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 the possible exposure and risk to human and ecological receptors due to the release of hazardous contaminants from the management of solid wastes.

This document is the third 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 describes the data developed and used to run the 3MRA modeling system.
- Volume III describes the verification and validation activities and peer reviews to ensure quality of the modeling system, modules, and data;
- Volume IV provides a discussion of uncertainty and sensitivity.

The rest of this section includes a brief description of the 3MRA modeling system development process, an overview of the 3MRA modeling system, and the organization of the rest of this volume.

1.1 3MRA Modeling System Development

EPA's 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 (legacy) models where appropriate, thus relying on the science behind them and the level of acceptance associated with their previous use. The following legacy 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 Transformation Products (EPACMTP) (U.S. EPA, 1996a,b,c, 1997a)

for waste constituent subsurface fate and transport; and EPA's Exposure Analysis Modeling System II (EXAMS II) (Burns et al., 1982; Burns, 1997) for waste constituent surface water fate and 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 twenty-five independent software components developed by five 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; ensure that adequate test plans were developed; and oversee the testing, verification, and documentation of the modules. All modules (legacy as well as new modules) were independently reviewed by external national experts. The core teams were assisted by experts from several nationally recognized organizations: Batelle Pacific Northwest National Lab (PNNL); HGL, Inc.; Research Triangle Institute (RTI); and TetraTech, Inc. For the sake of simplicity, this document attributes all model development, verification, and validation activities to "EPA" rather than specific EPA offices or contractors.

During the development of the 3MRA modeling system, EPA team was fully aware of the real world limitations that apply to validating the 3MRA modeling system The 3MRA modeling system team carried out several activities to ensure the quality fo the modules, data, and the modeling system. These activities included: peer review of the conceptual development plan (science plan containing the risk assessment strategy); use of legacy models; internal independent testing of the modules; external testing of the modules; peer reviews of modules; public comments on the beta version of the 3MRA modeling system and the model results. This volume briefly describe these activities which tend to increase the confidence in the system

1.2 Overview of the 3MRA Modeling System

The 3MRA modeling system was developed as a tool to provide risk assessment support for the evaluation of risks from the management of wastes in waste management systems (WMUs). The 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 developed 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 chemical constituents in waste undergoing a range of physical and biochemical processes. Because EPA needs to consider the impacts of a large number of chemicals, EPA requires a modeling tool that encompasses releases from WMUs to all media, subsequent fate and transport within those media, uptake in terrestrial and aquatic food webs, and the potential exposure of specific human and ecosystem receptors to the chemical constituents and contaminated food items.

The 3MRA modeling system was designed to estimate national distributions of human and ecological risks resulting from long-term (chronic) chemical constituent release from land-based and WMUs using a site-based approach. The national distribution of risks is constructed

by performing "site-based" assessments at a statistically significant number of randomly selected industrial waste site locations across the United States. The 3MRA framework (US EPA, 1999a) employs 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 chemical constituent 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., hydrogeological conditions and the 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 shown 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, as shown 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 the execution of all of the science modules linked together to predict the 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 incorporate Monte Carlo simulation methods to address both uncertainty and variability in the risk outputs. 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 Organization of This Document

The 3MRA modeling system comprises an overall system, 17 separate science modules, processors, and several databases. Figure 1-3 provides a guide to the organization of this document. Section 2 provides an overview of the verification and validation of 3MRA modeling

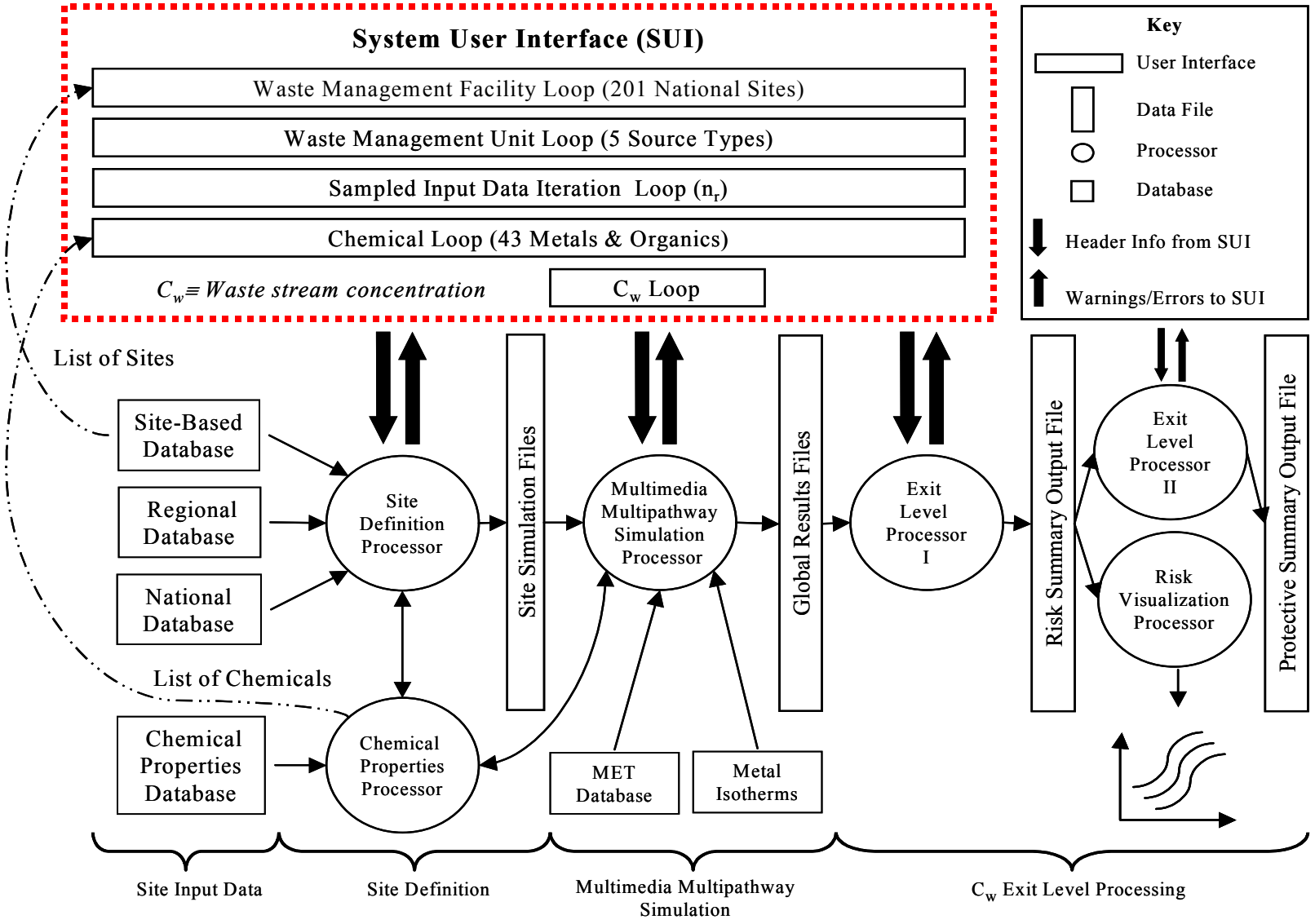
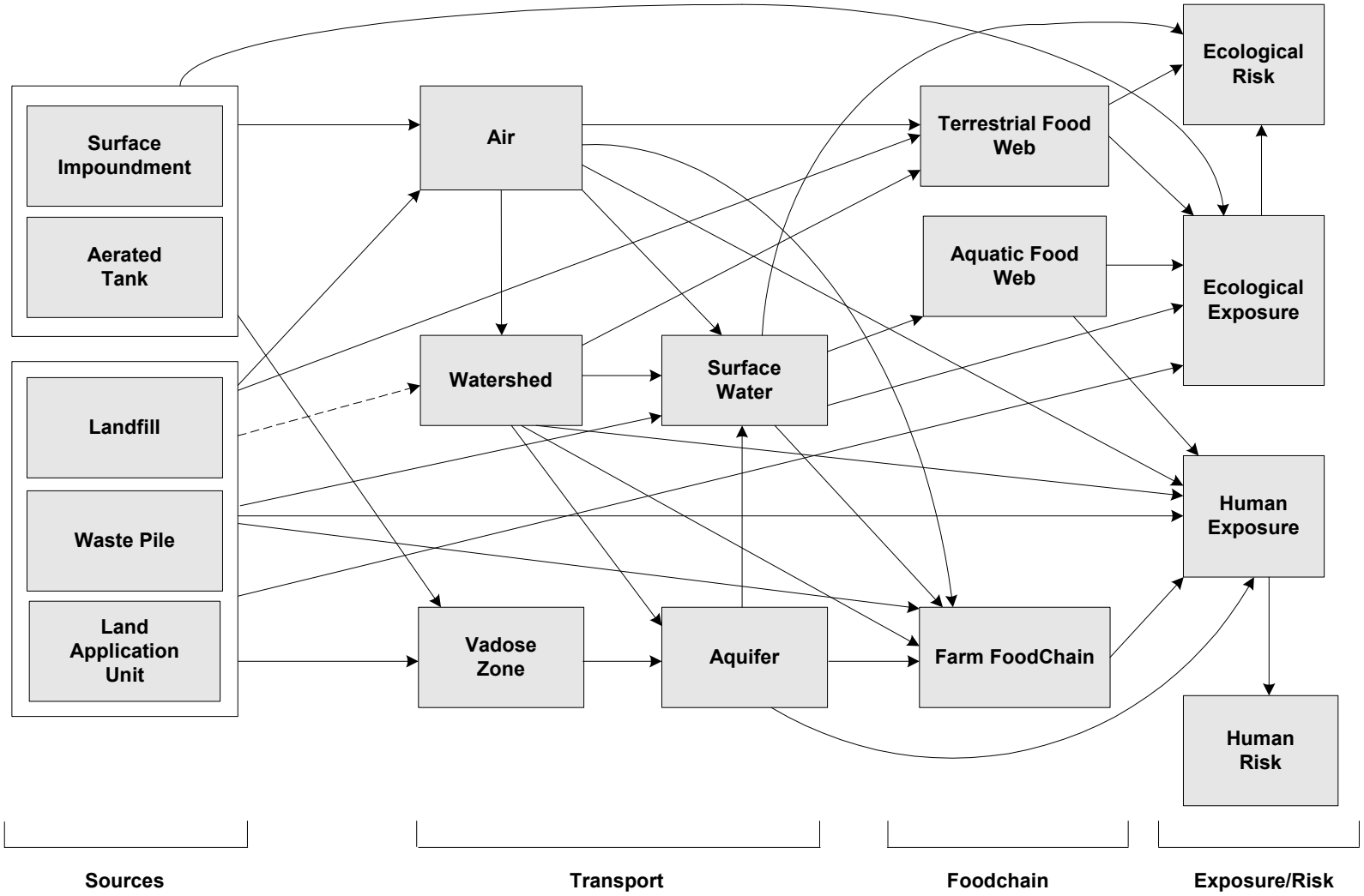


Figure 1-1. 3MRA modeling system design.



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.

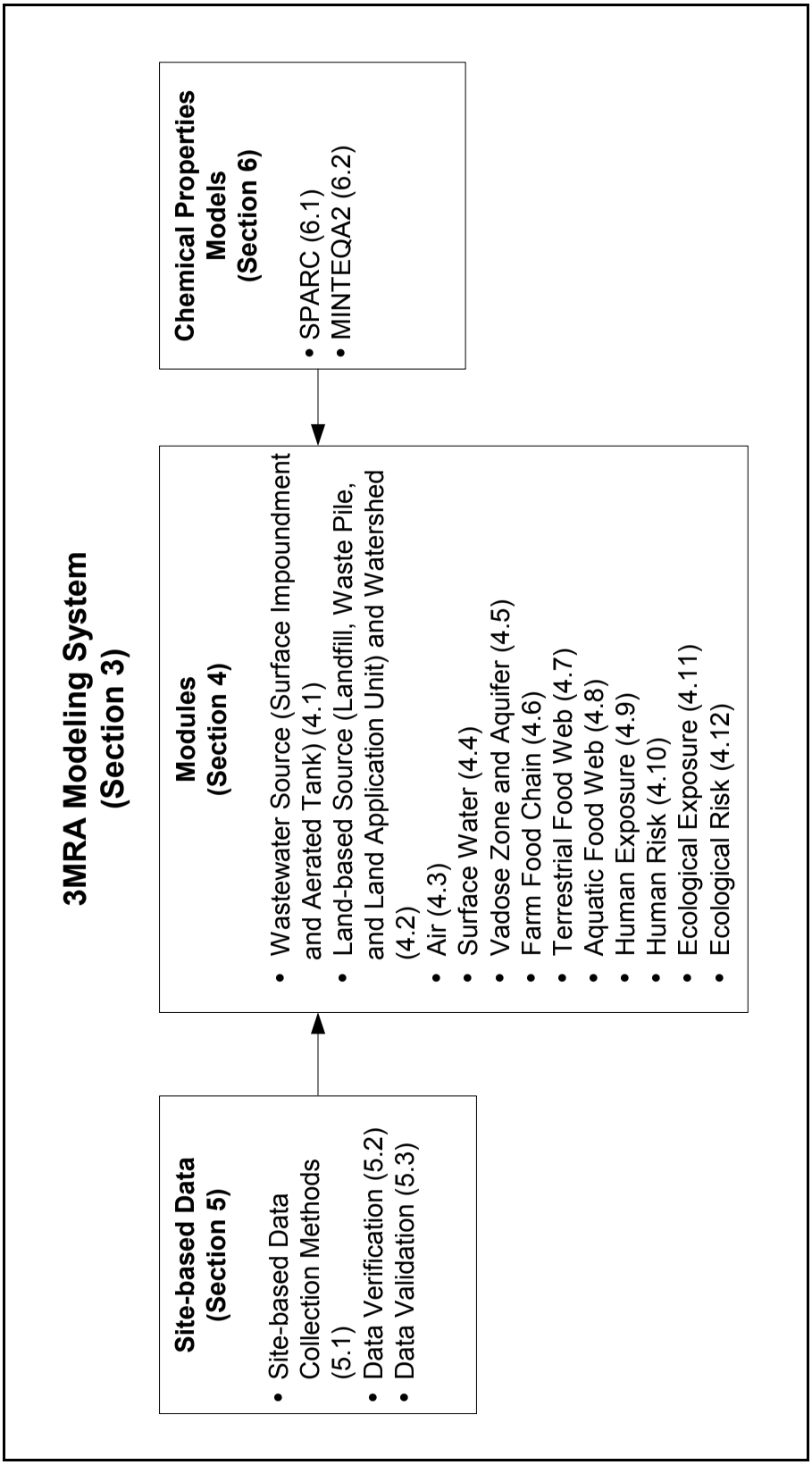


Figure 1-3. Organization of the 3MRA modeling system and this document.

system (including system, modules, and data). Section 3 describes the verification and validation of the modeling system. Section 4 describes verification and validation of the component modules. Section 5 describes the verification and validation of the site-based data in the representative national data set included in the 3MRA modeling system. Section 6 describes the verification and validation of the models (SPARC and MINTEQ) used to develop some of the chemical properties. Section 7 summarizes the results of the model evaluation process. Section 8 provides references cited in this document.