3MRA modeling system data collection effort involved systematically planning the data collection methodology around these specifications to ensure that a high-quality data set would be available for model testing. To assist in this planning process, a pilot data collection study was conducted to investigate and establish the feasibility of methods to be employed in the full-scale data collection effort. The end result was the 3MRA modeling system data collection plan, which was followed and updated as needed during the data collection effort. The updated plan became the basis for this volume.

1.5.1 Data Type

For the 3MRA modeling system, the types of data that needed to be collected were determined by both the input data requirements of the component modules, which are described in Volume I, and the data collection methodologies that are employed to collect data across the 201 sites and the 419 site/WMU settings to be modeled. Planning the data collection effort required developing methods for each data source and collection methodology. However, most of the data types defined in this way were required by multiple 3MRA modeling system component modules. For example, soil data are used by the Land-based Source Modules (landfill, waste pile, and LAU), the Surface Impoundment Module, the Watershed Module, the Vadose Zone Module, and the Aquifer Module, but are collected by a common methodology (involving geographic information systems [GIS] and database processing) from a common data source (the State Soil Geographic Data Base [STATSGO] soil database).

To ensure that the data requirements of the 3MRA modeling system's component modules were fully addressed by the data collection effort, detailed crosswalks were developed between the model inputs and the data types defined for the data collection effort. Table 1-4 illustrates the general crosswalk between these data types and the 3MRA modeling system component modules by showing which data types each model requires and, for each data type, whether data were collected for that model on a site-based, regional, or national basis. The data collection effort was organized around the data types shown in Table 1-4, and this volume reflects that organization. Each chapter addresses a specific data type and begins with the full list of module inputs addressed by the collection methodology for that data type.

1.5.2 Data Amount

The amount of data required for the 3MRA modeling system is substantial; as described in Section 1.5, the databases and data files that make up the 201-site example data set contain

Table 1-4. Data Types Used by the 3MRA Modeling System

Module	Data Type and Document Section												
	WMU Sec. 3	Waste property Sec. 16	Meteor-ological Sec. 4	Watershed and waterbody layout Sec. 5	Surface water Sec. 6	Soil / vadose zone Sec.7	Aquifer (saturated zone) Sec. 16	Food web/ food chain Sec. 10, 11	Chemical property[a] Sec. 17	Bio-uptake and bioaccumu-lation factors[a] Sec. 8, 10, 11	Exposure factor Sec. 8, 12	Receptor/ habitat type and location Sec. 9, 13	Health bench-mark[a] Sec. 14. 15
Source Modules													
Aerated Tank	N	N	R						N				
Landfill	S, N	N	R			S			N				
LAU	S, N	N	R	S		S			N				
Surface Imp.	S, N	N	R			S			N				
Waste Pile	S, N	N	R	S		S			N				
Fate and Transport Modules													
Air	S		R									S	
Watershed			R	S		S			N				
Surface Water			R	S	R,N				N				
Vadose Zone						S			N				
Aquifer				S			R,N		N			S	
Aquatic Food Web				S	R			N	N	N		S,R	
Farm Food Chain						S		N	N	N		S,R	
Terres. Food Web						S		N	N	N		S,R	
Exposure and Risk Modules													
Eco. Exposure				S	R	S			N	N	R,N	S,R	
Human Exposure				S		S			N	N	N	S,R,N	
Eco. Risk									N			S,R	N
Human Risk												S,R,N	N

[a] Chemical-specific.
S = Site-based Data; R = Regional Data; N = National Data; Blanks = Not Applicable to Module.

more than 700 variables and several million records and are more than 7 gigabytes in size. To help ensure that data are complete, the 3MRA modeling system contains automated programs that check the incoming data sets to ensure that all variables requested by the component modules are present for every site, that all units are specified correctly, and that variables are within reasonable ranges (see U.S. EPA, 1999b). Similar automated checks were also programmed into the data processing system, and the outgoing data were thoroughly checked for completeness and conformance to system specifications.

1.5.3 Data Quality

The DQOs for the 3MRA modeling system data collection effort included (1) a technical review of the quality of the incoming data (from the original data sources) to ensure that it was scientifically correct, obtained from the best available source, and adequate to characterize national conditions; and (2) comprehensive checks of both manual data entry and automated data processing to ensure that the data were accurately transferred from the original data sources into the 3MRA modeling system databases. For example, all manual data entries were checked against the original source, and automated programs were checked for correct functioning by hand calculations or independent programs. QA/QC procedures were developed for each data type in the data collection plan and are included in each of the sections of this volume as well.

Table 1-5 describes some of the specific data quality objectives and sample activities that were taken to achieve them. Additional details may be found in the individual sections. Section 1.4.3 describes the overall QA/QC methodology and record keeping for the data collection effort.

Table 1-5. 3MRA Data Quality Objectives: Specific Examples by Data Type

Data Type	Data Quality Objectives	Activities to Meet Objectives
Spatial Layout (Section 2)	Accurate facility locations with respect to waterbodies, land use	Facility matching to EPA locational data
		Visual review and adjustment of facility location
	Accurate transfer of spatial layout to 3MRA database	Consistent grid system for georeferencing spatial data points
		Automated and manual review of spatial assignments
Waste Management Unit (Section 3)	Complete and reasonable Industrial D area, capacity, waste volume data for all sites	Checks for outliers, unreasonable values
		Conditional random replacement of missing and culled values
	Correlated, reasonable dimensional and operational variables	Engineering relationships with WMU dimensions, other correlated variables
		Senior technical review

(continued)

Table 1-5. (continued)

Data Type	Data Quality Objectives	Activities to Meet Objectives
Meteorological (Section 4)	Comprehensive coverage of 3MRA climatic conditions	Met. station assignments via GIS processing of data from every meteorological station with adequate record length
	Data sets with at least 10 years of complete hourly records	Replacement routines for limited data gaps
Watersheds and waterbodies (Section 5)	Accurate representation of stream networks in digital elevation model (DEMs) coverage	Procedure to burn RF3 stream networks into DEMs
	Correct connectivity between stream reaches and watersheds; consistent delineations given inconsistent data sources	Visual review and adjustment of delineated watersheds and waterbody networks
Surface water quality and flow (Section 6)	Data quality concerns with STORET (e.g., unrealistic measurements)	Use median values of a 20-measurement minimum data set (to minimize outlier bias)
	Represent local water quality conditions with adequate data to support median statistic	Aggregate statistics over smallest drainage basin meeting 20-measurement minimum
Soil (Section 7)	Complete, consistent, well-documented source for soil properties	Extract soil data from STATSGO nationwide soil database
	Represent site-to-site variability while maintaining correlations between soil hydrologic properties	Specify hydrologic properties by soil texture through cross-correlation matrix based on national distribution
Human exposure factors (Section 8)	Distributions that accurately reflect nationwide variability in exposure factors	Use base data from EPA *Exposure Factors Handbook* as reputable, peer-reviewed source
		Develop distributions using established statistical techniques; use goodness of fit routines to select best fit and quantify uncertainty
Human receptor locations (Section 9)	Accurate placement and population of human receptors in area of interest	Use GIS coverages of U.S. Census, land use, and agricultural census data
	Correct assignment and calculation of receptor types to receptor points	Technical review of methodology; parallel checks of implementation
Farm food chain/ terrestrial food web variables (Section 10)	Best available values from extant literature	Use reviewed EPA sources first, then other compilations and selected literature reviews to fill data gaps
Aquatic food web variables (Section 11)	Best available values from extant literature	Develop and apply criteria to identify key, highly reviewed data sources (compilations, primary literature, and government databases)

(continued)

Table 1-5. (continued)

Data Type	Data Quality Objectives	Activities to Meet Objectives
Ecological exposure factors (Section 12)	Defensible methods for calculating exposure factors using data from accepted, well reviewed sources	Follow methods in EPA Handbook, using data from Handbook and other well reviewed compilations of wildlife data
Ecological receptors and habitats (Section 13)	Representative habitats that encompass nationwide variability, are spatially variable at each site, and are of appropriate detail	Develop and apply classification criteria that reflect species occurrence and existing nationwide ecological classifications
	Accurately delineated habitats that are consistent with a site's spatial layout	Application of GIS tool for delineation and review of habitats at each site, based on land use and the waterbody network
Ecological benchmarks (Section 14)	Defensible, well-documented benchmarks for each chemical and receptor type	Assemble database of quantitative effects from accepted synopses, databases, and literature review (for data gaps)
		Develop and apply taxa-specific methods to derive benchmarks
Human health benchmarks (Section 15)	Defensible, well-documented benchmarks that reflect latest EPA guidance and science	Apply hierarchy of EPA, State, and ATSDR data sources to up-to-date database of extant values,
Aquifer data (Section 16)	Correlated aquifer inputs that reflect nationwide variability in aquifer properties	Assign each site to a standard hydrogeologic environment
		Collect correlated data sets from EPA Hydrogeologic Database
Chemical Properties (Section 17)	Defensible chemical properties that are consistent across chemicals	Calculate thermodynamic properties using SPARC code
		Expert criteria-structured literature review for degradation rates
	Media partition coefficients that reflect nationwide geochemical conditions and waste chemical concentrations	Calculation of MINTEQA2 sorption isotherms for soil and groundwater
		Comprehensive literature reviews, modeling, and extrapolation for other media

The example data collection effort was limited to information that could be obtained from readily available electronic and published data sources. The strategy for collecting data to support the 3MRA modeling system included both automated and manual collection methodologies, as follows:

- *Automated methods* involved electronic processing of data using a combination of GIS technology and conventional electronic databases.

- *Manual techniques* involved desktop analysis, such as literature reviews and analyses, and manual data entry.

1.6 Data Collection Methodology

EPA considered data availability, accuracy, sample coverage, and available resources in developing and choosing collection methodologies for particular data types. There was a general preference for automated methods, although, in many cases, hybrid methods were required that involved some manual interaction with data collection or processing programs.

Figure 1-3 provides an overview of the data collection process, showing data sources, primary data processing operations, and the final files supplied to the 3MRA modeling system.

- *Data sources* included both conventional electronic data sources and GIS coverages (spatial data), as well as published literature and professional judgment.

- *Data processing* operations used both GIS software and more conventional database programs to process the data to the 3MRA modeling system requirements.

- *Final data files* were exported to the 3MRA modeling system in American Standard Code for Information Interchange (ASCII) format (meteorological data) and Microsoft Access databases.

Two separate lines of data processing are depicted in Figure 1-3. The Industrial Source Complex Short-Term Model, Version 3, (ISCST3) air model requires ASCII files processed through the PCRAMMET hourly data processing program. Other programs develop the PCRAMMET input files from meteorological and land use data (from the GIS), as well as derive, from the hourly data files, the longer-term average (climatic) meteorological ASCII data files required by other 3MRA modeling system modules (daily, monthly, annual, and long-term annual average).

The other processing system compiled the 3MRA modeling system input database and grid data used by the 3MRA modeling system Site Layout Processor to place air points in the input database. This system employed GIS programs (ArcInfo and ArcView), along with conventional database processing using structured query language (SQL) and Visual Basic, to automatically generate the input databases. Data collected from the literature or estimated using professional judgment were entered into the system manually. Other data were processed from electronic sources using a combination of GIS programs (for spatial data analysis) and database programs.

In general, GIS programs put data within the spatial context required by the modeling assumptions (i.e., a 2 km AOI; 500 m, 1,000 m, and 2,000 m receptor rings; a single average WMU for each setting) and interrelated different spatial data coverages using overlays to create the site layout variables required by the model. Database programs processed these and all other data to meet system requirements in terms of database format (table structure) and the variable specifications in the 3MRA modeling system input dictionary (ssf.dic) files.

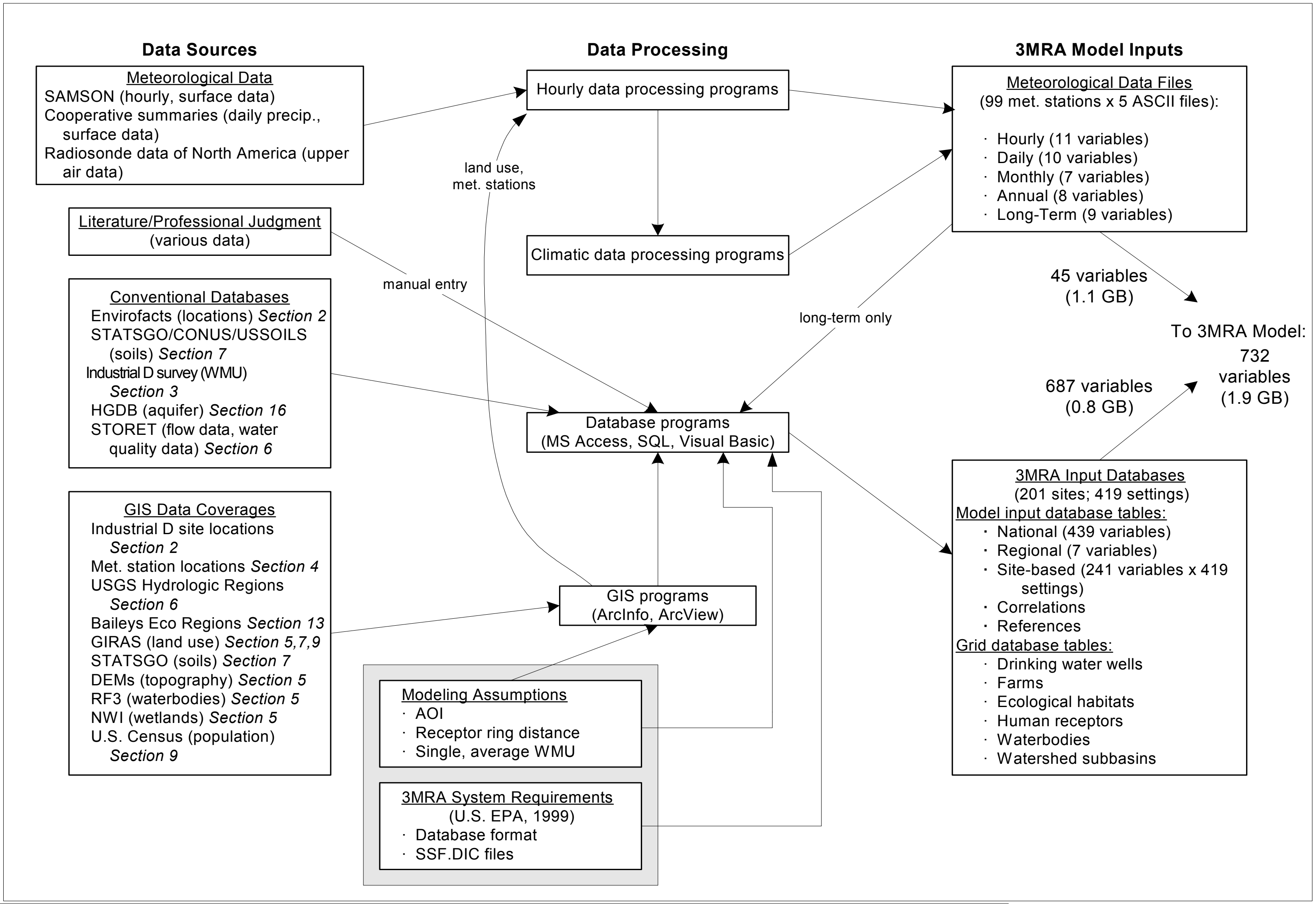


Figure 1-3. Overview of 3MRA data collection and processing.

1.6.1 GIS Data Collection and Processing

EPA selected a GIS as the platform for collecting much of the site-specific data for the 3MRA modeling system because it can be automated and can perform spatial overlay of georegistered data. Most of the GIS processing used ArcInfo for UNIX workstations; some processing occurred in the PC environment with ArcInfo and ArcView. This document uses the term GIS "program" to refer to arc macro language (AML) scripts, a batch-process scripting language used with the ArcInfo GIS software. The term "coverage" refers to a GIS map layer (e.g., geographically referenced digital points, lines, or polygons with attached data).

The GIS programs provided the following three primary data coverages for this risk analysis:

- Waterbody and watershed layout (Section 5.0);
- Human receptor locations, including farms and residences (Section 9.0); and
- Ecological habitats and home ranges (Section 13.0).

The data collection effort also used GIS processing to assign sites to meteorological and hydrologic regions (Sections 3.0 and 6.0), to identify soil types by watershed and WMU (Section 7.0), and to accurately locate facilities (Section 2.0). In general, these GIS methodologies combined automated and manual techniques. Details on the various GIS methodologies used to derive these data may be found in the previously referenced sections. Section 2.0 describes the overall spatial framework used to conduct site-based GIS data collection, data processing, and 3MRA modeling system assessments.

1.6.2 Conventional Database Processing and Export to 3MRA Modeling System

A conventional Microsoft Access database, using Visual Basic and SQL programs for data processing, was developed to import the GIS and other input data shown in Figure 1-3 and to process them to create the Microsoft Access input databases required by the 3MRA modeling system. As shown in Figure 1-3, the Access input data were exported in two primary file formats:

- The *model input database (687 variables)* includes national, regional, and site-based data tables containing the input variables needed by the 3MRA modeling system. Appendix 1A at the end of this section shows the structure of these data tables and Appendix 1B contains a full listing of these variables, by data table (national, regional, or site-based) and data group. Sections 3.0, 5.0 through 13.0, and 16.0 of this report describe collection and processing of these data by data type.

- The *grid database* includes six data tables containing *x,y* coordinates for watersheds, waterbodies, farms, human receptor points, drinking water wells, and ecological habitats. These are used by the 3MRA modeling system Site Layout Processor (SLP) to place air receptor points for the Air Module into the model input database and to determine the coordinates for drinking water wells and surface water discharge points for the Aquifer Module. Section 2.0 describes the preparation and formatting of the grid database files.

As mentioned previously, meteorological data files (45 variables) were processed and delivered separately from the Access database as a series of five sets of ASCII data files containing hourly, daily, monthly, and annual time series data, as well as long-term annual average climatic data for each meteorological station. Section 4.0 describes preparation of these files in detail. Together, these data files and databases account for more than 700 variables requested by the 3MRA modeling system and are almost 2 gigabytes in size uncompressed.

1.6.3 Quality Assurance/Quality Control and Record Keeping

Each of the subsequent sections of this report describes the QA/QC procedures that are unique to the data type discussed in each section. In addition to these, there are certain approaches that are common to all activities in this effort. These common approaches may or may not fit a particular data type, depending on the specific data collection methodology.

Prior to data collection, EPA developed a basic QA/QC protocol for each data type and briefed all involved staff to ensure that they were aware of these requirements. Each section of this report describes these simple protocols. Any necessary deviations from these protocols during data collection were discussed with and approved by the team leader and the QA officer.

QC staff checked 100 percent of the data manually entered into the input database from hardcopy sources after a senior staff member reviewed the data source and highlighted the data to be entered. Other general QA/QC and record-keeping procedures included the following:

- Recording the name of the staff member performing QC and the date as part of QC records.

- Maintaining files documenting QC activities. These files were used to track data sources, data entry, and changes to data, for instance, and included copies of the hardcopy data sources.

- Keeping metadata electronically for all electronic data sources.

- For automated import of data from electronic sources, using hand checks and hand calculations to validate the data extraction system before use. After initial system validation, QC staff manually checked a sufficient fraction of the data (usually 5 to 10 percent) to ensure that the data processing system was functioning properly. Automated checks were also built into the system to detect data inconsistencies. Data types checked in this fashion included automated portions of meteorological data, WMU data, soil data, watershed and waterbody data, soil data, and human and ecological receptor data collection.
- Similar to validation of the automatic data collection, validating the 3MRA input data processor system by manually checking a portion (usually 5 percent or more) of the processed data for each variable to ensure that the system was functioning

properly. The system also included automated checks to spot inconsistencies. Finally, the 3MRA modeling system Site Definition Processor (SDP) checked each database update for missing data and for consistency with the 3MRA modeling system input data specifications (i.e., the ssf.dic dictionary files).

In several cases, QC checks found that source data were of unacceptable quality (e.g., see Section 4.0, Meteorological Data). Approaches for spotting such errors and inconsistencies are described under each data type, as well as how the issues were resolved.

1.7 Organization of This Document

Table 1-4 shows which modules use which types of data and provides a guide to the organization of the rest of this volume. Section 2 describes the spatial framework of the data collection effort, including site location and site layout, and provides an overview of the collection and processing of site-based data. The rest of this report is then organized according to the major types of model input data shown in Table 1-4. Each report section is generally organized to provide the following information for the representative national data set data collection effort:

- Parameters addressed (by module)
- Data sources
- Data collection methodology, including
  - Data selection and retrieval
  - Data conversions and derivations
  - QA/QC
- Data collected (by parameter)
- Significant issues and uncertainties associated with data collection
- References for data sources and collection methodologies.

Although each section generally follows this scheme and includes this information at a minimum, some section-to-section variability in structure and content exists because of differences in the data collection scope and methodologies.

1.8 References

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Appendix 1A

Structure of the 3MRA Modeling System Input Database

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Appendix 1A. Structure of the 3MRA Modeling System Input Database

Figure 1A-1 shows the data structure for the 3MRA modeling system input database. The data are stored in a Microsoft Access database composed of seven separate data tables (i.e., the database is not relational). The table also lists the field (or column) names for each of these tables.

Three primary data tables with identical structures hold most of the 3MRA modeling system inputs:

- *National_Variable_Distribution_Data*, which contains data collected on a national scale that characterize values across the nation. In this table, the "Setting_ID" field is always "national" (i.e., for each variable, a single value or distribution characterizes the variable's value).

- *Regional_Variable_Distribution_Data*, which contains data collected for individual regions to characterize the nationwide distribution of values. In this table, the "Setting_ID" field contains the region (e.g., meteorological station, U.S. Geological Survey [USGS] Hydrologic Region, hydrogeologic environment) to which the data correspond. For a particular site, the 3MRA modeling system reads the site's regional assignments from the site-based data table and uses these data to select the correct regional data from the regional data table.

- *Site_Variable_Distribution_Data*, which contains site-based data collected by site. In this table, the "Setting_ID" field contains the setting ID, one of 419 unique site and WMU combinations.

Other 3MRA modeling system database data tables include *Cross_Correlation_Data*, which provides correlation coefficients between correlated variables; *User_Defined_Distribution_Data*, which provides empirical distributions for specific variables with a nonnull entry in the "User_Defined_Distribution_Index" field in the primary data tables above; *Facility*, which provides, for all 201 sites in the representative national data set, the number of each type of WMU (landfill, surface impoundment, LAU, waste pile, and aerated tank); and *Reference_Data*, which contains reference information (data sources) for each 3MRA modeling system variable.

Additional detail on the design and structure of the 3MRA modeling system database and its functioning within the 3MRA modeling system may be found in *FRAMES-HWIR Technology Software System for 1999: System Overview* (U.S. EPA, 1999b) and its supporting documents.

Table Structure for 3MRA Input Database

National_Variable_Distribution_Data

RowID LONG (AK)
Setting_ID TEXT(20) (IE)
Data_Group_Name TEXT(20) (IE)
Variable_Name TEXT(20) (IE)
Units TEXT(20) (IE)
Index_1 INT (IE)
Index_2 INT (IE)
Index_3 INT (IE)
Index_4 INT
Index_5 INT
Index_6 INT
Data_Type TEXT(10)
Reference_Index TEXT(20)
Distribution_Type TEXT(12)
Central_Tendency DOUBLE
Variance DOUBLE (IE)
Maximum DOUBLE
Minimum DOUBLE
User_Defined_Dist_Index TEXT(20)
String_Value TEXT(80)
Logical_Value BOOL
Weight SINGLE
AutoFilled BOOL

Regional_Variable_Distribution_Data

RowID LONG (AK)
Setting_ID TEXT(20) (IE)
Data_Group_Name TEXT(20) (IE)
Variable_Name TEXT(20) (IE)
Units TEXT(20) (IE)
Index_1 INT (IE)
Index_2 INT (IE)
Index_3 INT (IE)
Index_4 INT (IE)
Index_5 INT (IE)
Index_6 INT (IE)
Data_Type TEXT(10)
Reference_Index TEXT(20)
Distribution_Type TEXT(12) (IE)
Central_Tendency DOUBLE
Variance DOUBLE (IE)
Maximum DOUBLE
Minimum DOUBLE
User_Defined_Dist_Index TEXT(20)
String_Value TEXT(80)
Logical_Value BOOL
Weight SINGLE
AutoFilled BOOL

Site_Variable_Distribution_Data

RowID LONG
Setting_ID TEXT(20) (IE)
Data_Group_Name TEXT(20) (IE)
Variable_Name TEXT(20) (IE)
Units TEXT(20)
Index_1 INT (IE)
Index_2 INT (IE)
Index_3 INT (IE)
Index_4 INT (IE)
Index_5 INT (IE)
Index_6 INT (IE)
Data_Type TEXT(10)
Reference_Index TEXT(20)
Distribution_Type TEXT(12) (IE)
Central_Tendency DOUBLE
Variance DOUBLE
Maximum DOUBLE
Minimum DOUBLE
User_Defined_Dist_Index TEXT(20)
String_Value TEXT(80)
Logical_Value BOOL
Weight SINGLE
AutoFilled BOOL

Cross_Correlation_Data

V1_Setting_ID TEXT(20) (IE)
V1_DataGroup TEXT(20)
V1_Variable TEXT(50)
V1_Units TEXT(20)
V1_Index_1 INT
V1_Index_2 INT
V1_Index_3 INT
V1_Index_4 INT
V1_Index_5 INT
V1_Index_6 INT
V2_Setting_ID TEXT(20) (IE)
V2_DataGroup TEXT(20)
V2_Variable TEXT(20)
V2_Units TEXT(20)
V2_Index_1 INT
V2_Index_2 INT
V2_Index_3 INT
V2_Index_4 INT
V2_Index_5 INT
V2_Index_6 INT
Cross_Correlation DOUBLE

User_Defined_Distribution_Data

User_Defined_Dist_Index TEXT(20)
Value DOUBLE
CDF DOUBLE

Reference_Data

Reference_Index TEXT(20)
Reference_Description MEMO

facility

Setting_ID TEXT(255)
LF LONG
SI LONG
LAU LONG
WP LONG
AT LONG

Figure 1A-1. Table structure for 3MRA modeling system input database.

Appendix 1B

Model Inputs by Database Table

Note: Data groups in tables (column 1) correspond to specific 3MRA component modules requiring inputs. Variables in site layout data group are generally shared by multiple modules.

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Table 1B-1. Model Inputs in National Variable Distribution Table

Data Group	Variable Name	Description	Units
Air	AirSplineAngle	angles used in polar mesh	degrees
Air	AirSplineDistance	radial distances of polar mesh	m
Air	ArrayLen	number of particle size categories	unitless
Air	DryDpStr	dry depletion by WMU	
Air	IceScav	scavenging coefficient for frozen precipitation	h/s-mm
Air	LiqScav	scavenging coefficient for liquid precipitation	h/s-mm
Air	MASSFRAX	fraction of each particle size category by WMU	fraction
Air	MASSFRAXOption	flag for internal calculation of PMF (true) or (false) read from ar.ssf	
Air	NumAirSplineAngle	number of angles used to construct the polar mesh used to construct the spline	unitless
Air	NumAirSplineDist	number of distances used to construct the polar mesh used to construct the spline	unitless
Air	PARTDIAM	diameter of particles in the distribution	µm
Air	PARTSICE	particle scavenging coefficient for frozen precipitation	h/s-mm
Air	PARTSLIQ	particle scavenging coefficient for liquid precipitation	h/s-mm
Air	SCIMBYHR	number of hours to skip in processing	unitless
Air	ScimStr	first hour to start processing	
Air	SHight	source height	m
Air	SplineOption	0=no spline; 1 = spline	unitless
Air	WetDpStr	wet depletion, does not vary with WMU	
Aquatic foodweb	a_fish	model slope of BCF regression equation across all tissues in fish	unitless
Aquatic foodweb	a_mus	model slope of BCF regression equation for muscle tissue in fish	unitless
Aquatic foodweb	b_fish	model intercept of BCF regression equation across all tissues in fish	unitless
Aquatic foodweb	b_mus	model intercept of BCF regression equation for muscle tissue in fish	unitless
Aquatic foodweb	BiotaType	biota categories	
Aquatic foodweb	BiotaTypeIndex	index of biota	unitless
Aquatic foodweb	BWFish	fish body weight	kg
Aquatic foodweb	c_fish	error term in BCF regression equation across all tissues in fish	unitless
Aquatic foodweb	c_mus	error term in BCF regression equation for muscle tissue in fish	unitless
Aquatic foodweb	FiletFrac	fraction of fish that is filet	unitless
Aquatic foodweb	FishWaterFrac	water fraction across all tissues of fish	unitless
Aquatic foodweb	LipFrac	lipid fraction	unitless
Aquatic foodweb	LipFracMus	lipid fraction in fish muscle (filet)	unitless

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Aquatic foodweb	MaxPreyPref	maximum dietary preference for items in the AqFW	unitless
Aquatic foodweb	MinPreyPref	minimum dietary preference for items in the AqFW	unitless
Aquatic foodweb	MusWaterFrac	water fraction in muscle (filet) of fish	unitless
Aquatic foodweb	NumBiotaTypes	number of biota types in a given AqFW	unitless
Aquatic foodweb	rho_lip	density (organic carbon)	kg/L
Aquatic foodweb	rho_OC	density (lipids)	kg/L
Aquatic foodweb	T3EdibleFish	edible T3 fish for human consumption	unitless
Aquatic foodweb	T3NumEdibleFish	number of edible T3 fish in AqFW	unitless
Aquatic foodweb	T3NumFish	number of T3 fish in AqFW	fish
Aquifer	AL	Longitudinal dispersivity	m
Aquifer	ALATRatio	Horizontal Transverse dispersivity	m
Aquifer	ALAVRatio	Vertical Transverse dispersivity	m
Aquifer	ANIST	Anisotropy ratio	unitless
Aquifer	AquAnaBioRandUnif	Uniformly distributed random number used to choose the anaerobic biodegradation regime: 0=methanogenic; 1= sulfate reducing	unitless
Aquifer	AquDoFracture	Logical flag to turn fractures on or off	unitless
Aquifer	AquDoHetero	Logical flag to turn heterogeneity on or off	unitless
Aquifer	AquRandFractUnif	Uniformly distributed random number-used when AquDoFracture==TRUE	unitless
Aquifer	AquRandHeteroNorm	Normally distributed random numbers with 0 mean and std of 1-used when AquDoHetero==TRUE	unitless
Aquifer	AquRandHeteroUnif	Uniformly distributed random number-used when AquDoHetero==TRUE	unitless
Aquifer	BDENS	Bulk Density of soil	g/cm3
Aquifer	FOC	Fraction Organic Carbon	fraction
Aquifer	POR	Effective Porosity	volume fraction
AT	bio_yield	biomass yield	g/g
AT	CBOD	BOD (influent)	g/cm^3
AT	d_imp	impeller diameter	cm
AT	d_setpt	fraction of tank occupied by sediments (max.)	fraction
AT	d_wmu	depth (liquid)	m
AT	dmeanTSS	particle diameter (mean, waste suspended solids)	cm
AT	EconLife	economic life of a tank/SI	year
AT	F_aer	fraction surface area-turbulent	fraction
AT	focW	fraction organic carbon (waste solids)	mass fraction
AT	J	oxygen transfer factor	lb O_2/h-hp
AT	k_dec	digestion (sediments)	1/s

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
AT	kba1	biologically active solids/total solids (ratio)	unitless
AT	MWt_H2O	molecular weight (liquid [water])	g/mol
AT	n_imp	impellers/aerators (number)	unitless
AT	NumEcon	number of economic lifetimes	
AT	O2eff	oxygen transfer correction factor	unitless
AT	Powr	impellers/aerators (total power)	hp
AT	Q_wmu	volumetric flow rate (tank)	m^3/s
AT	rho_l	density (liquid [water])	g/cm^3
AT	rho_part	solids density	g/cm^3
AT	TSS_in	total suspended solids (influent)	g/cm^3
AT	w_imp	impeller speed	rad/s
Ecoexposure	BodyWt_rec	body weight for each receptor	kg
Ecoexposure	CR_food	consumption rate of food items (e.g., plants, animals) for each receptor	kg/d
Ecoexposure	CR_water	consumption rate of water for each receptor	L/d
Ecoexposure	CRfrac_sed	consumption rate of sediment for each receptor	mass fraction
Ecoexposure	CRfrac_soil	consumption rate of surficial soil for each receptor	mass fraction
Ecoexposure	HabitatIndex	index of habitat types	unitless
Ecoexposure	HabitatType	description of habitat type (e.g., grassland, pond, forested wetland)	
Ecoexposure	MaxPreyPref_HabRange	maximum dietary preference for items found in habitat range	unitless
Ecoexposure	MinPreyPref_HabRange	minimum dietary preference for items found in habitat range	unitless
Ecoexposure	NumHabitat	number of habitat types represented	unitless
Ecoexposure	NumPrey	number of potential prey items	unitless
Ecoexposure	PreyIndex	numerical index of potential prey items	unitless
Ecoexposure	PreyType	text description of each potential prey item	
Ecorisk	DoExposed	option on whether to include all receptors (false) or exposed receptors only (true) in CDF calculations	unitless
Ecorisk	EcoRegPercentile	policy criterion for selecting critical year for maximum HQ	unitless
Ecorisk	HabitatIndex	index of habitat types	unitless
Ecorisk	NumHabitat	number of habitat types represented	unitless
Farm foodchain	Fforage_beef	fraction of forage grown in contaminated soil (beef cattle)	fraction
Farm foodchain	Fforage_dairy	fraction of forage grown in contaminated soil (dairy cattle)	fraction
Farm foodchain	Fgrain_beef	fraction of grain grown in contaminated soil (beef cattle)	fraction
Farm foodchain	Fgrain_dairy	fraction of grain grown in contaminated soil (dairy cattle)	fraction
Farm foodchain	Fsilage_beef	fraction of silage grown in contaminated soil (beef cattle)	fraction
Farm foodchain	Fsilage_dairy	fraction of silage grown in contaminated soil (dairy cattle)	fraction

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Farm foodchain	Fw_exfruit	fraction of wet deposition that adheres to plant	unitless
Farm foodchain	Fw_exveg	fraction of wet deposition that adheres to plant	unitless
Farm foodchain	Fw_forage	fraction of wet deposition that adheres to plant	unitless
Farm foodchain	Fw_silage	fraction of wet deposition that adheres to plant	unitless
Farm foodchain	MAFexfruit	moisture adjustment factor to convert DW into WW for exposed above-ground fruits	percent
Farm foodchain	MAFexveg	moisture adjustment factor to convert DW into WW for above-ground vegetables	percent
Farm foodchain	MAFleaf	moisture adjustment factor for wet leaf	unitless
Farm foodchain	MAFprofruit	moisture adjustment factor to convert DW into WW for protected above-ground fruits	percent
Farm foodchain	MAFproveg	moisture adjustment factor to convert DW into WW for protected above-ground vegetables	percent
Farm foodchain	MAFroot	moisture adjustment factor to convert DW into WW for root vegetables	percent
Farm foodchain	Qp_forage_beef	consumption rate: forage (beef cattle)	kg DW/d
Farm foodchain	Qp_forage_dairy	consumption rate: forage (dairy cattle)	kg DW/d
Farm foodchain	Qp_grain_beef	consumption rate: grain (beef cattle)	kg DW/d
Farm foodchain	Qp_grain_dairy	consumption rate: grain (dairy cattle)	kg DW/d
Farm foodchain	Qp_silage_beef	consumption rate: silage (beef cattle)	kg DW/d
Farm foodchain	Qp_silage_dairy	consumption rate: silage (dairy cattle)	kg DW/d
Farm foodchain	Qs_beef	consumption rate: soil (beef cattle)	kg/d
Farm foodchain	Qs_dairy	consumption rate: soil (dairy cattle)	kg/d
Farm foodchain	Qw_beef	consumption rate: water (beef cattle)	L/d
Farm foodchain	Qw_dairy	consumption rate: water (dairy cattle)	L/d
Farm foodchain	rho_leaf	leaf density	g/L FW
Farm foodchain	Rp_exfruit	interception fraction	unitless
Farm foodchain	Rp_exveg	interception fraction	unitless
Farm foodchain	Rp_forage	interception fraction	unitless
Farm foodchain	Rp_silage	interception fraction	unitless
Farm foodchain	tp_exfruit	length of plant exposure to deposition	yr
Farm foodchain	tp_exveg	length of plant exposure to deposition	yr
Farm foodchain	tp_forage	length of plant exposure to deposition	yr
Farm foodchain	tp_silage	length of plant exposure to deposition	yr
Farm foodchain	VapDdv	vapor phase dry deposition velocity	cm/s
Farm foodchain	VGag_exfruit	empirical correction factor	unitless
Farm foodchain	VGag_exveg	empirical correction factor	unitless
Farm foodchain	VGag_forage	empirical correction factor	unitless

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Farm foodchain	VGag_silage	empirical correction factor	unitless
Farm foodchain	VGbg_root	empirical correction factor	unitless
Farm foodchain	Yp_exfruit	crop yield	kg DW/m^2
Farm foodchain	Yp_exveg	crop yield	kg DW/m^2
Farm foodchain	Yp_forage	crop yield	kg DW/m^2
Farm foodchain	Yp_silage	crop yield	kg DW/m^2
Human exposure	BF	event frequency (shower)	event/d
Human exposure	Bri_cr1	inhalation (breathing) rate (child 1 resident)	m^3/d
Human exposure	Bri_cr2	inhalation (breathing) rate (child 2 resident)	m^3/d
Human exposure	Bri_cr3	inhalation (breathing) rate (child 3 resident)	m^3/d
Human exposure	Bri_cr4	inhalation (breathing) rate (child 4 resident)	m^3/d
Human exposure	Bri_r	inhalation (breathing) rate (adult resident)	m^3/d
Human exposure	BWa	body weight (adult)	kg
Human exposure	BWc1	body weight (child 1)	kg
Human exposure	BWc2	body weight (child 2)	kg
Human exposure	BWc3	body weight (child 3)	kg
Human exposure	BWc4	body weight (child 4)	kg
Human exposure	CRb_af	consumption rate: beef (adult farmer)	g WW/kg/d
Human exposure	CRb_cf_2	consumption rate: beef (child 2 farmer)	g WW/kg/d
Human exposure	CRb_cf_3	consumption rate: beef (child 3 farmer)	g WW/kg/d
Human exposure	CRb_cf_4	consumption rate: beef (child 4 farmer)	g WW/kg/d
Human exposure	CRbm_cr_1	consumption rate: breast milk (child 1 resident)	mL/d
Human exposure	CRfr_cf_2	consumption rate: exposed fruit (child 2 farmer)	g WW/kg/d
Human exposure	CRfr_cf_3	consumption rate: exposed fruit (child 3 farmer)	g WW/kg/d
Human exposure	CRfr_cf_4	consumption rate: exposed fruit (child 4 farmer)	g WW/kg/d
Human exposure	CRfr_cg_2	consumption rate: exposed fruit (child 2 gardener)	g WW/kg/d
Human exposure	CRfr_cg_3	consumption rate: exposed fruit (child 3 gardener)	g WW/kg/d
Human exposure	CRfr_cg_4	consumption rate: exposed fruit (child 4 gardener)	g WW/kg/d
Human exposure	CRfr_f	consumption rate: exposed fruit (farmer)	g WW/kg/d
Human exposure	CRfr_g	consumption rate: exposed fruit (gardener)	g WW/kg/d
Human exposure	CRfs_a	consumption rate: fish (adult)	g/d
Human exposure	CRfs_c_2	consumption rate: fish (child 2)	g/d
Human exposure	CRfs_c_3	consumption rate: fish (child 3)	g/d
Human exposure	CRfs_c_4	consumption rate: fish (child 4)	g/d
Human exposure	CRl_cf_2	consumption rate: exposed vegetables (child 2 farmer)	g WW/kg/d
Human exposure	CRl_cf_3	consumption rate: exposed vegetables (child 3 farmer)	g WW/kg/d

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Human exposure	CRl_cf_4	consumption rate: exposed vegetables (child 4 farmer)	g WW/kg/d
Human exposure	CRl_cg2	consumption rate: exposed vegetables (child 2 gardener)	g WW/kg/d
Human exposure	CRl_cg3	consumption rate: exposed vegetables (child 3 gardener)	g WW/kg/d
Human exposure	CRl_cg4	consumption rate: exposed vegetables (child 4 gardener)	g WW/kg/d
Human exposure	CRl_f	consumption rate: exposed vegetables (adult farmer)	g WW/kg/d
Human exposure	CRl_g	consumption rate: exposed vegetables (gardener)	g WW/kg/d
Human exposure	CRm_af	consumption rate: milk (adult farmer)	g WW/kg/d
Human exposure	CRm_cf_2	consumption rate: milk (child 2 farmer)	g WW/kg/d
Human exposure	CRm_cf_3	consumption rate: milk (child 3 farmer)	g WW/kg/d
Human exposure	CRm_cf_4	consumption rate: milk (child 4 farmer)	g WW/kg/d
Human exposure	CRpfr_cf_2	consumption rate: protected fruit (child 2 farmer)	g WW/kg/d
Human exposure	CRpfr_cf_3	consumption rate: protected fruit (child 3 farmer)	g WW/kg/d
Human exposure	CRpfr_cf_4	consumption rate: protected fruit (child 4 farmer)	g WW/kg/d
Human exposure	CRpfr_cg_2	consumption rate: protected fruit (child 2 gardener)	g WW/kg/d
Human exposure	CRpfr_cg_3	consumption rate: protected fruit (child 3 gardener)	g WW/kg/d
Human exposure	CRpfr_cg_4	consumption rate: protected fruit (child 4 gardener)	g WW/kg/d
Human exposure	CRpfr_f	consumption rate: protected fruit (adult farmer)	g WW/kg/d
Human exposure	CRpfr_g	consumption rate: protected fruit (adult gardener)	g WW/kg/d
Human exposure	CRpl_cf_2	consumption rate: protected vegetables (child 2 farmer)	g WW/kg/d
Human exposure	CRpl_cf_3	consumption rate: protected vegetables (child 3 farmer)	g WW/kg/d
Human exposure	CRpl_cf_4	consumption rate: protected vegetables (child 4 farmer)	g WW/kg/d
Human exposure	CRpl_cg_2	consumption rate: protected vegetables (child 2 gardener)	g WW/kg/d
Human exposure	CRpl_cg_3	consumption rate: protected vegetables (child 3 gardener)	g WW/kg/d
Human exposure	CRpl_cg_4	consumption rate: protected vegetables (child 4 gardener)	g WW/kg/d
Human exposure	CRpl_f	consumption rate: protected vegetables (adult farmer)	g WW/kg/d
Human exposure	CRpl_g	consumption rate: protected vegetables (adult gardener)	g WW/kg/d
Human exposure	CRr_cf_2	consumption rate: root vegetables (child 2 farmer)	g WW/kg/d
Human exposure	CRr_cf_3	consumption rate: root vegetables (child 3 farmer)	g WW/kg/d
Human exposure	CRr_cf_4	consumption rate: root vegetables (child 4 farmer)	g WW/kg/d
Human exposure	CRr_cg_2	consumption rate: root vegetables (child 2 gardener)	g WW/kg/d
Human exposure	CRr_cg_3	consumption rate: root vegetables (child 3 gardener)	g WW/kg/d
Human exposure	CRr_cg_4	consumption rate: root vegetables (child 4 gardener)	g WW/kg/d
Human exposure	CRr_f	consumption rate: root vegetables (farmer)	g WW/kg/d
Human exposure	CRr_g	consumption rate: root vegetables (gardener)	g WW/kg/d
Human exposure	CRs_cr2	ingestion rate:soil (child 2 resident)	kg/d
Human exposure	CRs_cr3	ingestion rate:soil (child 3 resident)	kg/d

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Human exposure	CRs_cr4	ingestion rate:soil (child 4 resident)	kg/d
Human exposure	CRs_r	ingestion rate:soil (adult resident)	kg/d
Human exposure	CRw_cr1	ingestion rate: drinking water (child 1 resident)	mL/d
Human exposure	CRw_cr2	ingestion rate: drinking water (child 2 resident)	mL/d
Human exposure	CRw_cr3	ingestion rate: drinking water (child 3 resident)	mL/d
Human exposure	CRw_cr4	ingestion rate: drinking water (child 4 resident)	mL/d
Human exposure	CRw_r	ingestion rate: drinking water (adult resident)	mL/d
Human exposure	DD	water droplet diameter	cm
Human exposure	EFr	exposure frequency (adult resident)	d/y
Human exposure	Fb_f	fraction contaminated: beef (farmer)	fraction
Human exposure	fbp	fraction of whole blood that is plasma	fraction
Human exposure	Ff_s	fraction contaminated fish	fraction
Human exposure	ffm	fraction of mother's weight that is fat	fraction
Human exposure	Ffr_f	fraction homegrown: exposed fruit (farmer)	fraction
Human exposure	Ffr_g	fraction homegrown: exposed fruit (gardener)	fraction
Human exposure	Fl_f	fraction homegrown: exposed vegetables (farmer)	fraction
Human exposure	Fl_g	fraction contaminated: homegrown exposed vegetables (gardener)	fraction
Human exposure	Fm_f	fraction contaminated: milk (farmer)	fraction
Human exposure	fmbm	fraction of fat in maternal breast milk	fraction
Human exposure	Fpfr_f	fraction homegrown: protected fruit (farmer)	fraction
Human exposure	Fpfr_g	fraction homegrown: protected fruit (gardener)	fraction
Human exposure	Fpl_f	fraction homegrown: protected vegetables (farmer)	fraction
Human exposure	Fpl_g	fraction homegrown: protected vegetables (gardener)	fraction
Human exposure	fpm	fraction of mother's weight that is plasma	fraction
Human exposure	Fr_f	fraction homegrown: root vegetables (farmer)	fraction
Human exposure	Fr_g	fraction homegrown: root vegetables (gardener)	fraction
Human exposure	Fs	fraction contaminated: soil	fraction
Human exposure	FT3fish	fraction of fish consumed that is T3 fish	fraction
Human exposure	FT4fish	fraction of fish consumed that is T4 fish	fraction
Human exposure	Fw	fraction contaminated: drinking water	fraction
Human exposure	Hn	nozzle height	cm
Human exposure	Rshower	shower rate	L/min
Human exposure	t_sb	time in shower and bathroom	min
Human exposure	t_shower	shower time	min
human exposure	Vbath	bathroom volume	m^3
Human exposure	Vn	terminal velocity of droplet	cm/s

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Human exposure	VRbh	bathroom to house ventilation rate	L/min
Human exposure	VRsb	shower to bathroom ventilation rate	L/min
Human exposure	Vshower	shower volume	m^3
Human risk	DoExposed	option on whether to include all receptors (false) or exposed receptors only (true) in CDF calculations	unitless
Human risk	ExDur_Car_Block	exposure duration (carcinogens, residents)	unitless
Human risk	ExDur_Car_Farm	exposure duration (carcinogens, farmers)	unitless
Human risk	ExDur_NCar_Block	exposure duration (noncarcinogens, residents)	unitless
Human risk	ExDur_NCar_Farm	exposure duration (noncarcinogens, farmers)	unitless
Human risk	LifeTime	average receptor lifetime	unitless
Human risk	RegPercentile	policy criterion defining regulatory percentile (not used in example dataset)	unitless
LAU	asdm	mode of the aggregate size distribution (till zone surface)	mm
LAU	bcm	boundary condition multiplier (lower boundary)	unitless
LAU	BDw	dry bulk density (waste solids)	g/cm^3
LAU	ConVs	settling velocity (suspended solids)	m/d
LAU	CutOffYr	operating life	year
LAU	Cwmu	USLE cover factor (WMU)	unitless
LAU	deltDiv	time step divider (for debugging)	unitless
LAU	effdust	dust suppression control efficiency	unitless
LAU	focW	fraction organic carbon (waste solids)	mass fraction
LAU	fwmu	fraction hazardous waste in WMU	mass fraction
LAU	Infild	input infiltration rate (for debugging)	m/d
LAU	Lc	roughness ratio (till zone surface)	unitless
LAU	Pwmu	USLE erosion control factor (WMU)	unitless
LAU	RunID	run identification label (optional)	
LAU	solid	percent solids (waste)	mass percent
LAU	Sw	silt content (waste solids)	mass percent
LAU	thetawZ1d	input volumetric water content in till zone (for debugging)	volume fraction
LAU	thetawZ2d	input volumetric water content in LAU subsoil zone (for debugging)	volume fraction
LAU	veg	fraction vegetative cover (inactive LAU)	fraction
LAU	vs	vehicle speed (mean)	km/h
LAU	zava	averaging depth upper (depth averaged soil concentration)	m
LAU	zavb	averaging depth lower (depth averaged soil concentration)	m
LAU	zruf	roughness height (inactive LAU)	cm
LAU	zZ1sa	depth (modeled soil column, subareas other than WMU)	m

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Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
LAU	zZ2WMU	subsoil layer thickness	m
LF	asdm	mode of the aggregate size distribution (LF waste zone surface)	mm
LF	bcm	boundary condition multiplier (lower boundary)	unitless
LF	BDw	dry bulk density (waste)	g/cm^3
LF	deltDiv	time step divider (for debugging)	unitless
LF	DRZ_W	depth (root zone in LF waste zone)	cm
LF	effdust	dust suppression control efficiency	unitless
LF	focW	fraction organic carbon (waste)	mass fraction
LF	fwmu	fraction hazardous waste in WMU	mass fraction
LF	Infild	input infiltration rate (for debugging)	m/d
LF	KsatW	saturated hydraulic conductivity (waste)	cm/h
LF	Lc	roughness ratio (LF waste zone surface)	unitless
LF	mcW	volumetric water content (waste on trucks)	volume percent
LF	porW	porosity (total, waste)	volume fraction
LF	RunID	run identification label (optional)	
LF	SMbW	soil moisture coefficient b (waste)	unitless
LF	SMFC_W	soil moisture field capacity (LF waste zone)	volume %
LF	SMWP_W	soil moisture wilting point (LF waste zone)	volume %
LF	Sw	silt content (waste)	mass %
LF	thetawCd	input volumetric water content in LF cover soil (for debugging)	volume fraction
LF	thetawSd	input volumetric water content in LF subsoil zone (for debugging)	volume fraction
LF	thetawWd	input volumetric water content in LF waste zone (for debugging)	volume fraction
LF	veg	fraction vegetative cover (inactive LF cell)	fraction
LF	vs	vehicle speed (mean)	km/h
LF	zava	averaging depth upper (depth averaged soil concentration)	m
LF	zavb	averaging depth lower (depth averaged soil concentration)	m
LF	zC	optional soil cover thickness	m
LF	zruf	roughness height (inactive LF cell)	cm
LF	zS	thickness of liner (or subsoil zone)	m
Saturated zone	AL	longitudinal dispersivity	m
Saturated zone	ALATratio	longitudinal to transverse dispersivity ratio	m
Saturated zone	ALAVratio	longitudinal to vertical dispersivity ratio	m
Saturated zone	ANIST	anisotropy ratio	unitless

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Saturated zone	DIAM	particle diameter (d)	mm
Saturated zone	FOC	fraction organic carbon (aquifer)	fraction
SI	bio_yield	biomass yield	g/g
SI	CBOD	BOD (influent)	g/cm^3
SI	d_imp	impeller diameter	cm
SI	dmeanTSS	particle diameter (mean, waste suspended solids)	cm
SI	EconLife	economic life of a tank/SI	year
SI	focW	fraction organic carbon (waste solids)	mass fraction
SI	hydc_sed	saturated hydraulic conductivity (sediment layer)	m/s
SI	J	oxygen transfer factor	lb O_2/h-hp
SI	k_dec	digestion (sediments)	1/s
SI	kba1	biologically active solids/total solids (ratio)	unitless
SI	MWt_H2O	molecular weight (liquid [water])	g/mol
SI	NumEcon	number of economic lifetimes	
SI	O2eff	oxygen transfer correction factor	unitless
SI	rho_l	density (liquid [water])	g/cm^3
SI	rho_part	solids density	g/cm^3
SI	TSS_in	total suspended solids (influent)	g/cm^3
SI	w_imp	impeller speed	rad/s
Site Layout	AquFEOX	fraction iron-hydroxide adsorbent	fraction
Site Layout	AquLOM	leachate organic matter	mg/L
Site Layout	AquPh	average aquifer pH	pH units
Site Layout	ATIndex	uniform distribution needed to select AT index for national tank data	
Site Layout	BinRange_Min_C	minimum values of bins for human risk -- cancer	unitless
Site Layout	BinRange_Min_NC	minimum values of bins for human risk -- HQ	unitless
Site layout	BinRange_Label_C	Labels for human risk bins -- cancer	unitless
Site layout	BinRange_Label_NC	Labels for human risk bins -- noncancer	unitless
Site layout	EcoBinRange_Label	Labels for ecological risk bins	unitless
Site Layout	EcoBinRange_Min	minimum values of bins for eco risk HQ	unitless
Site Layout	FarmRcpType	type of human receptor (beef farmer, dairy farmer, beef farmer fisher, dairy farmer fisher)	
Site Layout	HabGroup	group in which habitat type is attributed: 1 = terrestrial, 2 = aquatic, 3 = wetland	not applicable
Site Layout	HabRangeRecType	type of receptor (e.g., erbivert, omnivert, small mammal, small bird)	not applicable
Site Layout	HumRcpTemp	typical shower temperature	degrees Celsius

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Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Site Layout	HumRcpType	type of human receptor (resident, home gardener, resident fisher, home gardener fisher)	
Site Layout	NumBinC	number of bins for human -- carcinogen	unitless
Site Layout	NumBinNC	number of bins for human -- noncarcinogen	unitless
Site Layout	NumEcoBin	number of HQ range bins to assign receptor-specific HQs	unitless
Site Layout	NumEcoRing	number of eco rings (3rd ring is for entire site)	unitless
Site Layout	NumFarmRcpType	number of farmer receptor types	
Site Layout	NumHabGroup	number of general groups into which habitat types are placed	unitless
Site Layout	NumHumRcpType	number of human receptor types	
Site Layout	NumReceptor	complete receptor list across all habitat types	unitless
Site Layout	NumRecGroup	total receptor groups considered (terrestrial plants; aquatic plants; mammals; birds; amphibians; reptiles; soil biota; sediment biota; aquatic biota)	unitless
Site Layout	NumRing	number of rings at site	
Site Layout	NumTrophicLevel	number of possible trophic levels	unitless
Site Layout	NyrMax	maximum model simulation time	years
Site Layout	ReceptorIndex	indices assigned to each receptor	unitless
Site Layout	ReceptorName	receptor name	not applicable
Site Layout	ReceptorType	description of receptor (e.g., red-tailed hawk; aquatic biota; frog; plants)	not applicable
Site Layout	RecGroup	general receptor groups (e.g., mammals, birds, amphibians, reptiles, soil biota, terrestrial plants, aquatic biota, sediment biota, aquatic plants)	not applicable
Site Layout	RecTrophicLevel	trophic level into which each receptor falls	not applicable
Site Layout	RingDistance	distance of ring from source edge	m
Site Layout	SrcArea	area of source	m^2
Site Layout	SrcPh	average waste/source pH	pH units
Site Layout	TermFrac	peak output fraction for simulation termination	fraction
Site Layout	WBNfocAbS	fraction organic carbon (abiotic solids)	fraction
Site Layout	WBNfocBioS	biotic solids organic content	fraction
Site Layout	WBNfocSed	fraction organic carbon in sediments of stream, lake, and wetland reaches	fraction
Surface water	ahyd_d	stream depth hydraulic coefficient a	m
Surface water	ahyd_W	stream width hydraulic coefficient a	m
Surface water	bhyd_d	stream depth hydraulic coefficient b	

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Surface water	bhyd_W	stream width hydraulic coefficient b	
Surface water	DepthBenthos	surficial sediment layer depth	cm
Surface water	DepthSedRes	underlying sediment layer depth	cm
Surface water	E_sw	sediment-water column diffusion coefficient	cm^2/sec
Surface water	E_thermocline	thermocline diffusion coeff.	cm^2/sec
Surface water	k_PlankCMin	plankton carbon mineralization rate constant	yr^{-1}
Surface water	k_SedG2	sediment mineralization rate constant, G2 fraction	yr^{-1}
Surface water	k_SedG3	sediment mineralization rate constant, G3 fraction	yr^{-1}
Surface water	porBenthos	surficial sediment layer porosity	Lw/L
Surface water	rhoDBenthos	surficial sediment layer dry bulk density	g/mL
Surface water	porSedRes	underlying sediment layer porosity	Lw/L
Surface water	rhoDSedRes	underlying sediment layer dry bulk density	g/mL
Surface water	S_upstream	upstream suspended solids concentration	mg/L
Surface water	TrophicIndex	trophic index	
Surface water	v_bury	underlying sediment layer burial rate	mm/yr
Terrestrial foodweb	Bv_ecf_plant	empirical correction factor for Bv	unitless
Terrestrial foodweb	Fw_exfruit	fraction of wet deposition that adheres to plant	unitless
Terrestrial foodweb	Fw_exveg	fraction of wet deposition that adheres to plant	unitless
Terrestrial foodweb	Fw_forage	fraction of wet deposition that adheres to plant	unitless
Terrestrial foodweb	Fw_silage	fraction of wet deposition that adheres to plant	unitless
Terrestrial foodweb	MAFexfruit	moisture adjustment factor to convert DW into WW for exposed above-ground fruits	percent
Terrestrial foodweb	MAFexveg	moisture adjustment factor to convert DW into WW for above-ground vegetables	percent
Terrestrial foodweb	MAFforage	moisture adjustment factor to convert DW into WW for forage	percent
Terrestrial foodweb	MAFgrain	moisture adjustment factor to convert DW into WW for grain (analogy to profruit)	percent
Terrestrial foodweb	MAFleaf	moisture adjustment factor for wet leaf	unitless
Terrestrial foodweb	MAFroot	moisture adjustment factor to convert DW into WW for root vegetables	percent

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Terrestrial foodweb	MAFsilage	moisture adjustment factor to convert DW into WW for silage	percent
Terrestrial foodweb	rho_leaf	leaf density	g/L FW
Terrestrial foodweb	Rp_exfruit	interception fraction	unitless
Terrestrial foodweb	Rp_exveg	interception fraction	unitless
Terrestrial foodweb	Rp_forage	interception fraction	unitless
Terrestrial foodweb	Rp_silage	interception fraction	unitless
Terrestrial foodweb	tp_exfruit	length of plant exposure to deposition	yr
Terrestrial foodweb	tp_exveg	length of plant exposure to deposition	yr
Terrestrial foodweb	tp_forage	length of plant exposure to deposition	yr
Terrestrial foodweb	tp_silage	length of plant exposure to deposition	yr
Terrestrial foodweb	VapDdv	vapor phase dry deposition velocity	cm/s
Terrestrial foodweb	VGag_exfruit	empirical correction factor	unitless
Terrestrial foodweb	VGag_exveg	empirical correction factor	unitless
Terrestrial foodweb	VGag_forage	empirical correction factor	unitless
Terrestrial foodweb	VGag_silage	empirical correction factor	unitless
Terrestrial foodweb	VGbg_root	empirical correction factor	unitless
Terrestrial foodweb	Yp_exfruit	crop yield	kg DW/m^2
Terrestrial foodweb	Yp_exveg	crop yield	kg DW/m^2
Terrestrial foodweb	Yp_forage	crop yield	kg DW/m^2
Terrestrial foodweb	Yp_silage	crop yield	kg DW/m^2
Watershed	bcm	boundary condition multiplier (lower boundary)	unitless

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
Watershed	ConVs	settling velocity (suspended solids)	m/d
Watershed	deltDiv	time step divider (for debugging)	unitless
Watershed	Infild	input infiltration rate (for debugging)	m/d
Watershed	RunID	run identification label (optional)	
Watershed	thetawZ1d	input volumetric water content in till zone (for debugging)	volume fraction
Watershed	zava	averaging depth upper (depth averaged soil concentration)	m
Watershed	zavb	averaging depth lower (depth averaged soil concentration)	m
Watershed	zZ1sa	depth (modeled soil column)	m
WP	bcm	boundary condition multiplier (lower boundary)	unitless
WP	BDw	dry bulk density (waste)	g/cm^3
WP	ConVs	settling velocity (suspended solids)	m/d
WP	CutOffYr	operating life	year
WP	Cwmu	USLE cover factor (WMU)	unitless
WP	deltDiv	time step divider (for debugging)	unitless
WP	DRZ_W	depth (WP root zone)	cm
WP	effdust	dust suppression control efficiency	unitless
WP	focW	fraction organic carbon (waste)	mass fraction
WP	fwmu	fraction hazardous waste in WMU	mass fraction
WP	Infild	input infiltration rate (for debugging)	m/d
WP	KsatW	saturated hydraulic conductivity (waste)	cm/h
WP	mcW	volumetric water content (waste on trucks)	volume %
WP	porW	porosity (total, waste)	volume fraction
WP	Pwmu	USLE erosion control factor (WMU)	unitless
WP	RunID	run identification label (optional)	
WP	SMbW	soil moisture coefficient b (waste)	unitless
WP	SMFC_W	soil moisture field capacity (WP)	volume %
WP	SMWP_W	soil moisture wilting point (WP)	volume %
WP	Sw	silt content (waste)	mass %
WP	thetawZ1d	input volumetric water content in WP (for debugging)	volume fraction
WP	thetawZ2d	input volumetric water content in WP subsoil zone (for debugging)	volume fraction

(continued)

Table 1B-1. (continued)

Data Group	Variable Name	Description	Units
WP	vs	vehicle speed (mean)	km/h
WP	zava	averaging depth upper (depth averaged soil concentration)	m
WP	zavb	averaging depth lower (depth averaged soil concentration)	m
WP	zZ1sa	depth (modeled soil column, subareas other than WMU)	m
WP	zZ2WMU	subsoil layer thickness	m

Table 1B-2. Model Inputs in Regional Variable Distribution Table

Data Group	Variable Name	Description	Units
Site layout	AquGrad	regional groundwater gradient	
Site layout	AquSatk	hydraulic conductivity in direction of gradient	m/yr
Site layout	AquThick	saturated zone thickness	m
Site layout	GWClassIndex	count of rows being passed for aquifer GWClass data	unitless
Site layout	VadThick	vadose zone thickness	m
Watershed	a_BF	regression coefficient "a" for baseflow model	m/d
Watershed	b_BF	regression coefficient "b" for baseflow model	unitless

Table 1B-3. Model Inputs in Site Variable Distribution Table

Data Group	Variable Name	Description	Units
Air	AirData	station number for upper air data	
Air	AnemHght	anemometer height	m
Air	RuralStr	rural or urban	
Air	SHight	source height	m
Air	StartYr	first year of meteorological data in the met. file	
Air	SurfData	station number of surface meteorological data	
Data Group	Variable Name	Description	Units
Aquifer	AquFractureID	Indicator for degree of fracturing of saturated porous media	unitless
LAU	C	USLE cover factor	unitless
LAU	CN	SCS curve number	unitless
LAU	CNwmu	SCS curve number (WMU)	unitless
LAU	DRZ	depth (root zone)	cm
LAU	fcult	number of cultivations per application	unitless
LAU	fd	frequency of surface disturbance per month (active LAU)	1/mo

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
LAU	focS	fraction organic carbon (surface soil)	mass fraction
LAU	HydroGroup	hydrologic soil group	
LAU	K	USLE erodibility factor	kg/m^2
LAU	Ksat	saturated hydraulic conductivity (surface soil)	cm/h
LAU	Kwmu	USLE erodibility factor (WMU)	kg/m^2
LAU	mt	distance vehicle travels on LAU surface	m
LAU	Nappl	waste applications per year	1/year
LAU	nv	vehicles/day (mean annual)	1/d
LAU	nw	wheels per vehicle (mean)	unitless
LAU	P	USLE erosion control factor	unitless
LAU	Rappl	wet waste application rate	Mg/m^2-year
LAU	SMb	soil moisture coefficient b (surface soil)	unitless
LAU	SMFC	field capacity	volume %
LAU	SMWP	wilting point	volume %
LAU	Ss	silt content (soil at lau)	mass %
LAU	Theta	slope (local watershed)	degrees
LAU	vw	vehicle weight (mean)	Mg
LAU	WCS	saturated water content (surface soil)	volume fraction
LAU	X	flow length (local watershed, all subareas)	m
LAU	zZ1WMU	depth (tilling, LAU)	m
LF	fd	frequency of surface disturbance per month (active LF cell)	1/mo
LF	focC	fraction organic carbon (cover soil)	mass fraction
LF	focS_lf	fraction organic carbon (subsoil)	mass fraction
LF	KsatC	saturated hydraulic conductivity (cover soil)	cm/h
LF	load	waste loading rate (dry)	Mg/y
LF	mt	distance vehicle travels on active LF cell surface	m
LF	Nly	number of waste layers in a cell	unitless
LF	Nop	spreading/compacting operations per day	1/d
LF	nv	vehicles/day (mean annual)	1/d
LF	nw	wheels per vehicle (mean)	unitless
LF	SMbC	soil moisture coefficient b (cover soil)	unitless
LF	SMbS	soil moisture coefficient b (subsoil)	unitless
LF	vw	vehicle weight (mean)	Mg
LF	WCS_C	saturated water content (cover soil)	volume fraction
LF	zW	waste zone thickness	m

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Saturated zone	AquFractureID	indicator for degree of fracturing of saturated porous media	
Saturated zone	AquRandHeteroNorm	normally distributed random numbers with 0 mean and std of 1 - used when AquDoHetero ==TRUE	
SI	d_setpt	fraction of SI occupied by sediments (max.)	fraction
SI	d_wmu	depth of wmu	m
SI	F_aer	fraction surface area-turbulent	fraction
SI	n_imp	impellers/aerators (number)	unitless
SI	Powr	impellers/aerators (total power)	hp
SI	Q_wmu	volumetric influent flow rate	m^3/s
Site Layout	AirTemp	temperature (air, annual average, long-term)	° Celsius
Site Layout	AquDir	groundwater flow direction in degrees from North	degrees
Site Layout	AquId	environmental setting ID for aquifer	
Site Layout	AquLWSIndex	local watershed index for aquifer	
Site Layout	AquLWSSubAreaIndex	LWS subarea index for aquifer	
Site Layout	AquTemp	average aquifer temperature	° Celsius
Site Layout	AquVadIndex	vadose zone index per aquifer	
Site Layout	AquWellFracZ	fraction of aquifer covered by well screen	fraction
Site Layout	AquWSSubIndex	index of watershed for each aquifer	
Site Layout	EcoRingHabIndex	index of habitat contained within ecoring (1 = 0 - 1km; 2 = 1 - 2 km)	unitless
Site Layout	EcoRingNumHab	number of habitats contained within each eco ring	unitless
Site Layout	FarmAquIndex	well index associated with each farm	
Site Layout	FarmAquWellFrac	fraction farm uses aquifer well as animal DW source	fraction
Site Layout	FarmAquWellIndex	well index associated with each farm	
Site Layout	FarmArea	area of farm	m^2
Site Layout	FarmBlockGroup	census block group associated with farm	unitless
Site Layout	FarmLWSIndex	index of local watersheds associated with each farm	not applicable
Site Layout	FarmLWSSubAreaFrac	fraction of local watershed subarea on farm	fraction
Site Layout	FarmLWSSubAreaIndex	indices of each local watershed on farm	not applicable
Site Layout	FarmNumAquWell	number of wells in each aquifer on farm (= 1)	
Site Layout	FarmNumLWS	number of local watersheds on farm	
Site Layout	FarmNumLWSSubArea	number of local watershed subareas on farm	not applicable
Site Layout	FarmNumWBNRch	number of WBN reach that impact farm or crop area	
Site Layout	FarmNumWSSub	number of watersheds per farm	unitless
Site Layout	FarmPh	pH (subsoil)	pH units
Site Layout	FarmPopulation	population of a farm	unitless

(continued)

Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Site Layout	FarmTemp	average farm food chain temperature	° Celsius
Site Layout	FarmWBNIndex	selected WBN associated with each farm	
Site Layout	FarmWBNRchFrac	fraction of farm or crop area impacted by WBN reach	fraction
Site Layout	FarmWBNRchIndex	selected WBNRch associated with each farm	
Site Layout	FarmWSSubFrac	fraction of each watershed on farm	unitless
Site Layout	FarmWSSubIndex	watershed indices associated with each farm	not applicable
Site Layout	focS	fraction organic carbon (surface soil)	mass fraction
Site Layout	HabArea	area of habitat	m^2
Site Layout	HabIndex	index of habitat type	unitless
Site Layout	HabNumRange	number of ranges per habitat	unitless
Site Layout	HabNumWBNRch	number of WBN reaches that impact habitat range	unitless
Site Layout	HabRangeAreaFrac	fraction of range that falls within habitat	fraction
Site Layout	HabRangeFishWBNIndex	index of WBN containing fishable reaches that impact habitat range	unitless
Site Layout	HabRangeLWSIndex	indices of local watersheds in a habitat range	unitless
Site Layout	HabRangeLWSSubAFrac	fraction of LWS subarea within a habitat range	fraction
Site Layout	HabRangeLWSSubAIndex	index of LWS subarea in a habitat range	unitless
Site Layout	HabRangeNumLWSSubA	number of local watershed subareas in a habitat range	unitless
Site Layout	HabRangeNumSISrc	number of surface impoundments intersecting habitat range	unitless
Site Layout	HabRangeNumWBNRch	number of WBN reaches found within habitat range	unitless
Site Layout	HabRangeNumWSSub	number of watersheds that impact habitat range	unitless
Site Layout	HabRangeRecIndex	receptor index associated with each habitat range (a single receptor)	unitless
Site Layout	HabRangeWBNIndex	index of WBN that impacts habitat range	unitless
Site Layout	HabRangeWBNRchIndex	Index of WBN reaches that impact habitat range	unitless
Site Layout	HabRangeWSSubFrac	fraction of habitat range impacted by watershed	fraction
Site Layout	HabRangeWSSubIndex	index of watershed that impacts habitat range	unitless
Site Layout	HabType	type of representative habitat (e.g., grassland, pond, wetland)	Not applicable
Site Layout	HabWBNIndex	index of WBN that impacts habitat range	unitless
Site Layout	HabWBNRchFrac	fraction of habitat range impacted by aquatic	fraction
Site Layout	HabWBNRchIndex	index of WBN reaches that impact habitat	unitless

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Site Layout	HRangeFishWBNRchIn de	index of WBN fishable reaches that impact habitat range	unitless
Site Layout	HRangeNumFishWBNR ch	number of fishable reaches that cross habitat range	unitless
Site Layout	HumRcpAquIndex	well index associated with each farm	unitless
Site Layout	HumRcpAquWellFrac	fraction of population drinking from wells	
Site Layout	HumRcpAquWellIndex	well index associated with a human receptor point	unitless
Site Layout	HumRcpLWSIndex	local watershed indices for each human receptor point	not applicable
Site Layout	HumRcpLWSSubAreaIn de	LWS subarea indices for each human receptor point	not applicable
Site Layout	HumRcpPopulation	population represented by a human receptor point	unitless
Site Layout	HumRcpWSSubIndex	watershed indices for each human receptor point	not applicable
Site Layout	HydroGroup	hydrologic soil group	
Site Layout	HydrologicRegion	hydrologic regions	
Site Layout	MaxSrcArea	maximum tank area (= SI SrcArea for AT, null for other sources)	m^2
Site Layout	MetSta	National Weather Service station number (surface)	
Site Layout	NumAqu	number of aquifers	
Site Layout	NumAquWell	number of wells in an aquifer	
Site Layout	NumFarm	number of farms at site	
Site Layout	NumHab	number of ecological habitats	unitless
Site Layout	NumHabType	number of habitat types represented at the site	unitless
Site Layout	NumHumRcp	number of human receptor points	unitless
Site Layout	NumVad	number of vadose zones	
Site Layout	NumWBN	number of waterbody networks	
Site Layout	NumWSSub	number of watershed subbasins	
Site Layout	RingFarmFrac	fraction of a farm in a ring	fraction
Site Layout	RingFarmIndex	index of a farm in a ring	unitless
Site Layout	RingHumRcpIndex	index of a human receptor point in a ring	unitless
Site Layout	RingNumFarm	number of farms in a ring	unitless
Site Layout	RingNumHumRcp	number of human receptor points in a ring	unitless
Site Layout	SettingID	setting ID (SrcType+SiteID)	
Site Layout	SiteGeoRefX	Easting in UTM coordinates (facility centroid)	m
Site Layout	SiteGeoRefY	Northing in UTM coordinates (facility centroid)	m
Site Layout	SiteLatitude	latitude (source)	degrees
Site Layout	SiteLongitude	longitude (source)	degrees
Site Layout	SiteUTMZone	UTM zone of SiteGeoRefX and SiteGeoRefY	
Site Layout	SoilType	soil texture (subsoil)	

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Site Layout	SrcArea	area of source	m^2
Site Layout	SrcDepth	depth of source (0 for AT, WP)	m
Site Layout	SrcId	environmental setting ID for source	
Site Layout	SrcLocX	WMU Easting in site coordinate system (0)	m
Site Layout	SrcLocY	WMU Northing in site coordinate system (0)	m
Site Layout	SrcLWSNumSubArea	number of local watershed subareas	
Site Layout	SrcLWSSubAreaArea	area of LWS subarea	m^2
Site Layout	SrcLWSSubAreaIndex	local watershed subarea containing WMU	unitless
Site Layout	SrcNumLWS	number of local watersheds	
Site Layout	SrcTemp	average waste/source temperature	° Celsius
Site Layout	SrcType	WMU type (AT, SI, LAU, WP, or LF)	
Site Layout	VadALPHA	soil moisture parameter alpha (subsoil)	1/cm
Site Layout	VadBETA	soil moisture parameter beta (subsoil)	unitless
Site Layout	VadId	environmental setting ID for aquifer	
Site Layout	VadLWSIndex	LWS index for vadose zone	
Site Layout	VadPh	pH (subsoil)	pH units
Site Layout	VadSATK	saturated hydraulic conductivity (subsoil)	cm/h
Site Layout	VadSoilType	soil type/texture (subsoil)	
Site Layout	VadTemp	soil column temperature (annual average)	° Celsius
Site Layout	VadWCR	residual water content (subsoil)	L/L
Site Layout	VadWCS	saturated water content (subsoil)	L/L
Site Layout	WBNDOC	dissolved organic carbon (stream, lake, wetland)	mg/L
Site Layout	WBNFishableRchIndex	index of reaches that are fishable	unitless
Site Layout	WBNId	environmental setting id of waterbody network	
Site Layout	WBNNumFishableRch	number of fishable reaches	unitless
Site Layout	WBNNumRch	number of reaches in waterbody network	
Site Layout	WBNpH	pH of stream, lake, and wetland reaches in waterbody network	pH units
Site Layout	WBNRchAquFrac	fraction of waterbody network reach impacted by the aquifer	fraction
Site Layout	WBNRchAquIndex	index of aquifer that impacts waterbody network reach	
Site Layout	WBNRchArea	reach surface area (nonstream reaches)	m^2
Site Layout	WBNRchBodyType	type of waterbody for each reach (lake, stream or wetland)	
Site Layout	WBNRchHypoAreaFrac	fraction of total surface area for hypolimnion	fraction
Site Layout	WBNRchLength	waterbody reach length	m
Site Layout	WBNRchNumAqu	number of aquifers that impact waterbody reach	
Site Layout	WBNRchNumRch	number of waterbody reaches that impact waterbody reach	

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Site Layout	WBNRchNumWSSub	number of watershed subasins that impact waterbody network reach	
Site Layout	WBNRchOrder	stream order	unitless
Site Layout	WBNRchRchFrac	fraction of waterbody network reach impacted by another waterbody network reach	fraction
Site Layout	WBNRchRchIndex	index of waterbody network reach that impacts waterbody network reach	
Site Layout	WBNRchSrcLWSFrac	fraction of waterbody network reach area impacted by the source local watershed	fraction
Site Layout	WBNRchSrcLWSIndex	index of local watershed from source	
Site Layout	WBNRchType	type of waterbody network reach; selected from (headwater, exiting or other)	
Site Layout	WBNRchWSSubFrac	fraction of watershed subbasin impacting waterbody network reach	fraction
Site Layout	WBNRchWSSubIndex	index of watershed subbasin that impacts waterbody network reach	
Site Layout	WBNTemp	median temperature of stream, lake, and wetland reaches in waterbody network	° Celsius
Site Layout	WBNTempMax	maximum temperature of stream, lake, and wetland reaches in waterbody network	° Celsius
Site Layout	WBNTOC	TOC of stream, lake, and wetland reaches in waterbody network	mg/L
Site Layout	WBNTSS	TSS of stream, lake, and wetland reaches in waterbody network	mg/L
Site Layout	WBNWaterHardness	water hardness	mg $CaCO_3$ eq/L
Site Layout	WSPh	pH (subsoil)	pH units
Site Layout	WSSubArea	area (watershed subarea j)	m^2
Site Layout	WSSubNumSubArea	number of watershed subbasin subareas (= 1)	
Site Layout	WSTemp	average watershed temperature	° Celsius
Surface water	d_epil	epilimnion depth	m
Surface water	d_hypol	hypolimnion depth	m
Surface water	d_pond	depth of pond	m
Surface water	d_wtlnd	depth of wetland	m
Surface water	Q_upstream	upstream flow rate	m^3/day
Vadose zone	POM	percentage organic matter	g/g
Vadose zone	RHOB	dry bulk density (subsoil)	g/cm^3
Watershed	C	USLE cover factor	unitless
Watershed	CN	SCS curve number	unitless
Watershed	DRZ	depth (root zone)	cm
Watershed	HydroGroup	hydrologic soil group	
Watershed	K	USLE erodibility factor	kg/m^2

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Table 1B-3. (continued)

Data Group	Variable Name	Description	Units
Watershed	Ksat	saturated hydraulic conductivity (surface soil)	cm/h
Watershed	P	USLE erosion control factor	unitless
Watershed	SMb	soil moisture coefficient b (surface soil)	unitless
Watershed	SMFC	field capacity	volume %
Watershed	SMWP	wilting point	volume %
Watershed	Theta	slope (watershed)	degrees
Watershed	WCS	saturated water content (surface soil)	volume fraction
Watershed	X	flow length (watershed)	m
WP	C	USLE cover factor	unitless
WP	CN	SCS curve number	unitless
WP	CNwmu	SCS curve number (WMU)	unitless
WP	DRZ	depth (root zone)	cm
WP	focS	fraction organic carbon (surface soil)	mass fraction
WP	HydroGroup	hydrologic soil group	
WP	K	USLE erodibility factor	kg/m^2
WP	Ksat	saturated hydraulic conductivity (surface soil)	cm/h
WP	Kwmu	USLE erodibility factor (WMU)	kg/m^2
WP	load	waste loading rate (dry)	Mg/yr
WP	mt	distance vehicle travels on WP surface	m
WP	Nop	spreading/compacting operations per day	1/d
WP	nv	vehicles/day (mean annual)	1/d
WP	nw	wheels per vehicle (mean)	unitless
WP	P	USLE erosion control factor	unitless
WP	SMb	soil moisture coefficient b (surface soil)	unitless
WP	SMFC	field capacity	volume %
WP	SMWP	wilting point	volume %
WP	Theta	slope (local watershed)	degrees
WP	vw	vehicle weight (mean)	Mg
WP	WCS	saturated water content (surface soil)	volume fraction
WP	X	flow length (local watershed, all subareas)	m
WP	zZ1WMU	height (WP)	m