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Industrial Waste Management Evaluation Model (IWEM) User's Guide

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Industrial Waste Management Evaluation Model (IWEM) User's Guide

Office of Solid Waste and Emergency Response (5305W)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., N.W.
Washington, DC 20460

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FORMAT AND NOTATION

The main font for this document is 12-point *Times New Roman* font. The IWEM command buttons, icons, menu items and other action-controls are shown in 11-point *Arial Narrow* font, with small capitals style and with vertical bars at the beginning and end; for example, |FILE| and |EVALUATION| are two of the menu items contained in the IWEM menu bar. When referring to a sequential series of menu selections, such as "click on File, then click on Open," this sequence of keystrokes is presented as |FILE|OPEN|.

IWEM screen and dialog box titles are presented in underlined text; user-entry labels are using the same format as IWEM menu items and other action-controls; and references to user-supplied text are shown in 12-point *Courier* font. For example, the user could provide `Rodney's Waste Dump` as *Facility Name* in screen Tier 2 Input: WMU Type (17).

The IWEM software is organized into screens and dialog boxes and, for easy reference, these components are labeled using a common numbering scheme. Within the main IWEM program window, there are a number of screens that are displayed one at a time as you move through an IWEM analysis. Each of these screens has a title that tells you what part of the IWEM software you are in; if the IWEM screen is stretched to fill the IWEM program window, then the title bar containing these titles is located directly beneath the IWEM toolbar. Additionally, within some of these screens there are several tabbed screens that resemble tabbed file folders. Each of these tabbed screens has a title (placed on the screen itself) that tells you more specifically what type of information is being requested or displayed on the screen. We refer to all screens and tabbed screens in this document simply as screens. Finally, when you use certain options on the Infiltration (19) and Constituent List (20) screens, dialog boxes are displayed to allow entry of additional information. Each of these dialog boxes has a title (placed on the title bar at the top of the dialog box) that identifies the type of information requested.

Although there are other ways to navigate through the IWEM software, it is anticipated that most users will generally start at the beginning of a Tier 1 or Tier 2 analysis and then move through the screens sequentially using the |NEXT| and |BACK| buttons. In order to facilitate the reporting of user comments and problems, EPA has organized all IWEM components into one common sequential numbering scheme according to the order in which they would be displayed in a typical analysis. Hence, a first-time IWEM Tier 1 user will see the following sequence screens:

- Introductory Screens (screens 1 through 5)
- Tier 1 Input screen group (tabbed screens 6 through 8)

- Tier 1 Results screen group (tabbed screens 9 through 13)
- Tier 1 Evaluation Summary Screen (screen 14)

Similarly, a Tier 2 user will typically see the following sequence of screens and dialog boxes (however, there are some slight differences in this sequence depending upon the WMU type and infiltration option chosen by the user):

- Tier 2 input screen group (tabbed screens 16 through 23, including dialog box 19a that is associated with tabbed screen 19 and dialog boxes 20a to 20d that are associated with tabbed screen 20)
- EPACMTP Run Manager located on the Tier 2 Evaluation Screen (screen 24)
- Tier 2 Output tabs (tabbed screens 25 through 28)
- Tier 2 Evaluation Summary Screen (screen 29)

Please note that the screenshots presented in this *User's Guide* were captured using the following settings to ensure maximum legibility:

- monitor set to 800 x 600 resolution
- large system font
- IWEM program window (parent window) maximized
- IWEM (tabbed) screen (child window) enlarged to its fullest extent

If you use other settings while running IWEM, you may need to use the sliders that appear as necessary on the right and bottom edge of the IWEM windows in order to see the entire screen.

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ACRONYMS AND ABBREVIATIONS

CAS Number	Chemical Abstract Service Registry Number
cm/sec	centimeters per second
CSF	Cancer Slope Factor
DAF	Dilution and Attenuation Factor
EPA	Environmental Protection Agency
EPACMTP	EPA's Composite Model for Leachate Migration with Transformation Products
GUI	Graphical User Interface
Guide	Guide for Industrial Waste Management
HBN	Health-Based Number
HELP	Hydrologic Evaluation of Landfill Performance
HQ	Hazard Quotient
IWEM	Industrial Waste Management Evaluation Model
k_d	Soil - Water Partition Coefficient
K_{oc}	Organic Carbon Partition Coefficient
LAU	Land Application Unit (also called a Land Treatment Unit)
LCTV	Leachate Concentration Threshold Value
LF	Landfill
MB	megabyte
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/L	milligrams per liter
MINTEQA2	EPA's geochemical equilibrium speciation model for dilute aqueous systems
MS	Microsoft™
NPDWR	National Primary Drinking Water Regulation
OSW	EPA's Office of Solid Waste

ACRONYMS AND ABBREVIATIONS (continued)

RAM	Random Access Memory
RCRA	Resource Conservation and Recovery Act
RGC	Reference Ground-Water Concentration
SI	Surface Impoundment
SPLP	Synthetic Precipitation Leaching Procedure
STORET	EPA's Data Storage and Retrieval System, National Water Quality Database
TC Rule	Toxicity Characteristic Rule
TCLP	Toxicity Characteristic Leaching Procedure
U.S. EPA	United States Environmental Protection Agency
WMU	Waste Management Unit
WP	Waste Pile

1.0 Introduction

This document describes how to use the Industrial Waste Management Evaluation Model (IWEM). IWEM is the ground-water modeling component of the *Guide for Industrial Waste Management* (***Guide***) (U.S. EPA, 2002d), which has been developed by the U.S. Environmental Protection Agency's (EPA's) Office of Solid Waste (OSW) for the management of non-hazardous industrial wastes. A companion document, the *Industrial Waste Management Evaluation Model Technical Background Document* (U.S. EPA, 2002c), provides technical background information. It is strongly recommended that you take the time to understand the technical background of IWEM in order to make the best use of this program. This section of the *User's Guide* provides an overview of IWEM and its purpose, operation, and application; describes the major components of the system; and provides an overview of how the remainder of the document is organized.

1.1 Guide for Industrial Waste Management

The EPA and representatives from 12 state environmental agencies have developed a voluntary ***Guide*** (U.S. EPA, 2002d) to recommend a baseline of protective design and operating practices to manage nonhazardous industrial wastes throughout the country. The guidance was designed for facility managers, regulatory agency staff, and the public, and it reflects four underlying objectives:

- Adopt a multimedia approach to protect human health and the environment;
- Tailor management practices to risk using the innovative, user-friendly modeling software provided in the ***Guide****;*
- Affirm state and tribal leadership in ensuring protective industrial waste management, and use the ***Guide*** to complement state and tribal programs; and
- Foster partnerships among facility managers, the public, and regulatory agencies.

The ***Guide*** recommends best management practices and key factors to consider to protect ground water, surface water, and ambient air quality in siting, designing and operating waste management units (WMUs); monitoring WMUs' impact on the environment; determining necessary corrective action; closing WMUs; and providing post-closure care. In particular, the guidance recommends risk-based approaches to choosing liner systems and waste application rates for ground-water protection and to evaluate the need for air controls. The CD-ROM version of the ***Guide*** includes user-friendly air and ground-water models to conduct these risk evaluations. The IWEM software described in this *User's Guide* is the ground-water model that was developed to support the ***Guide***.

1.2 The IWEM Software

The IWEM software is designed to assist you in determining the most appropriate WMU design to minimize or avoid adverse ground-water impacts, by evaluating types of liners, the hydrogeologic conditions of the site, and the toxicity and expected leachate concentrations of the anticipated waste constituents. That is, this software helps you compare the ground-water protection afforded by various liner systems with the anticipated waste leachate concentrations, so that you can determine what minimum liner system is needed to be protective of human health and ground-water resources (or in the case of land application units (LAUs), determine whether or not land application is recommended).

The anticipated users of the IWEM computer program are managers of proposed or existing units, state regulators, interested private citizens, and community groups. For example:

- **Managers of a proposed unit** could use the software to determine what type of liner would be appropriate for the particular type of waste that is expected at the WMU and the particular hydrogeologic characteristics of the site.

- **Managers of an existing unit** could use the software to determine whether or not to accept a particular waste at that WMU by evaluating the performance of the existing liner design.

- **State regulators** may wish to use the software in developing permit conditions for a WMU.

- **Interested members of the public or community groups** may wish to use the software to evaluate a particular WMU and participate during the permitting process.

In an effort to meet the needs of various stakeholders, the guidance for the ground-water pathway uses a tiered approach that is based on modeling the fate and transport of waste constituents through subsurface soils and ground water to a well[1] to produce a liner recommendation (or a recommendation concerning land application) that protects human health and the environment. The successive tiers in the analysis incorporate increasing amount of site-specific data to tailor protective management practices to the particular circumstances at the modeled site:

- **Tier 1**: A screening analysis based upon national distributions of data;
- **Tier 2**: A location-adjusted analysis using a limited set of the most sensitive waste- and site-specific data; and
- **Tier 3**: A comprehensive and detailed site assessment.

The IWEM software is designed to support the Tier 1 and Tier 2 analyses. The unique aspect of the IWEM software is that it allows the user to perform Tier 1 and Tier 2 analyses and obtain liner recommendations with minimal data requirements. Users interested in a Tier 3 analysis should consult the ***Guide*** for information regarding the selection of an appropriate ground-water fate and transport model.

1.3 Objectives

The objective of this *User's Guide* is to provide the information necessary to perform Tier 1 and Tier 2 analyses for four types of WMUs:

- **Landfills (LFs);**
- **Waste Piles (WPs);**
- **Surface Impoundments (SIs);** and
- **Land Application Units (LAUs)** (which are also called Land Treatment Units).

This *User's Guide* is organized as follows:

- <u>Section 2</u> provides an overview of the IWEM software;
- <u>Section 3</u> summarizes the computer system requirements for the IWEM software;
- <u>Section 4</u> provides instructions for installing the IWEM software;
- <u>Section 5</u> provides detailed instructions on how to run the IWEM software, and guides you step-by-step through Tier 1 and Tier 2 evaluations;

[1] In IWEM, the term "well" is used to represent an actual or hypothetical ground-water monitoring well or drinking water well, downgradient from a WMU.

- Section 6 presents background information to assist in understanding the Tier 1 and Tier 2 input values; how they affect the model evaluation; and how to obtain input values for a Tier 2 evaluation;
- Section 7 presents background information to assist in understanding the Tier 1 and Tier 2 IWEM results;
- Section 8 provides troubleshooting information for some commonly encountered problems;
- Section 9 lists all references cited;
- Appendix A presents the list of waste constituents included in IWEM; and
- Appendix B presents the Tier 1 and Tier 2 reports for the example evaluations presented in this document.

If you have a copy of the CD, you can open and read this *User's Guide* on-screen while the IWEM software is running on your computer. You may, however, find it easier to use IWEM's online help or to print out a copy of the *User's Guide* and refer to this hard copy while you are using the software.

2.0 IWEM Overview

The IWEM software developed by the EPA provides a two-tiered analysis that requires a minimum of data. The analysis produces recommendations for the type of liner to be used in a WMU and/or whether land application is appropriate. The two-tiered analysis is presented within a user-friendly, Windows-based program called IWEM. IWEM will operate on any standard personal computer using Windows™ 95 or later operating system (see Section 3.0 for system requirements). A brief overview of IWEM is provided in the remainder of Section 2.0.

2.1 What does the software do?

The IWEM software is designed to assist you in determining a recommended liner design for different types of Resource Conservation and Recovery Act (RCRA) Subtitle D (non-hazardous) WMUs. IWEM compares the expected leachate concentration[2] entered by the user for each waste constituent with the leachate concentration threshold value (LCTVs)[3] calculated by a ground-water fate and transport model for three standard liner types[4].

The IWEM software compiles the results for all constituents expected in the leachate and then reports the minimum liner scenario that is protective for all constituents. Table 2.1 shows the combinations of WMUs and liners that are represented in IWEM. For LAUs, only the *no-liner* scenario is evaluated because liners are not typically used at this type of facility.

The IWEM software supports file saving and retrieval so that evaluations can be archived or retrieved later and modified. The software also has report generation capabilities to document in hard-copy the input values and resulting liner recommendations.

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[2] The expected leachate concentration means the concentration, in milligrams per liter (mg/L), of each constituent of concern that is expected to be present in the leachate after emplacement of the waste in a WMU. Typically this concentration is measured using a laboratory leachate test. Chapter 2 (Characterizing Waste) of the ***Guide*** provides more information on selecting a leachate test.

[3] The LCTV represents the maximum allowable leachate concentration that is protective of ground water; if the expected leachate concentrations of all constituents are less than their LCTVs for a particular waste management scenario, then we recommend you select that WMU design to manage that particular waste.

[4] The three liner designs in IWEM are: no liner, single clay liner, and composite liner (see Table 2.1).

Table 2.1 IWEM WMU and Liner Combinations

WMU Type	Liner Type: No Liner (in-situ soil)	Liner Type: Single Clay Liner	Liner Type: Composite Liner
Landfill	✔	✔	✔
Surface Impoundment	✔	✔	✔
Waste Pile	✔	✔	✔
Land Application Unit	✔	N/A	N/A

N/A = Not applicable

2.1.1 Tier 1 Evaluation

In a Tier 1 evaluation, the required inputs are the WMU type you wish to evaluate, constituents of concern, and the expected leachate concentration for each constituent of concern. After providing these inputs, IWEM determines a minimum recommended liner design that is protective for all waste constituents. This determination is made by comparing the expected leachate concentration for each constituent to tabulated values of liner- and constituent-specific LCTVs, and identifying for which liner designs the LCTV of each constituent is equal to, or greater than the input value of expected leachate concentration. IWEM incorporates LCTV values for 206 organic and 20 metal constituents (see Appendix A) that are part of the software's built-in database. These LCTVs were generated by running **EPA**'s **C**omposite **M**odel for Leachate Migration with **T**ransformation **P**roducts (EPACMTP, described in Section 2.2.2 below) for a wide range of site conditions expected to occur at waste sites across the United States.

The process used to simulate varying site conditions is known as *Monte Carlo analysis*. The Monte Carlo analysis determines the statistical probability that the release of leachate would result in a ground-water

About Monte Carlo Analysis:

Monte Carlo analysis is a computer-based method of analysis developed in the 1940's that uses statistical sampling techniques to obtain a probabilistic approximation to the solution of a mathematical equation or model. The name refers to the city on the French Riviera that is known for its gambling and other games of chance. Monte Carlo analysis is increasingly used in risk assessments where it allows the risk manager to make decisions based on a statistical level of protection that reflects the variability and/or uncertainty in risk parameters or processes, rather than making decisions based on a single point estimate of risk. For further information on Monte Carlo analysis in risk assessment, see the EPA's *Guiding Principles for Monte Carlo Analysis* (U.S. EPA, 1997).

concentration exceeding regulatory or risk-based standards. The Tier 1 LCTVs, are designed to be protective with 90% certainty for possible waste sites in the United States.

The advantages of a Tier 1 evaluation are that it is fast and does not require site-specific information. Tier 1 is designed to be a screening analysis that is protective for most sites. This means that a Tier 1 analysis may result in a liner recommendation that is more stringent - - and costly to implement - - than is needed for a particular site. For instance, site-specific conditions such as low precipitation and a deep unsaturated zone may warrant a less stringent liner design.

2.1.2 Tier 2 Evaluation

A Tier 2 evaluation utilizes information on the unit's location and other site-specific data enabling you to perform a more precise assessment. If appropriate for site conditions (*e.g.*, an arid climate), it may allow you to avoid constructing an unnecessarily costly WMU design. It may also provide an additional level of certainty that liner designs are protective of sites in vulnerable settings, such as areas with high rainfall and shallow ground water.

To perform Tier 2 evaluations, IWEM runs a complete EPACMTP fate and transport simulation using site-specific input data, and generates a probability distribution of expected ground-water well concentrations for each waste constituent and liner scenario. It then compares the 90th percentile of the modeled ground-water well concentration to a reference ground-water concentration (RGC[5]) value (for instance, a regulatory maximum contaminant level (MCL)) until it has identified the liner design for which the 90th percentile of the expected ground-water concentration does not exceed the RGC.

IWEM is designed to allow Tier 2 evaluations with varying levels of available site-specific information and data. IWEM allows you to provide site-specific values for the most important modeling parameters, but if you have limited site data available, IWEM will use default values or distributions for parameters for which you have no data. IWEM will also assist you in making the most appropriate use of the information you have available. For instance, if you know that a site has an alluvial aquifer, but you do not have site-specific values for ground-water parameters such as hydraulic conductivity, IWEM will assign representative values for alluvial aquifers from its extensive built-in database of ground-water modeling parameters.

[5] See Section 6.1.4 (page 6-4) for a definition of RGC.

Tier 2 users can perform an evaluation for any of the waste constituents that are included in Tier 1; Tier 2 users also have the option to include additional waste constituent(s) and/or modify constituent properties in the default database. Specifically, you can provide constituent-specific soil - water partition coefficient (k_d) and degradation (λ) coefficients, and a user-defined RGC and exposure duration.

In many cases, a Tier 2 evaluation will allow a less stringent and less costly liner design than the Tier 1 screening analysis will allow. If a site is vulnerable to ground-water contamination, a Tier 2 analysis will allow you to determine appropriate waste management options and liner designs with greater confidence than a Tier 1 analysis. Chapter 4 of the ***Guide*** discusses siting considerations for WMUs, including how to recognize a vulnerable hydrogeological setting. The trade-off in performing a Tier 2 evaluation is that the fate and transport simulations are computationally demanding and can take hours to complete, even with a very fast personal computer. The reason is that the Tier 2 model simulations incorporate Monte Carlo analysis to handle the uncertainty associated with default values and other modeling parameters that are not user-specified.

2.1.3 Tier 3 Evaluation vs IWEM

If the IWEM Tier 1 and Tier 2 evaluations do not adequately simulate conditions at a proposed site because the hydrogeology of the site is complex, you may consider a comprehensive site-specific risk assessment. For example, if ground-water flow is subject to seasonal variations, performing a Tier 2 Evaluation in IWEM may not be appropriate because the model is based on steady-state flow conditions. A comprehensive site-specific ground-water fate and transport analysis may be required to evaluate risk to ground water and alternative liner designs or land application rates. This type of analysis is beyond the scope of IWEM. If appropriate, consult with your state agency and use a qualified professional, experienced in ground-water modeling. EPA recommends that you talk to state officials and/or appropriate trade associations to solicit recommendations

Why it is important to use a qualified professional?

- Fate and transport modeling can be very complex; appropriate training and experience are required to correctly use and interpret models.
- Incorrect fate and transport modeling can result in a liner system that is not sufficiently protective or an inappropriate land application rate.
- To avoid incorrect analyses, check to see if the professional has sufficient training and experience in analyzing ground-water flow and contaminant fate and transport.

for a good consultant to perform the analysis. For more details see Chapter 7A of the ***Guide***.

2.2 IWEM Software Components

The IWEM software consists of three main components (or modules): (*i*) a Graphical User Interface (GUI) which guides you through a series of user-friendly screens to perform Tier 1 and Tier 2 evaluations; (*ii*) the EPACMTP computational engine and integrated Monte Carlo processor that perform the ground-water fate and transport simulations for Tier 2 evaluations; and (*iii*) a series of databases of waste constituents, WMUs, and site-specific parameters. Each of these three components is discussed briefly in this section.

2.2.1 IWEM User Interface

When you use the IWEM software, you are interacting with the GUI module. This module consists of a series of data input and display screens, that enable you to define a Tier 1 and/or a Tier 2 evaluation; view and select parameter input values from IWEM's built-in database; enter your own site-specific data; and view the results of the IWEM evaluation. Figure 2.1 shows a sample IWEM user interface screen. A detailed description of each IWEM user interface screen is provided in Section 5 of this *User's Guide*.

If you are performing a Tier 1 evaluation, the software simply performs a table look-up of the Tier 1 LCTV tables that are built into the software for the WMU and waste constituent(s) you selected. Once you have specified all the Tier 1 data inputs, the results of the evaluation are instantaneously available for on-screen display or printing in a hard-copy report.

If you are performing a Tier 2 evaluation, the GUI will take you through a step-wise process of assembling the pertinent site-specific data. The GUI module also includes options to view and modify constituent-specific data, as well as add additional constituents to IWEM's constituent database. Once IWEM has gathered all your data, it will then run the EPACMTP model. Upon completion of the site-specific fate and transport simulations, IWEM will display the liner recommendation and generate a printed report if desired.

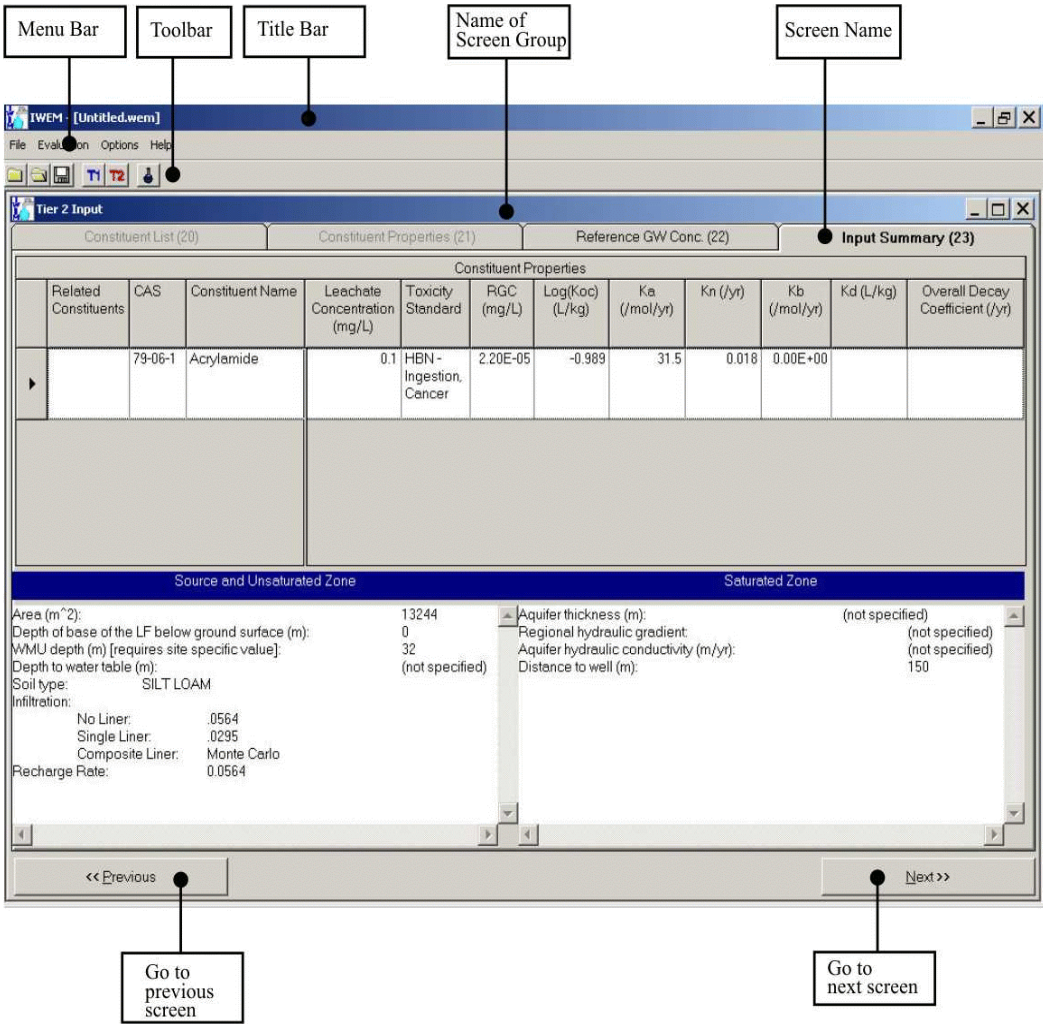


Figure 2.1 Sample IWEM Screen.

2.2.2 EPACMTP Fate and Transport Model

EPACMTP is a sophisticated fate and transport model that simulates the migration of waste constituents in leachate from land disposal units through soil and ground water. EPACMTP has been developed by EPA's OSW to support risk-based ground-water assessments under RCRA. EPACMTP has been applied to waste identification, hazardous waste listing and other regulatory evaluations. This *User's Guide* provides only a brief summary of the EPACMTP; a complete description of the model is provided in the *EPACMTP Technical Background Document* (U.S. EPA, 2002a). The *IWEM Technical Background Document* (U.S. EPA, 2002c) describes how we used EPACMTP to develop the Tier 1 and Tier 2 Evaluations in IWEM.

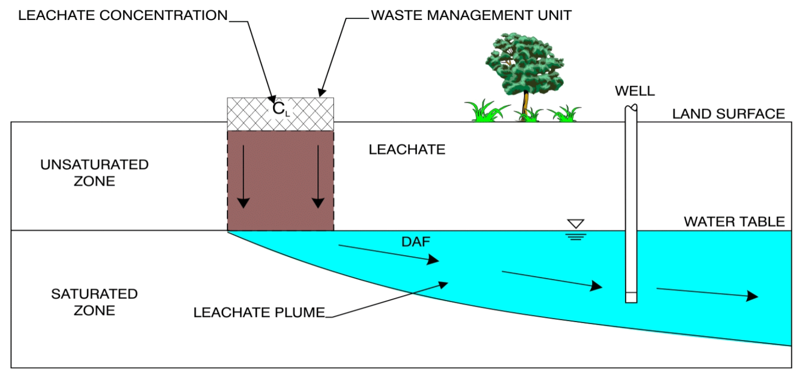


Figure 2.2 Conceptual View of Aquifer System Modeled by EPACMTP.

EPACMTP simulates fate and transport of constituents in both the unsaturated zone and the saturated zone. Figure 2.2 shows a conceptual, cross-sectional view of fate and transport modeled by EPACMTP. The source of constituents is a WMU located at or near the ground surface overlying an unconfined aquifer. Waste constituents leach from the base of the WMU into the underlying soil. They migrate vertically downward until they reach the water table. As the leachate enters the saturated zone, it will mix with ambient ground water (which is assumed to be free of pollutants) and a ground-water plume will develop that extends in the direction of downgradient ground-water flow. Although it is not shown in Figure 2.2, EPACMTP accounts for the spreading of the plume in all three dimensions.

Leachate generation is driven by the infiltration of precipitation that has percolated through the WMU into the soil. The type of liner at the base of the WMU affects the rate of infiltration that can occur and, hence, the release of leachate into the soil. EPACMTP models flow in the unsaturated zone and in the saturated zone as steady-state processes, that is, it models long-term average flow conditions. EPACMTP also simulates the ground-water mounding that may occur underneath a WMU with a high infiltration rate and its effect on ground-water flow. This may be significant, particularly in the case of unlined SIs. In cases of very high infiltration rates in settings with shallow ground water, EPACMTP may cap the infiltration rate to avoid having the modeled ground-water mound rise above the bottom of the WMU.

EPACMTP accounts for the dilution of the constituent concentration caused by the mixing of the leachate with ground water. EPACMTP also accounts for attenuation due to sorption of waste constituents in the leachate onto soil and aquifer solids, as well as bio-chemical transformation (degradation) processes in the unsaturated and saturated zone. These processes decrease constituent concentrations in the ground water as the distance from the WMU increases.

Sorption refers to the process whereby constituents in the leachate attach themselves to soil particles. For organic constituents, EPACMTP models sorption between the constituents and the organic matter in the soil or aquifer, based on constituent-specific organic carbon partition coefficients (K_{oc}) and a site-specific organic carbon fraction in the soil and aquifer. For metal constituents, EPACMTP accounts for more complex geochemical reactions by using effective sorption isotherms for a range of aquifer geochemical conditions, as generated using the MINTEQA2[6] geochemical speciation model.

In Tier 1 and as the default in Tier 2, EPACMTP only accounts for constituent transformations caused by hydrolysis reactions. Hydrolysis refers to constituent decomposition that results from chemical reactions with water. In Tier 2 analyses, however, you may also enter site-specific biodegradation rates. Biodegradation refers to constituent decomposition reactions involving bacteria and other micro-organisms. EPACMTP simulates all transformation processes as first-order reactions, that is, as processes that can be characterized with a half-life.

EPACMTP accounts for constituents which hydrolyze into toxic daughter products. In that case, the final liner recommendations are determined in such a way that they accommodate both the parent constituent as well as any toxic daughter products. For instance, if a parent waste constituent rapidly hydrolyzes into a persistent daughter product, the ground-water exposure caused by the parent itself may be minimal (it has already degraded before it reaches the well), but the final liner recommendation would be based on the exposure caused by the daughter product.

In Tier 2, IWEM makes liner recommendations by comparing ground-water exposure concentration values predicted by EPACMTP against RGCs that are either regulatory MCLs or cancer and non-cancer Health-Based Numbers (HBNs). For the IWEM analysis, the ground-water exposure concentration is evaluated at a hypothetical well that is located downgradient from the WMU. EPACMTP accounts for the finite life-span of WMUs, which results in a time-dependent ground-water exposure concentration. The exposure concentration calculated by EPACMTP is the maximum average concentration during the time period in which the ground-water exposure at the well occurs. The length of the exposure averaging period is adjusted to match the assumptions

[6] MINTEQA2 (U.S. EPA, 1991) is a geochemical equilibrium speciation model for computing equilibria among the dissolved, absorbed, solid, and gas phases in dilute aqueous solution.

incorporated in the RGC. For instance, when the ground-water exposure concentration is compared to a RGC that is based on cancer risk, the averaging period is set to 30 years; whereas for non-cancer effects caused by ingestion of water, EPA considered only childhood exposure, and set the averaging period to 7 years (covering the time period from birth through the 6^{th} year of life).

In both Tier 1 and Tier 2 analyses, the groundwater modeling results of the EPACMTP model are summarized by IWEM in terms of Dilution and Attenuation Factors (DAFs). A DAF is a numerical value that represents the reduction in the concentration of a constituent arriving at the modeled ground-water well as compared to the concentration of that constituent in the waste leachate. A DAF value of 10 means that the concentration at the well is 10 times less than the concentration in the leachate. Using DAFs is a convenient way to go back-and forth between leachate concentrations and exposure concentrations, or ground-water reference concentrations.

2.2.2.1 <u>IWEM vs. EPACMTP</u>

As an IWEM user, you should understand the differences between IWEM and EPACMTP. EPACMTP is a full-featured ground-water flow and transport model with probabilistic modeling capabilities; it is a sophisticated software program which requires a significant amount of computer and ground-water modeling expertise to create the necessary input files, execute the model, and interpret the results.

In contrast, IWEM is a relatively simple and user-friendly program created specifically to conduct Tier 1 and/or Tier 2 analyses of the ground-water pathway within the context of the EPA's ***Guide***. Specifically, within Tier 1, IWEM can be used to query a database of existing EPACMTP modeling results in the form of LCTV values, and to analyze these tabulated results to produce a Tier 1 WMU design recommendation that is specific to your waste. Within Tier 2, IWEM converts your input values into the required EPACMTP input files, executes a series of EPACMTP modeling runs, and then compiles and analyzes the results to produce a Tier 2 WMU design recommendation that is specific to your waste and your waste site. In addition, for both tiers of analysis the IWEM software has the capability to print and save document-ready reports that include the liner recommendations and the input data on which they are based.

In summary, IWEM can be thought of as an application of EPACMTP that is tailored specifically for use in non-hazardous industrial waste management decision-making. In order to make IWEM appropriate and easy to use in performing these Tier 1 and Tier 2 analyses, not all of the EPACMTP functionality is available to the IWEM user; however, the IWEM provides added capabilities to interpret results and develop reports, which are not available within EPACMTP.

2.2.3 IWEM Databases

The third component of IWEM is an integrated set of databases that include waste constituent properties and other ground-water modeling parameters. The waste constituent database includes 206 organics and 20 metals. Appendix A provides a list of the constituents in the database. The constituent properties include physical and chemical data needed for ground-water transport modeling, as well as RGCs. These RGC's include: 1) regulatory MCLs, and 2) cancer and non-cancer HBNs for drinking water ingestion and inhalation of volatiles during showering. Section 7 of this *User's Guide* discusses how IWEM uses these RGC's to calculate LCTVs.

In addition to constituent data, IWEM includes a comprehensive database of ground-water modeling data, including infiltration rates for different WMU types and liner designs for a range of locations and climatic conditions throughout the United States; and soil and hydrogeological data for different soil types and aquifer conditions across the United States. Details of these databases are provided in the *EPACMTP Parameters/Data Background Document* (U.S. EPA, 2002b), and in the *IWEM Technical Background Document* (U.S. EPA, 2002c).

EPA used these databases to develop the IWEM Tier 1 LCTVs, and they are incorporated into the IWEM software to perform Tier 2 evaluations. When site-specific data are available for a Tier 2 evaluation, they will override default database values. Conversely, when site-specific data are not available for a Tier 2 evaluation, IWEM will use default values or random sampling of values from distributions in its databases to augment the user-provided data.

2.3 Assumptions and Limitations of Ground-Water Modeling

The tiered approach developed to evaluate WMU designs uses sophisticated probabilistic techniques to account for uncertainty and parameter variability. To perform the evaluations recommended by the ***Guide***, the mathematical models represent conditions that may potentially be encountered at waste management sites within the United States. Efforts have been made to obtain representative, nationwide data and account for the uncertainty in the data.

However, given the complex nature of the evaluations, a number of limitations and caveats must be delineated. These limitations are described in this section. Before using this software, you need to verify that the model assumptions are appropriate for the site you are evaluating. The *IWEM Technical Background Document* (U.S. EPA, 2002c) provides additional information to assist you in this process.

EPACMTP represents WMU's in terms of a source area and a defined rate and duration of leaching. EPACMTP only accounts for the release of leachate through the base of the WMU and assumes that the only mechanism of constituent release is through dissolution of waste constituents in the water that percolates through the WMU. EPACMTP does not account for the presence of non-aqueous free-phase liquids, such as an oily phase that might provide an additional release mechanism into the subsurface. EPACMTP does not account for releases from the WMU via other environmental pathways, such volatilization or surface run-off. EPACMTP assumes that the rate of infiltration through the WMU is constant, representing long-term average conditions; the model does not account for fluctuations in rainfall rate, or degradation of liner systems that may cause the rate of infiltration and release of leachate to vary over time.

EPACMTP does not explicitly account for the presence of macro-pores, fractures, solution features, faults or other heterogeneities in the soil or aquifer that may provide pathways for rapid movement of constituents. A certain amount of heterogeneity always exists at actual sites, and it is not uncommon in ground-water modeling to use average parameter values. This means that the input values for parameters such as hydraulic conductivity, dispersivity, etc. represent effective site-wide average values. However, EPACMTP may not be appropriate for sites overlying fractured or very heterogeneous aquifers.

EPACMTP is designed for relatively simple ground-water flow systems. EPACMTP treats flow in the unsaturated zone and saturated zone as steady state and does not account for fluctuations in the infiltration or recharge rate, either in time or areally. As a result, the use of EPACMTP may not be appropriate at sites with large seasonal fluctuations in rainfall conditions, or at sites where the recharge rate varies locally. Examples of the latter include the presence of surface water bodies such as rivers and lakes or ponds, and/or man-made recharge sources near the WMU. EPACMTP does not account for the presence of ground-water sources or sinks such as pumping or injection wells.

Leachate constituents can be subject to complex biological and geochemical interactions in soil and ground water. EPACMTP treats these interactions as equilibrium sorption and first-order degradation processes. In the case of sorption processes, the equilibrium assumption means that the sorption process occurs instantaneously, or at least very quickly relative to the time-scale of constituent transport. Although sorption, or the attachment of leachate constituents to solid soil or aquifer particles, may result from multiple chemical processes, EPACMTP lumps these processes together into an effective soil-water partition coefficient. In the case of metals, EPACMTP allows the partition coefficient to vary as a function of a number of primary geochemical parameters, including pH, leachate organic matter, soil organic matter, and the fraction of iron-oxide in the soil or aquifer.

Although EPACMTP is able to account for the most important ways that the geochemical environment at a site affects the mobility of metals, the model assumes that the geochemical environment at a site is constant and is not affected by the presence of the leachate plume. In reality, the presence of a leachate plume may alter the ambient geochemical environment. EPACMTP does not account for colloidal transport or other forms of facilitated transport. For metals and other constituents that tend to strongly sorb to soil particles, and which EPACMTP will simulate as relatively immobile, movement as colloidal particles can be a significant transport mechanism. However given sufficient site-specific data, it is possible to approximate the effect of these transport processes by using a lower value for the k_d as a user-input in Tier 2.

EPA's ground-water modeling database includes constituent-specific hydrolysis rate coefficients for constituents that are subject to hydrolysis transformation reactions; for these constituents, EPACMTP simulates transformation reactions subject to site-specific values of pH and soil and ground-water temperature, but other types of transformation processes are not explicitly simulated in EPACMTP. For many organic constituents, biodegradation can be an important fate mechanism, but EPACMTP has only limited ability to account for this process. The user must provide an appropriate value for the effective first-order degradation rate. In the IWEM application of EPACMTP, the model uses the same degradation rate coefficient for the unsaturated and saturated zones if this parameter is provided as a user-input in Tier 2 evaluations. In an actual leachate plume, biodegradation rates may be different in different regions in the plume; for instance in portions of the plume that are anaerobic some constituents may biodegrade more readily, while other constituents will biodegrade only in the aerobic fringe of the plume. EPACMTP does not account for these or other processes that may cause a constituent's rate of transformation to vary in space and time.

3.0 System Requirements

The IWEM software is designed to run under the Microsoft (MS) Windows operating system. Version 1.0 of IWEM has been designed and tested to run on the latest versions of Windows 95, 98, NT version 4.0, 2000, and XP. In addition, in order to ensure that all the files required to run IWEM are present on your computer, the latest version of MS Internet Explorer that is compatible with your operating system needs to be installed. Details are given in the table below:

Latest versions of MS Windows operating systems	Corresponding version of MS Internet Explorer
95 (Version 4.00.950B)	Version 5.5 Service Pack 2
98 Second Edition (Version 4.10.2222A)	Version 6.0
NT 4.0 (Service Pack 6a)	Version 6.0
2000 (Service Pack 2)	Version 6.0
XP (Version 2002)	Version 6.0

If you do not have the latest version of your particular operating system, you may encounter IWEM installation or execution problems (see Section 8.0). To avoid these problems, make sure that you have the latest version MS Windows and Internet Explorer installed on your computer before installing the IWEM software. To check the version number of the operating system installed on your computer, **right-click** on the |MY COMPUTER| icon on your desktop. Then choose |PROPERTIES| from the displayed list. The |SYSTEM PROPERTIES| dialog box is then displayed, and the |GENERAL| screen is displayed by default. The operating system name and version number are displayed under the |SYSTEM| heading.

If you find that you do not have the latest version of your particular operating system, consult with your computer system administrator, or you may download the updated version for free from the following website:

http://www.microsoft.com

From the main menu, click on |DOWNLOADS|WINDOWS UPDATE|. Then click on the link for |PRODUCT UPDATES|. The first time you do this, you will be asked to install the Windows Update Control Package. Doing so will enable the automatic creation of a list of available updates that is customized for your computer and operating system. Then install the recommended updates to ensure that you are running the latest version of your operating system.

To check the version of MS Internet Explorer that is installed on your computer, double-click on the |INTERNET EXPLORER| icon on your desktop. From the main menu, choose |HELP|ABOUT INTERNET EXPLORER|. The version number is displayed beneath the MS Internet Explorer banner; make sure that the version number is at least 5.50.xxxx.xxxx if you are running Windows 95 or is at least 6.00.xxxx.xxxx if you are running Windows 98 or later. Only the first few digits of the Internet Explorer version number are important to ensure correct operation of the IWEM software.

If you find that you do not have the latest version of MS Internet Explorer, you may download the updated version for free from the following website:

http://www.microsoft.com

From the main menu, click on |DOWNLOADS|WINDOWS UPDATE|. Then click on the link for |PRODUCT UPDATES|. The first time you do this, you will be asked to install the Windows Update Control Package. Doing so will enable the automatic creation of a list of available updates that is customized for your computer and operating system. If you do not have the latest version of MS Internet Explorer, then this program will be included in the list of recommended updates. In that case, download and install the recommended file(s) in order to ensure that IWEM will operate correctly.

Your computer must meet the minimum hardware requirements for the version of Windows that is installed on your computer. In addition, it is recommended that the computer have at least 128 megabytes (MB) of RAM and 100 MB or more of available hard-drive space. A printer is required for printing hard-copy reports.

To check your computer's random access memory (RAM), **right-click** on the |MY COMPUTER| icon on your desktop. Then choose |PROPERTIES| from the displayed list. The |SYSTEM PROPERTIES| dialog box is then displayed, and the |GENERAL| screen is displayed by default. The amount of RAM is displayed as the last item under the |COMPUTER| heading. To check your computer's available hard-drive space, double-click on the |MY COMPUTER| icon on your desktop. Then choose |VIEW|DETAILS| from the main menu. The |MY COMPUTER| dialog box is then displayed where you can check the amount of free space on your hard-drive.

> Running Tier 2 evaluations is computationally demanding. A fast computer processor (*e.g.*, at least a 500 MHz Pentium III) is strongly recommended. Even so, you should expect that Tier 2 analyses for multiple waste constituents may take several hours to complete. A screen will be displayed during your Tier 2 evaluation to keep you informed about the progress of the computations.

4.0 IWEM Software Installation

To use the IWEM software for the first time, you must install the software on your hard-drive from the ***Guide*** CD-ROM, or download it from the EPA's non-hazardous industrial waste website (http://www.epa.gov/industrialwaste/). Depending on the security settings of your operating system, if your computer is connected to a network, or if your computer uses the Windows NT, 2000, or XP operating systems, this software may need to be installed and uninstalled by someone with administrator privileges. Instructions for installing and uninstalling the program are provided below. Any updates to these instructions are located in the Readme.txt file on the ***Guide*** CD-ROM and on the website. If you have difficulty implementing the instructions below, please see your network administrator for help, or contact the RCRA Information Center as explained in Section 5.2.5.

Installation from the ***Guide*** CD-ROM

1. Close all applications, such as word processing and e-mail programs. Close or disable virus protection software.

2. If you have previously installed the ***Guide*** on your computer, then insert the ***Guide*** CD into your CD-ROM drive. Depending upon your computer settings, the ***Guide*** CD may automatically be launched.

   If not, double-click on |MY COMPUTER|, double-click on your CD-ROM drive, and then double-click on |START.EXE|

   OR

   Select |START|RUN| and type "D:\START.EXE," replacing the "D:" in this command with the correct drive designation for your CD-ROM, as appropriate.

3. After following the prompts to log onto the ***Guide*** CD, use the command buttons within the interactive ***Guide*** CD to navigate to the *Industrial Waste Management Main Menu.* From there, select the *Protecting Ground Water* section, and then select the *Assessing Risk to Ground Water* subsection.

4. Click the |NEXT| button to display the *Assessing Risk to Ground Water Topic Menu*, and then click on the following sequence of command buttons:
   |TOOLS AND RESOURCES|
   |TOOLS|
   |INFO| for the IWEM model
   |LAUNCH|

|INSTALL NOW|

5. The IWEM Welcome screen then appears. If all your other applications are already closed (Step 1), click |NEXT|. If not, press the |TAB| key while the |ALT| key is depressed to scroll through your open applications, closing each in turn.

6. The next screen is titled Choose Destination Location. This screen displays the default installation location for the IWEM files. If you want to change the location, click the |BROWSE| button and specify a different directory. Click the |NEXT| button to proceed with the IWEM installation process.

7. The next screen is titled Select Program Manager Group. The default setting is to create a new program group named "IWEM;" however, if desired, you can instead choose one of the existing program groups from the list below or replace "IWEM" with a name that you type in. Then click the |NEXT| button to proceed with the IWEM installation process.

8. The next screen is titled Start Installation. If you are happy with your selections up to this point, click the |NEXT| button to install the IWEM software to your hard-drive. Otherwise, click the |BACK| button to change your installation settings.

9. The next screen is titled Installing. The Current File and All Files progress bars are automatically updated as files are copied to your hard drive, and an estimate of the time required to finish the installation is displayed on-screen.

10. As the installation process is finishing, a message box will be displayed that says "Updating System Configuration, please wait..."

11. If you do not encounter any installation problems, the Installation Complete screen will display the message, "IWEM has been successfully installed." In this case, all you need to do is click on the |FINISH| button to complete the installation. However, if you do experience installation problems, please see your computer system administrator for help, or contact the RCRA Information Center as explained in Section 5.2.5.

Installation from the EPA's non-hazardous industrial waste website

1. Close all applications, such as word processing and e-mail programs. Close or disable virus protection software.

2. Open your internet browser and type in the following website:

http://www.epa.gov/industrialwaste/

3. From the bulleted list, double-click on the link for the *Guide*.

4. Scroll down to the bottom of the page and click on the link for the *IWEM*.

5. Scroll down the page and click on the *Download Model* link.

6. The File Download dialog box will then appear. Choose the option to save the program to disk and click the |OK| button to download this IWEM setup file to your hard-drive.

7. The Save As dialog box will then appear. Navigate to the folder where you would like the file to be saved and then click the |SAVE| button. The progress bar is automatically updated as the IWEM setup file (IWEMSetup.exe) is downloaded to your hard drive.

8. At the bottom of the Save As dialog box is a checkbox to specify if you want the dialog box to close automatically when the download is complete. If you leave the checkbox empty, then click on the |OPEN| button when the download is complete. If you have the checkbox selected, the dialog box will close upon completion of the download. In this case, open |MY COMPUTER|, browse to the folder location where you saved the IWEM setup file, and double-click on the icon for |IWEMSETUP.EXE|

   OR

   Select |START|RUN|, and either browse to the folder location where you saved the IWEM setup file or type this folder location directly into the textbox. Then click on the |OK| button.

9. The IWEM Welcome screen then appears. If all your other applications are already closed (Step 1), click |NEXT|. If not, press the |TAB| key while the |ALT| key is depressed to scroll through your open applications, closing each in turn.

10. The next screen is titled Choose Destination Location. This screen displays the default installation location for the IWEM files. If you want to change the location, click the |BROWSE| button and specify a different directory. Click the |NEXT| button to proceed with the IWEM installation process.

11. The next screen is titled Select Program Manager Group. The default setting is to create a new program group named "IWEM;" however, if desired, you can instead

choose one of the existing program groups from the list below or replace "IWEM" with a name that you type in. Then click the |NEXT| button to proceed with the IWEM installation process.

12. The next screen is titled Start Installation. If you are happy with your selections up to this point, click the |NEXT| button to install the IWEM software to your hard-drive. Otherwise, click the |BACK| button to change your installation settings.

13. The next screen is titled Installing. The Current File and All Files progress bars are automatically updated as files are copied to your hard drive, and an estimate of the time required to finish the installation is displayed on-screen.

14. As the installation process is finishing, a message box will be displayed that says "Updating System Configuration, please wait..."

15. If you do not encounter any installation problems, the Installation Complete screen will display the message, "IWEM has been successfully installed." In this case, all you need to do is click on the |FINISH| button to complete the installation. However, if you do experience installation problems, please see your computer system administrator for help, or contact the RCRA Information Center as explained in Section 5.2.5.

Uninstalling

1. Click on the Microsoft Windows |START| button in the extreme lower left corner of your screen.

2. Select |SETTINGS|, and then |CONTROL PANEL|.

3. Double-click on |ADD/REMOVE PROGRAMS|.

4. Select |IWEM| and then click on the |CHANGE/REMOVE| button.

5. The IWEM Select Uninstall Method screen is now displayed. You can choose either an automatic or a custom uninstall process. The automatic process removes only the IWEM files that were copied to your computer during IWEM installation; that is, files of saved IWEM analyses are not deleted if you choose the automatic uninstallation process. The custom uninstallation process allows you to specify exactly which files you want to delete. Clicking on the |SELECT ALL| button each time it appears in the custom process can be used to delete every file that is associated with the IWEM application, including shared files and saved IWEM analyses.

6. The IWEM Perform Uninstall screen then appears. If you are happy with your selections up to this point, click the |FINISH| button to uninstall the IWEM software from your hard-drive. Otherwise, click the |BACK| button to change your uninstallation settings.

7. If the IWEM uninstall program finds that any of the files to be deleted is a shared file that is no longer used by any programs, a message box titled Remove Shared Component then appears. The filename will be displayed and you will be asked if you want to delete this file. If any programs are still using this file and it is removed, then those programs may not function correctly. Leaving the file on your computer will not harm your system, but it does take up space on your hard-drive. If you are unsure what to do, then you should select the |NO TO ALL| button.

8. If you do not encounter any uninstallation problems, the IWEM program will then be removed from the list of programs on the Add/Remove Programs dialog box. However, if you do experience uninstallation problems, please see your computer system administrator for help, or contact the RCRA Information Center as explained in Section 5.2.5.

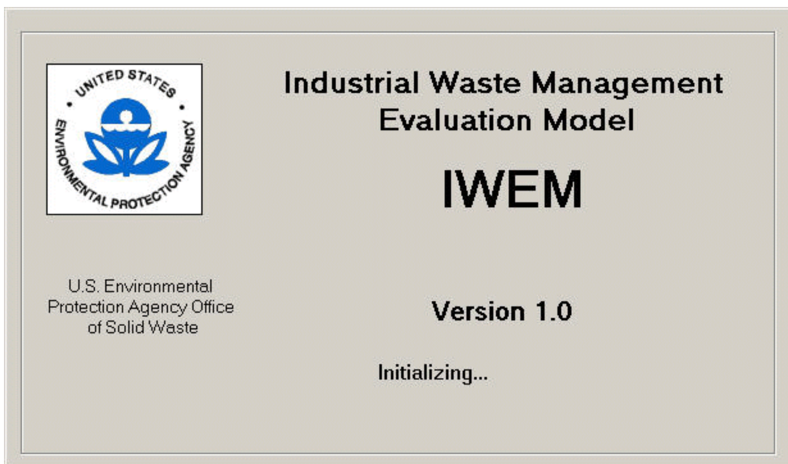
5.0 Running the IWEM Software

This section provides detailed instructions on how to run the IWEM software. Specifically, this section:

- Instructs you how to launch the IWEM software;
- Explains the key features of the IWEM software; and
- Guides you step-by-step through Tier 1 and Tier 2 evaluations.

5.1 How do I start the IWEM software?

To use the program for the first time, you can install the software from the ***Guide*** CD (or download it from EPA's website: http://www.epa.gov/industrialwaste) to your hard-drive. Section 4 gives detailed installation instructions.



After installation, you can launch the program by choosing |START|PROGRAMS| (at the lower left corner of the screen) and then choosing |IWEM| program group and the program |IWEM|. Alternatively, you can create a short-cut to the |IWEM| program and move it to your Windows desktop. In this case, the program can be launched by double-clicking the |IWEM| icon on your desktop.

5.2 What are the key features of the IWEM software?

The IWEM software has a user-friendly interface which is designed to operate in accordance with MS Windows™ conventions. The first screen that you see after launching the program is the Start-Up screen (shown above) which will appear only while the program is loading.

The first time you run the IWEM software, it displays five Introduction screens. After reading them once, you can skip these screens in the future by un-checking the box at the lower left of the introduction screens (see Section 5.3).

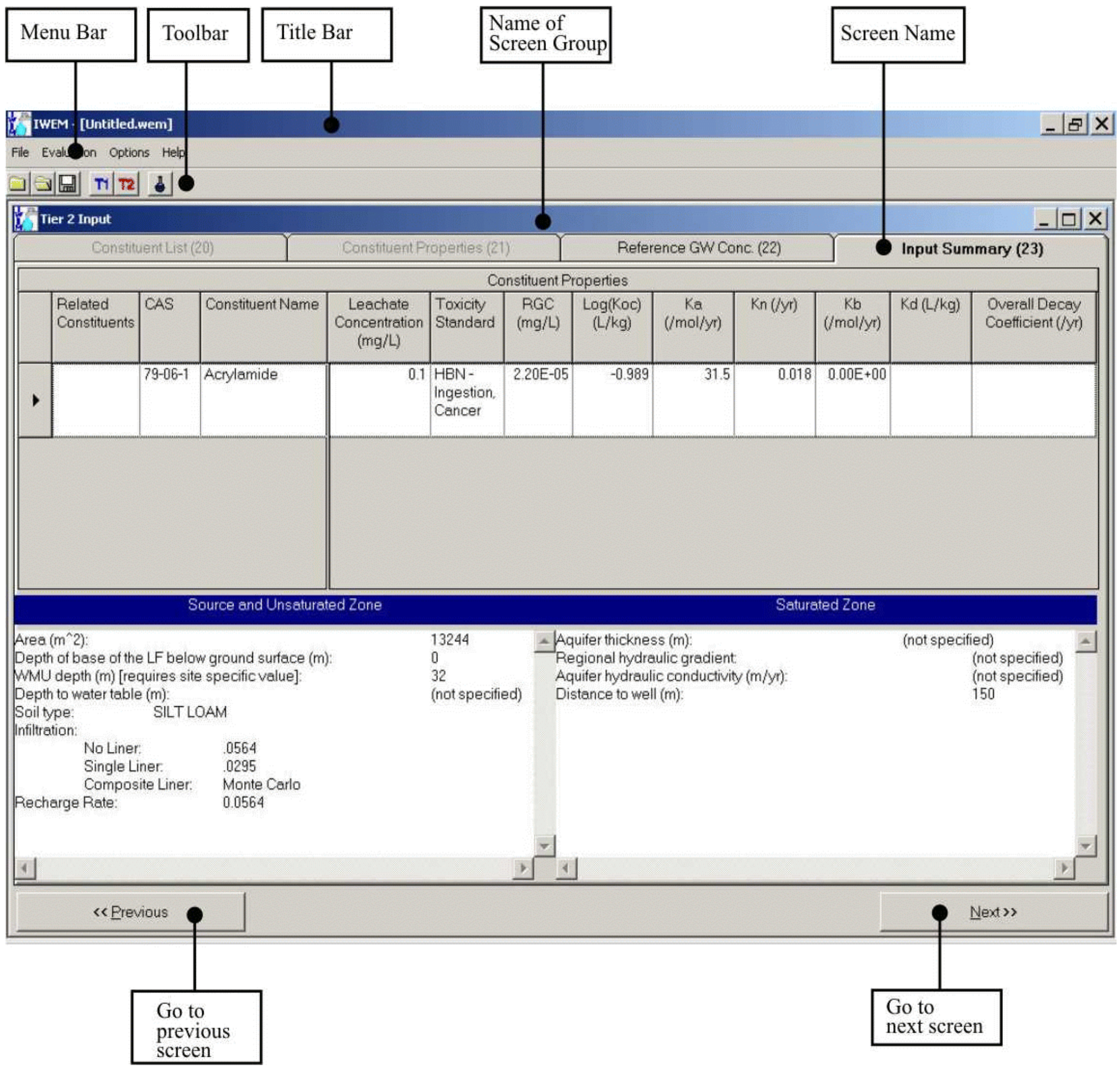


Figure 5.1 General IWEM Screen Features.

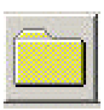
As shown in Figure 5.1, the IWEM software interface follows a common layout with the following features:

- **Menu Bar** allows you to perform common file operations;
- **Toolbar** also allows you to perform common operations efficiently;
- **Title Bar** at the top displays the software title and the name of the current IWEM project file;
- **Name of Screen Group** identifies the general topic addressed by the individual screens that comprise this group (e.g., Tier 2 input screen group);
- **Screen Name** more specifically identifies the type of information being requested or displayed in the screen;
- │PREVIOUS│ button takes you to the previous screen; and
- │NEXT│ button allows you to proceed to the next screen.

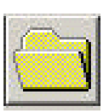
From the menu bar, you can select among the following menu items:

- ***File:*** performs general file operations, such as open and save;
- ***Evaluation:*** proceeds directly to either the Tier 1 Evaluation or the Tier 2 Evaluation;
- ***Options:*** enables or suppresses toolbar visibility; and
- ***Help:*** provides access to the following information: search IWEM online help; view IWEM introductory screens; browse constituent properties; view contact information for IWEM technical support; and view the IWEM <u>About</u> screen.

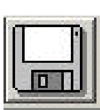
Using the toolbar is a quick way to perform common operations:



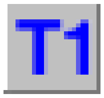
Clicking on this button begins a │NEW EVALUATION│;



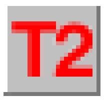
Clicking on this button launches the │OPEN FILE│ dialog box to select the previously saved evaluation file to be opened;



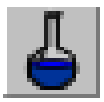
Clicking on this button launches either the │SAVE AS│or │SAVE│ dialog box so that you can specify the filename and folder for your analysis;



Clicking on this button begins the |TIER 1 EVALUATION|;



Clicking on this button begins the |TIER 2 EVALUATION|; and


Clicking on this button opens the |CONSTITUENT PROPERTIES BROWSER| dialog box.

If you are unsure about the function of any of the toolbar buttons, you can display |TOOL TIPS| (which identifies the button's function) for each button by placing the mouse cursor on top of the button.

In this section of the *User's Guide*, we present detailed, step-by-step instructions for running the IWEM software. These instructions include screenshots for each of the screens and dialog boxes that you will see when performing a Tier 1 or Tier 2 analysis in IWEM. The screenshots presented in Section 5 have added annotations (in small boxes above and below the screenshot) to point out the important features on each screen. These annotations are each labeled with a letter (A, B, C, etc) and are then listed and explained sequentially in the text immediately following each screenshot.

5.2.1 What is the Constituent Properties Browser?

The Constituent Properties Browser, accessed from the Main Menu sequence |HELP| CONSTITUENT PROPERTIES| or by clicking on the flask toolbar button, displays the data in the constituent properties database that is distributed with IWEM (see Figure 5.2). You can select a constituent by Chemical Abstract Service Registry number (CAS number) or by name. The information displayed in the upper portion of the browser includes chemical and physical properties required for fate and transport modeling. RGC values, cancer slope factors (CSFs), and non-cancer reference doses and reference concentrations are given in the lower portion of the screen. For each property value in the database (except constituent type, carcinogenicity, and molecular weight), the |DATA SOURCE| field provides access to a complete bibliographic citation (see Figure 5.3).

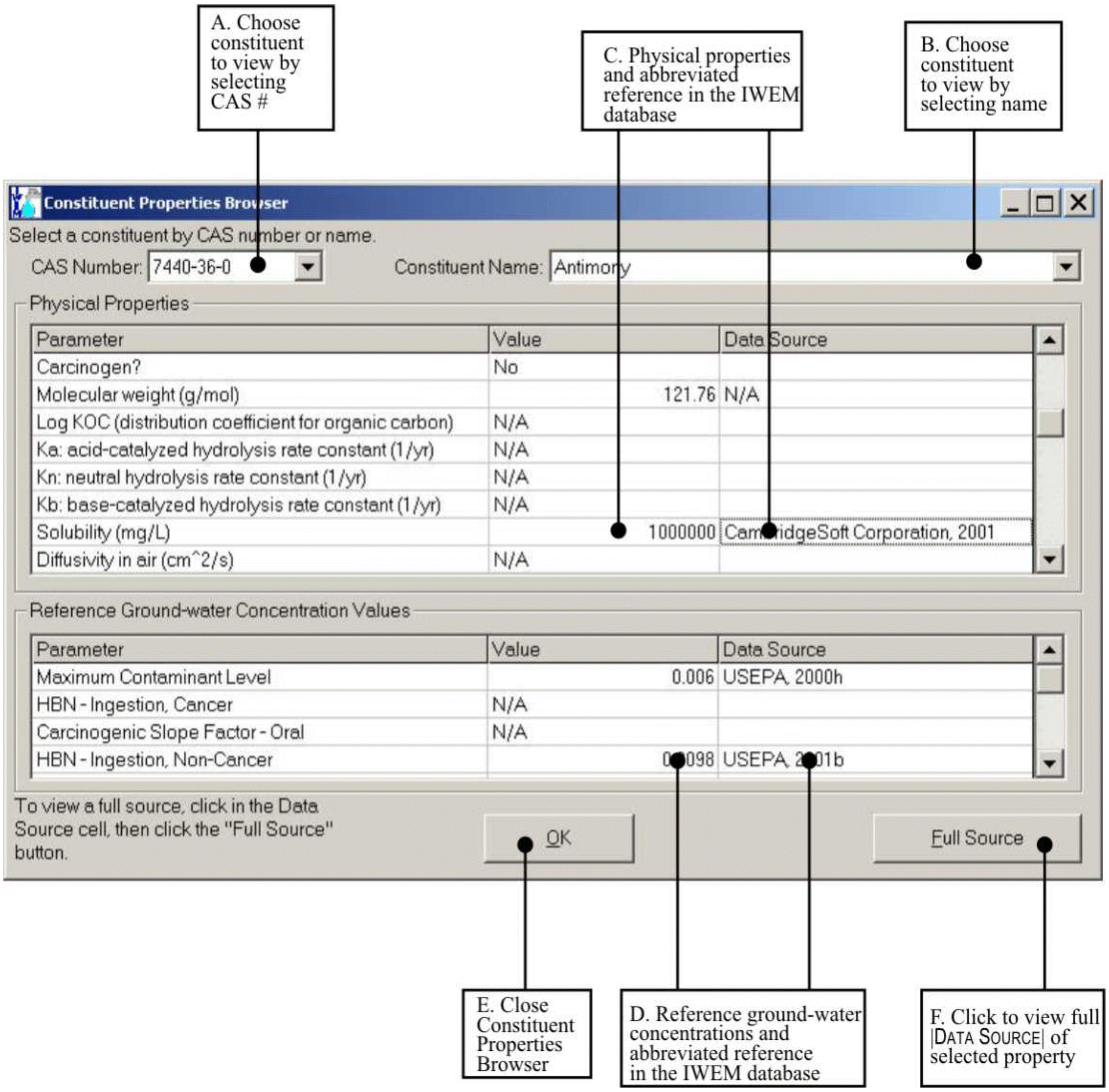


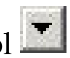
Figure 5.2 Constituent Properties Browser.

The features identified in Figure 5.2 are explained in more detail in the following paragraphs.

A. Choose Constituent to View by Selecting CAS Number

To select which constituent to view, use either of the two list boxes at the top of the screen. You can click on the drop-down list control  at the right edge of the |CAS NUMBER| listbox to display a drop-down list of all available waste constituents. Then use the mouse or the |ARROW| keys on your keyboard to scroll through the list of constituents until the desired constituent is highlighted. You can also type in the leading digits of the CAS number for the constituent you would like to view. IWEM will then skip forward in the list to the first constituent whose CAS number starts with the entered digits, and you can then use the mouse or the |ARROW| keys on your keyboard to move to the desired constituent. Left click on the mouse or hit the |ENTER| key to make your selection.

B. Choose Constituent to View by Selecting Name

You can also select which constituent to view by using the |CONSTITUENT NAME| listbox on the right side of the screen. Click on the drop-down list control  at the right edge of the |CONSTITUENT NAME| listbox to display a drop-down list of all available waste constituents. Then use the mouse or the |ARROW| keys on the keyboard to scroll through the list of constituents until the desired constituent is highlighted. You can also type in the first letter of the name of the constituent that you would like to view. IWEM will then skip forward in the list to the first constituent whose name begins with the entered letter, and you can then use the mouse or the |ARROW| keys on your keyboard to move to the desired constituent. Left click on the mouse or hit the |ENTER| key to make your selection.

C. Physical Properties and Abbreviated Reference in the IWEM Database

For the selected waste constituent, the pertinent physical and chemical property values that are used in the IWEM analysis and their corresponding data sources are listed in the upper window on this screen.

D. Reference Ground-water Concentrations and Abbreviated Reference in the IWEM Database

For the selected waste constituent, the RGC input parameter values that are used in the IWEM analysis and their corresponding data sources are listed in the lower table on this screen.

E. Close Constituent Properties Browser

Click the |OK| button at the bottom of the screen to close this screen.

F. Click to View Full |DATA SOURCE| *of Selected Property*

You can view the complete bibliographic citation of a constituent property by selecting the corresponding entry under the |DATA SOURCE| heading and clicking on the |FULL SOURCE| button on the lower right-hand side of the screen. Doing so will cause a message box to appear on-screen, as is shown in Figure 5.3.

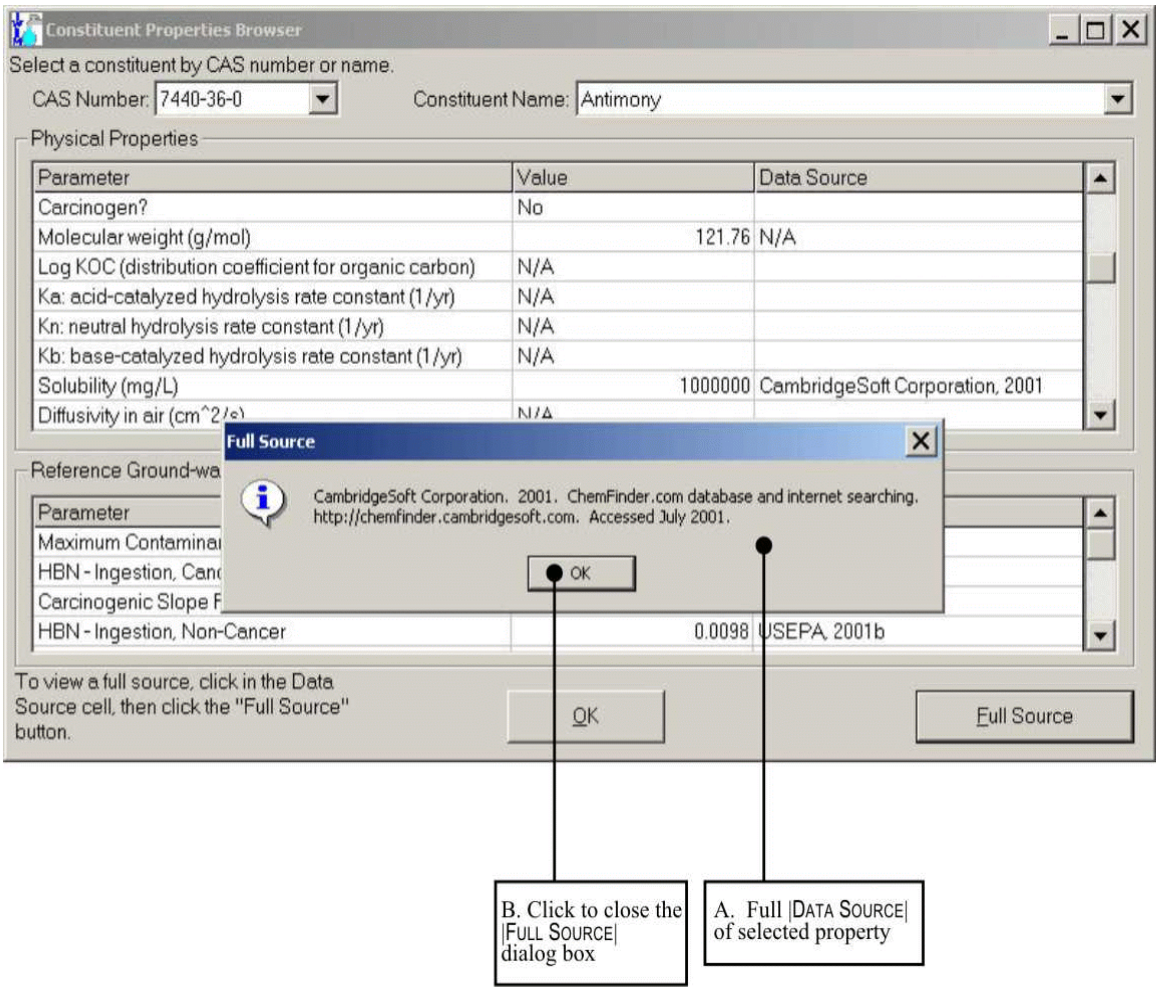


Figure 5.3 Constituent Properties Browser Full Source Dialog Box.

The features identified in Figure 5.3 are explained in more detail in the following paragraphs.

A. Full |DATA SOURCE| of Selected Property

The bibliographic citation of the selected property is displayed in the |FULL SOURCE| dialog box.

B. Click to Close the |FULL SOURCE| Dialog Box

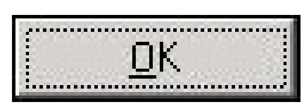
Click the |OK| button to close the dialog box.

5.2.2 How Do I Navigate Through the IWEM Software?

The IWEM software is comprised of a series of screens containing controls for entering data and viewing results. This section describes in detail how to move from screen to screen and control to control, as well as how the various controls are used together to facilitate your use of the IWEM software. Although this guide assumes you will be using a mouse to navigate through the screens and features, you may also navigate using the keyboard exclusively.

Navigating with the keyboard involves the use of the following keys: the |TAB| key, the |BACK-TAB| key, the |ARROW| keys, the |ALT| key, and the |ENTER| key. The |TAB| key moves the cursor from one control to the next in a predefined order. The term cursor refers to either a vertical bar "|" that indicates the position of the next typed character, or the change in a control's appearance from normal to a highlighted appearance, as presented below.

Normal



Highlighted

When a control is highlighted, it is considered actively awaiting input from the keyboard or mouse. The |BACK-TAB| key (press the |TAB| key while holding down the |SHIFT| key) moves the cursor in the reverse order. When the cursor is on a command button, press the |ENTER| key to "click" the button. Radio buttons always appear in a set of two or more options; when the cursor is on any radio button, press the |ARROW-UP| or |ARROW-DOWN| key to select a different radio button. The |TAB| key moves you off the radio button group. The |TAB|, |BACK-TAB|, and |ARROW| keys are also used to move from cell to cell in a data grid. A drop-down list displays the current choice of several possible choices; when the drop-down list is active (highlighted), use the |ARROW-UP| or |ARROW-DOWN| keys to display the desired choice.

The |ALT| key is used in combination with other key strokes to access controls or menu items quickly through pre-defined "hot-keys" that correspond to underlined characters on a control or menu item. For example, the underlined "O" on the |OK| button above indicates that pressing and holding down the |ALT| key and then pressing the |O| key would have the same result as a mouse click on the button. Similarly, the main menu system is activated by pressing the |ALT| key; the first letter of each menu item is underlined and can be accessed in the manner just described.

5.2.2.1 Screens

Screens in IWEM appear as a single screen or as a group of screens with manila folder-like "tabs" along the top to differentiate between the individual screens. The Introductory screens (see Figures 5.9 through 5.13) are examples of individual screens that have |PREVIOUS| and/or |NEXT| command buttons along the bottom for navigating from screen to screen. The Tier 1 Input screen group (see Figure 5.14) consists of three screens where you select a WMU type, identify the constituents in your waste, and enter your leachate data. In addition to the navigational command buttons available on single screens, you can also move to adjacent screens by clicking on their corresponding "tab".

5.2.2.2 Controls

The following controls make the IWEM software easy-to-use:

- Text boxes;
- Dialog boxes;
- List boxes;
- Radio Buttons;
- Data grids;
- Command buttons; and
- Drop-down lists.

Each of these controls is explained in more detail in this section. In general, a control is activated or selected by clicking on it with the mouse or by using the keyboard (e.g., using the |TAB| key or the hot-key).

Text Boxes

Text boxes are used to display or accept information. The screen shown in Figure 5.4, text boxes (box B) are used to accept the name or CAS number of a constituent. As you type characters or numbers into the text box, the list box cursor moves to the constituent in the list that best matches your input. The screen shown in Figure 5.5 uses text boxes to display data (box B) and to receive inputs (box E).

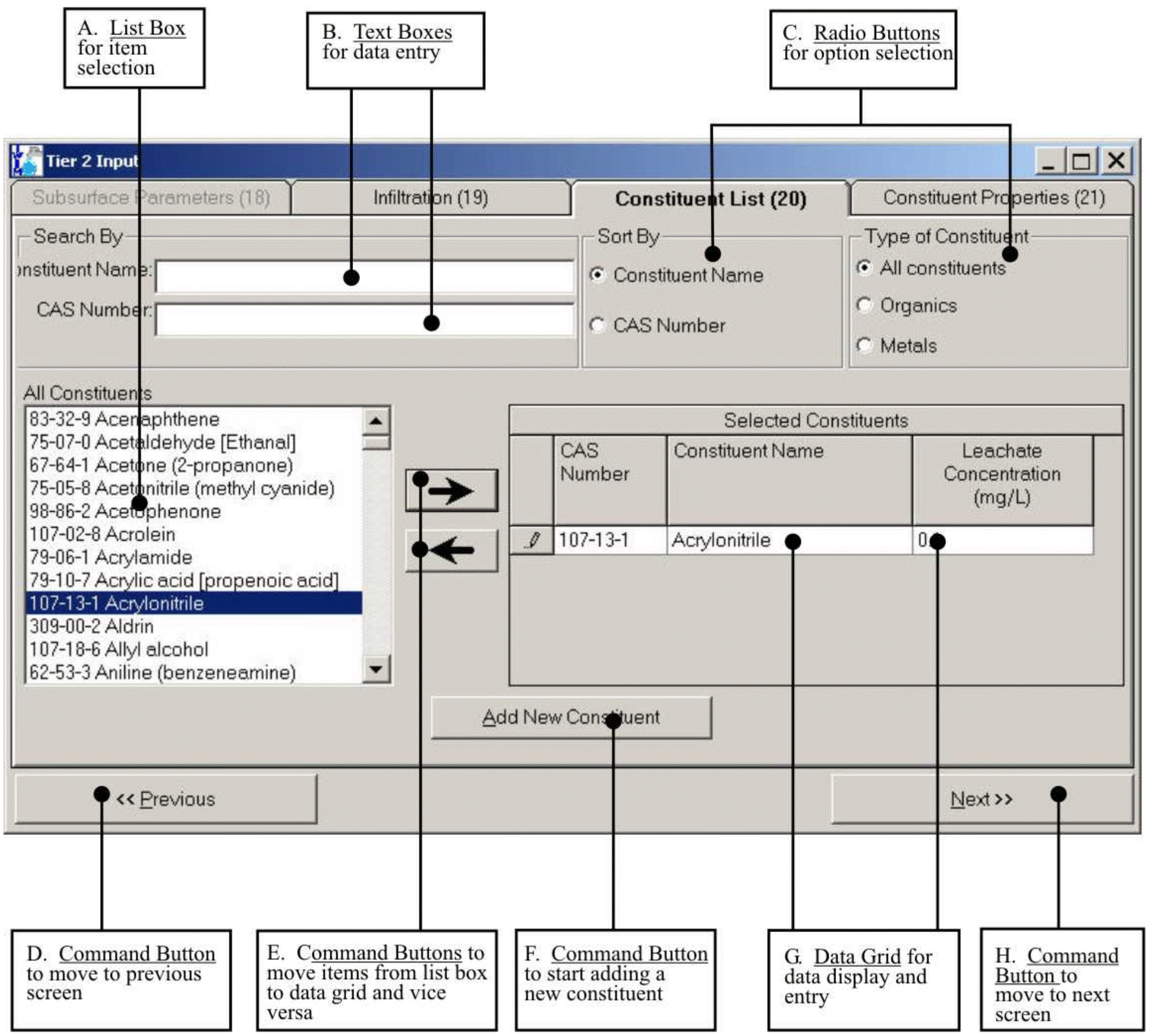


Figure 5.4 Example IWEM Screen Identifying Several Types of Controls.

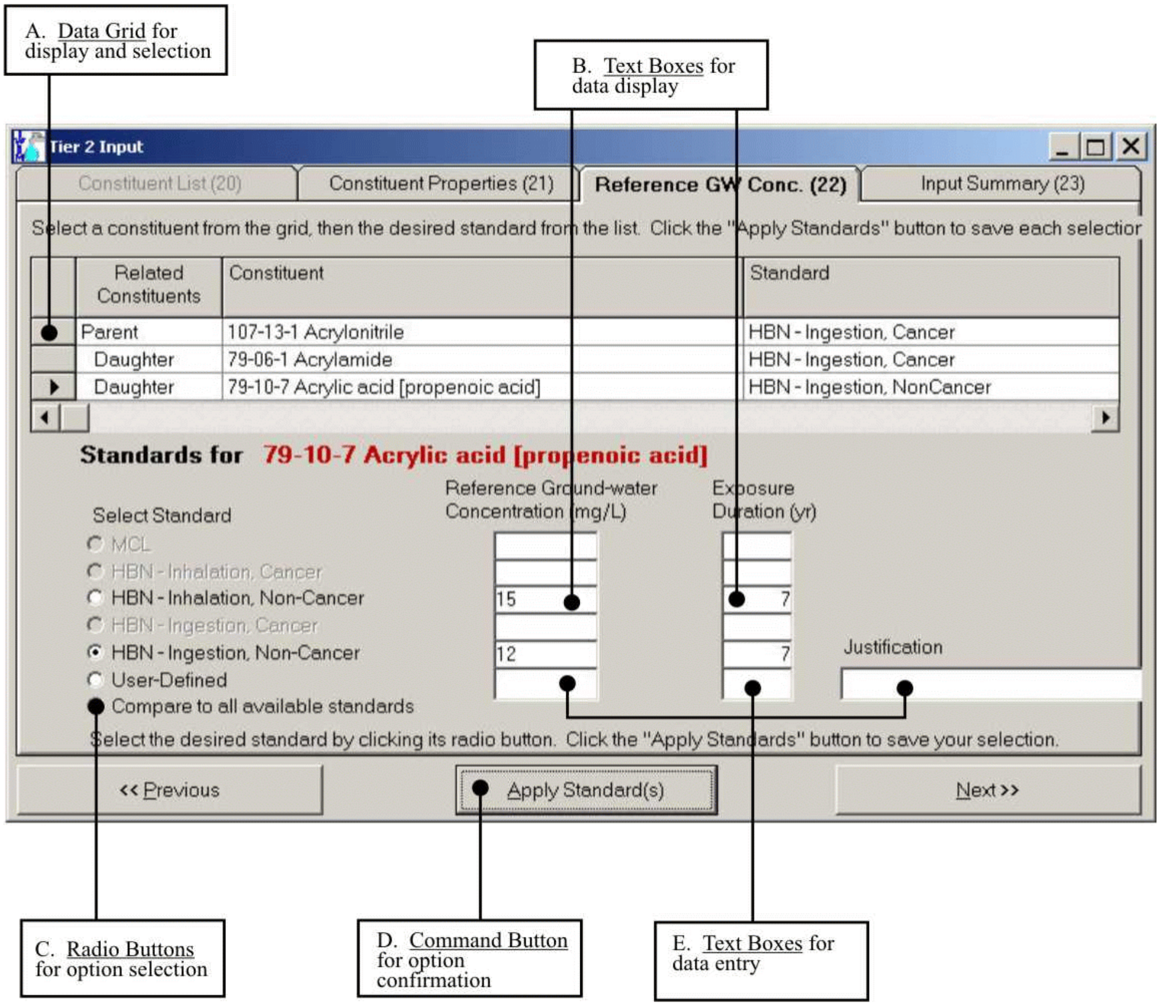


Figure 5.5 Example IWEM Screen Identifying Several Types of Controls.

Dialog and Message Boxes

Dialog boxes appear throughout the IWEM software as additional data entry screens containing one or more of the controls mentioned above (i.e., see Figure 5.35: the Climate Center List dialog box), or as a way of informing the user (i.e., see Figure 5.3: the Full Source message box). Data entry dialog boxes usually appear as a direct result of clicking on a command button, whereas message boxes appear as the result of a user's input, or the model's calculation.

List Boxes

List boxes are used to display a list from which you can select one or many of the listed items. In Figure 5.4, the list box (box A) displays all of the constituents in the IWEM database that can be used in a Tier 2 analysis. This list permits multiple selections and is described in more detail in Section 5.5.1.6 of this document.

Radio Buttons

Radio buttons always appear in a set of two or more options and have a variety of uses. In the screen in Figure 5.4, the radio buttons (box C) control the display of constituents in the list box (box D). In the screen in Figure 5.5, you can use the radio buttons to select one of the available standards for the current constituent (box C). The selection is not recorded, however, until the |APPLY STANDARD| command button is pressed.

Data Grids

Data grids are used in many different ways throughout the IWEM software: to display data, to accept data, a combination of data display and entry, or to select a grid item that affects other controls on a screen. As a user, you will need to manipulate these grids to view, enter and select information. The grids are very similar to a spreadsheet in that the column widths and row heights can be manipulated with the mouse by moving the mouse cursor over the separators along the left side or top of the grid until the cursor changes to a horizontal or vertical bar. When the cursor changes, click and drag the mouse until you are happy with the new grid dimension, then release the mouse button. Moving from cell to cell can be controlled by mouse clicks or by the |TAB| or |ARROW| keys as explained in Section 5.2.2.

Selecting a particular row of the grid is accomplished by clicking on the cell in that row or along the left border of the grid or using the |TAB| or |ARROW| keys to move to a particular row. In the screen in Figure 5.4, removing a constituent from the list displayed in the data grid (box G) requires selecting the row of the grid and then clicking the command button with the left-pointing arrow (box E). Selecting a row in a grid is also required when you are assigning a standard to a constituent on the screen presented in Figure 5.5. When moving from row to row in this grid (box A), the radio buttons (box C) and text boxes (box E) change as a function of the constituent displayed in the selected grid row. In addition, when a standard has been selected, the last column in the grid is updated to reflect the selected standard.

Command Buttons

Command buttons are used throughout the tool to execute an action, to navigate from screen to screen, to verify a choice, or to acknowledge a message. Figure 5.4 shows a screen from IWEM where command buttons are used for various purposes: navigation (boxes D, H), moving information (box E), and initiating some action (box F). Command buttons are activated by a mouse click or by pressing the |ENTER| key when the button is highlighted or active. The screen in Figure 5.5 (box D) uses a command button to verify a selection made with a radio button group and then updates a cell in a data grid with the selected standard.

Drop-down Lists

Drop-down lists are used to make one selection from a list and then display only the selected item. In some cases, the list may be modified by the user. In Figure 5.6, you can select from the list of chosen constituents (box A) to view and/or edit constituent properties. The data grids are updated based upon the selection in the drop-down list. In Figure 5.7, a drop-down list is used to choose from a pre-defined list of options (box A), however, you may enter your own data. This type of control is usually referred to as "combo" box control: a combination of a text box control and drop-down box control.

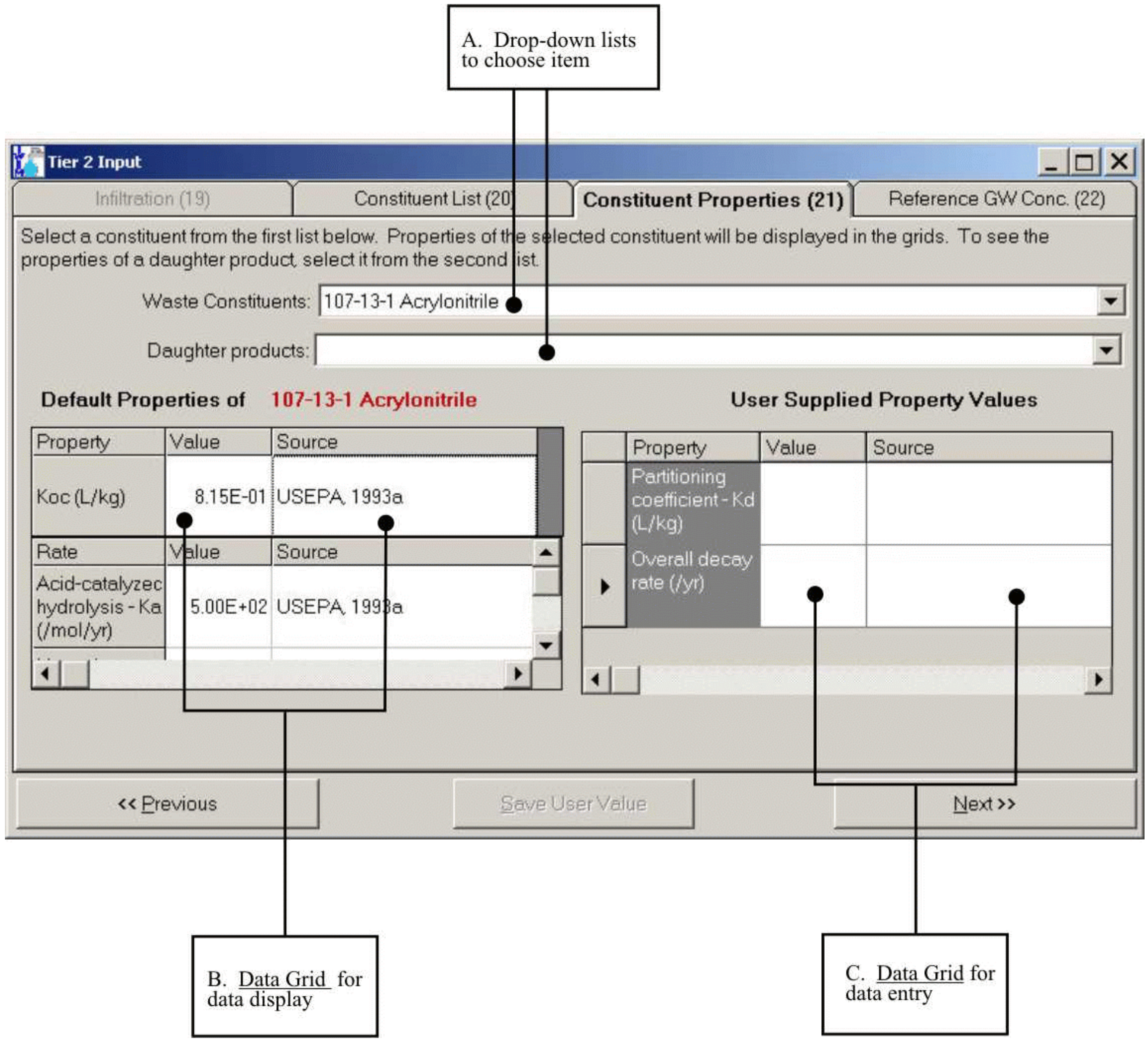


Figure 5.6 Example IWEM Screen Identifying Several Types of Controls.

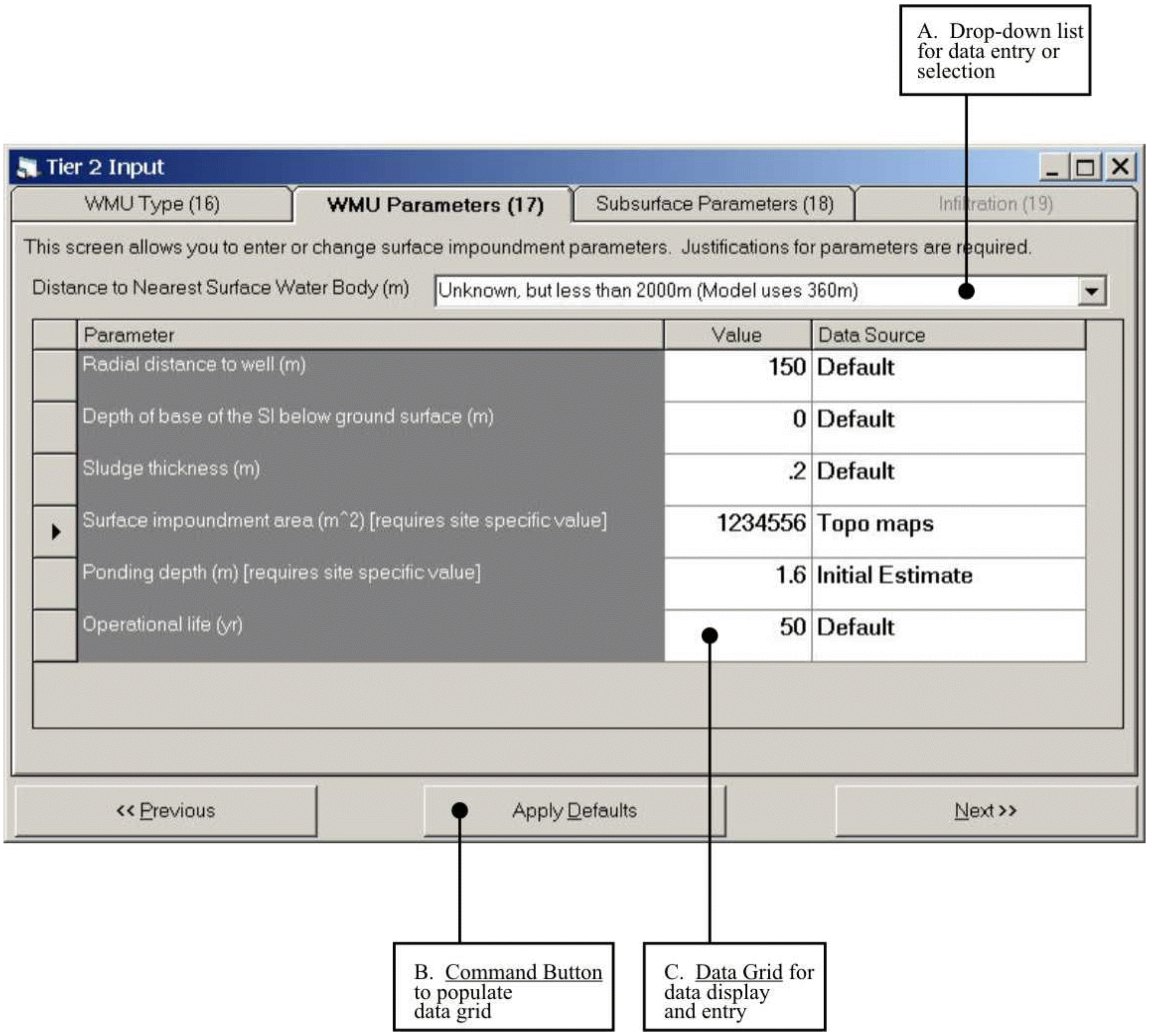


Figure 5.7 Example IWEM Screen Identifying Several Types of Controls.

5.2.3 How Do I Use Online Help?

IWEM provides online |HELP| that can be accessed from any screen either by pressing the |F1| key or by selecting |HELP| CONTENTS| from the IWEM menu bar. Selecting |HELP| CONTENTS| from the IWEM menu bar will cause the screen shown as Figure 5.8 to be displayed.

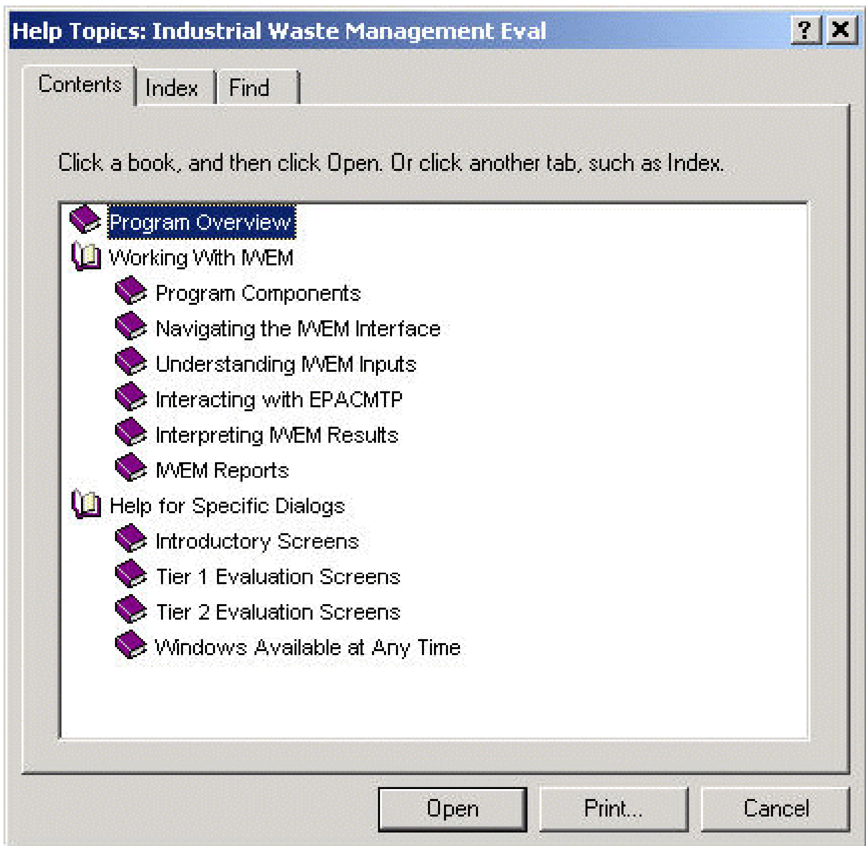


Figure 5.8 IWEM Online Help.

From this main |HELP| screen (shown in Figure 5.8), you can use the mouse or keyboard keys to explore the |CONTENTS| tab which is automatically displayed by default, or you can navigate to either of the other two tabs: |INDEX| and |FIND|. On the |CONTENTS| tab, you can double-click on the book icon to the left of each topic to expand that topic; some main topics contain multiple levels of sub-topics, but after navigating down to the most detailed level, a |HELP| screen will be displayed that contains descriptive text that explains a particular feature of the IWEM software. Many of these text descriptions contain hyper-text links to related items in the online |HELP|; these hyper-text links are formatted with colored and underlined text. Double-click on any hyper-text link to display detailed information about that topic. On the |INDEX| tab, you can find help for a particular topic by typing a phrase into the text box at the top or by selecting a topic from the list box at the bottom and then clicking the |DISPLAY| button. The |FIND| tab enables you to search for specific words and phrases in online |HELP|, instead of searching for information by category. Just follow the on-screen prompts on the |FIND| tab to create and search a list of words in online |HELP|.

Pressing the |F1| key will automatically display an online |HELP| screen that is appropriate for the current IWEM screen that you are using. This information is similar to that presented in Sections 5.4 and 5.5 of this document and is also presented in the last topic listed on the |CONTENTS| tab: |HELP FOR SPECIFIC DIALOGS|.

Once you find the information you need in online |HELP|, you can use the main menu or the command buttons at the top of the |HELP| screen to skip to other sections of online |HELP| or to print out a particular topic.

5.2.4 How Do I Save My Work?

You have several options within the IWEM software to save your analysis. After performing a new Tier 1 or Tier 2 analysis, you can click on the |SAVE| button on the Toolbar or choose |FILE|SAVE| or |FILE|SAVE AS| from the Menu Bar to launch the standard Windows |Save As| dialog box. If you open a saved analysis, and then make changes to it, clicking on the |SAVE| button on the Toolbar or choosing |FILE|SAVE| from the Menu Bar will overwrite the contents of your original file with the current analysis settings; if you want to save these changes to a new file, you must choose |FILE|SAVE AS| from the Menu Bar. If you forget to save before trying to exit the IWEM software, a dialog box will automatically ask if you want to save your data before exiting the software.

For each saved analysis, IWEM creates two project files:

- *.wem file
- *.mdb file

The combination of these two files completely describes the information you have entered (*.mdb) and any model-generated results (*.wem). The asterisk (*) is replaced by the name you assign to the project; the files will be saved in the project folder you specified.

Note that IWEM will not allow you to save both model inputs and results at a point where the inputs do not correspond to the model-generated results (e.g., when Tier 2 results have been generated, you return to an input screen, change an input and attempt to save the project). If you do choose to save your work in a situation like this, only the inputs will be saved; that is, when you later open up this file, you will have to run either the Tier 1 or Tier 2 analysis to create the corresponding results.

You may open a previously saved IWEM analysis by clicking on any one of the following options:

- |OPEN| button on the Toolbar
- |FILE|OPEN| selection from the Menu Bar
- |OPEN SAVED ANALYSIS (*.WEM FILE)| radio button from the |IWEM ANALYSIS OPTIONS| dialog box (see Item B in Section 5.3)

Once the |OPEN| dialog box is displayed, highlight the appropriate file and click the |OPEN| button to open the desired file. You will then see a dialog box in which you can specify what type of analysis you want to perform – Tier 1 or Tier 2 (see Item B in Section 5.3).

5.2.5 How Do I Get Help If I Have a Problem or a Question?

If you have a copy of the ***Guide*** CD, you can open and read this *User's Guide* on-screen while the IWEM software is running on your computer. You may find it easier to use IWEM's online help or to print out a copy of the *User's Guide* and refer to this hard copy while you are learning to use the IWEM software or to use the IWEM online |HELP| (see Section 5.2.3). This section of the *User's Guide* contains screen-by-screen instructions for using the software.

A dialog box containing a keyword or parameter definition used in IWEM can be displayed by clicking on any underlined text in the <u>Data Requirements</u> screen (see Screen 3, in Section 5.3). These definitions can also be displayed at any time by choosing |DEFINITION WINDOW| from the |HELP| menu.

If you have a technical question about installing or running the IWEM software, you should contact the RCRA Information Center. This information center is a publicly accessible clearinghouse that provides up-to-date information on RCRA rulemakings and responds to requests for regulatory publications and information resources. Please note that the information center cannot provide regulatory interpretations.

To get your technical questions about the IWEM software answered, please contact the RCRA Information Center in any of the following ways:

- E-mail: rcra-docket@epa.gov
- Phone: 703-603-9230
- Fax: 703-603-9234
- In person: Hours: 9:00 am to 4:00 pm, weekdays, closed on Federal Holidays
  Location: U. S. EPA
  West Building, Basement
  1300 Constitution Avenue, NW
  Washington, DC
- Mail: RCRA Information Center (5305W)
  U.S. Environmental Protection Agency
  Ariel Rios Building
  1200 Pennsylvania Avenue, NW
  Washington, DC 20460-0002

When contacting the RCRA Information Center, please cite RCRA Docket number: F1999-IDWA-FFFFF.

5.2.6 How Do I Begin Using the IWEM Software?

The following subsections provide a screen-by-screen tutorial that describes the data you are asked to enter at each screen and your data entry options (for instance, some Tier 2 input data are required and others are optional). The guidance will assist you in performing a Tier 1 and a Tier 2 analysis for an industrial WMU to determine the minimum recommended WMU design that will be protective of ground water. You will not need all the information provided here because this document addresses all WMU liner designs and several different levels of site-specific data for Tier 2. Follow only those subsections that are applicable to your particular waste and WMU.

5.3 Introductory Screens (Screens 1 through 5)

The text on Screens 1 through 5 provides a brief introduction to the IWEM software. Specifically, these screens present an overview of IWEM statement regarding proper use of the model and coordination with regulatory agencies, a list of data input requirements, a summary of model limitations, and the option to begin a Tier 1 or Tier 2 evaluation.

The key operational features of the introductory screens are as follows.

The features identified in Figures 5.9 through 5.13 are explained in more detail in the following paragraphs.

A. Explanatory Text about IWEM

The following five screens contain brief introductory information on the following aspects of the software:

- Screen 1: An overview of the IWEM software
- Screen 2: How to use IWEM
- Screen 3: Data requirements
- Screen 4: Model limitations
- Screen 5: Evaluation types

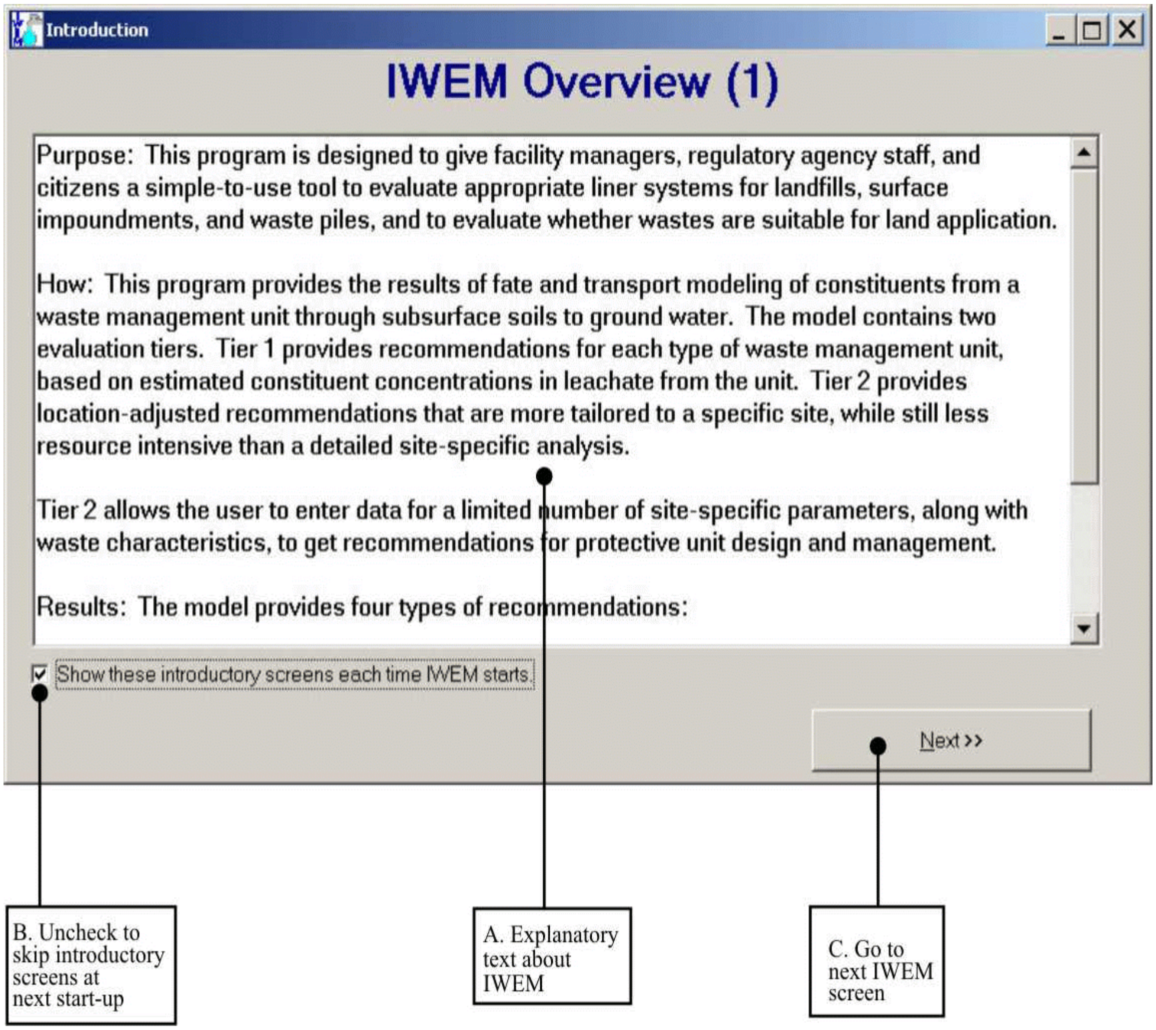


Figure 5.9 Introduction: IWEM Overview (1).

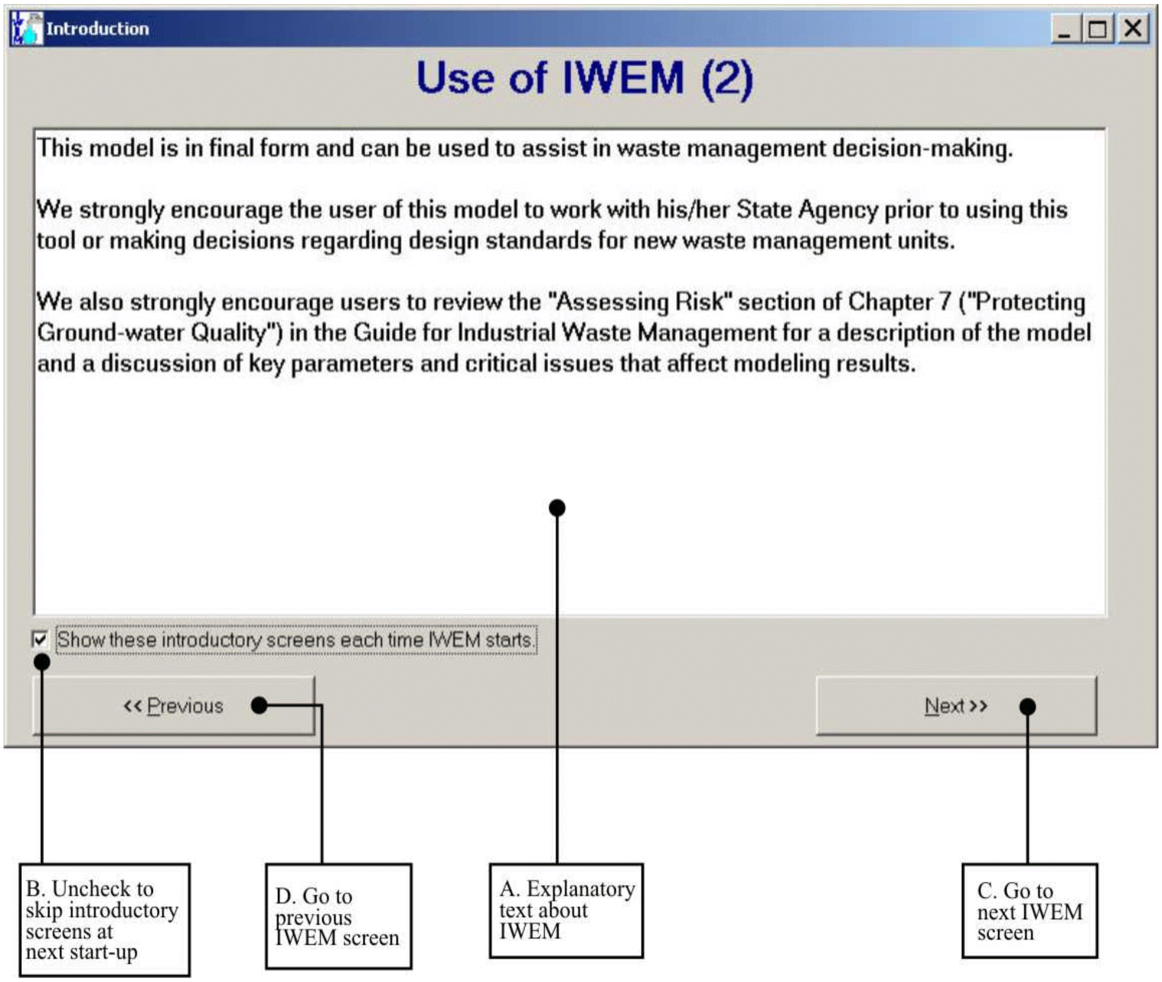


Figure 5.10 Introduction: Use of IWEM (2).

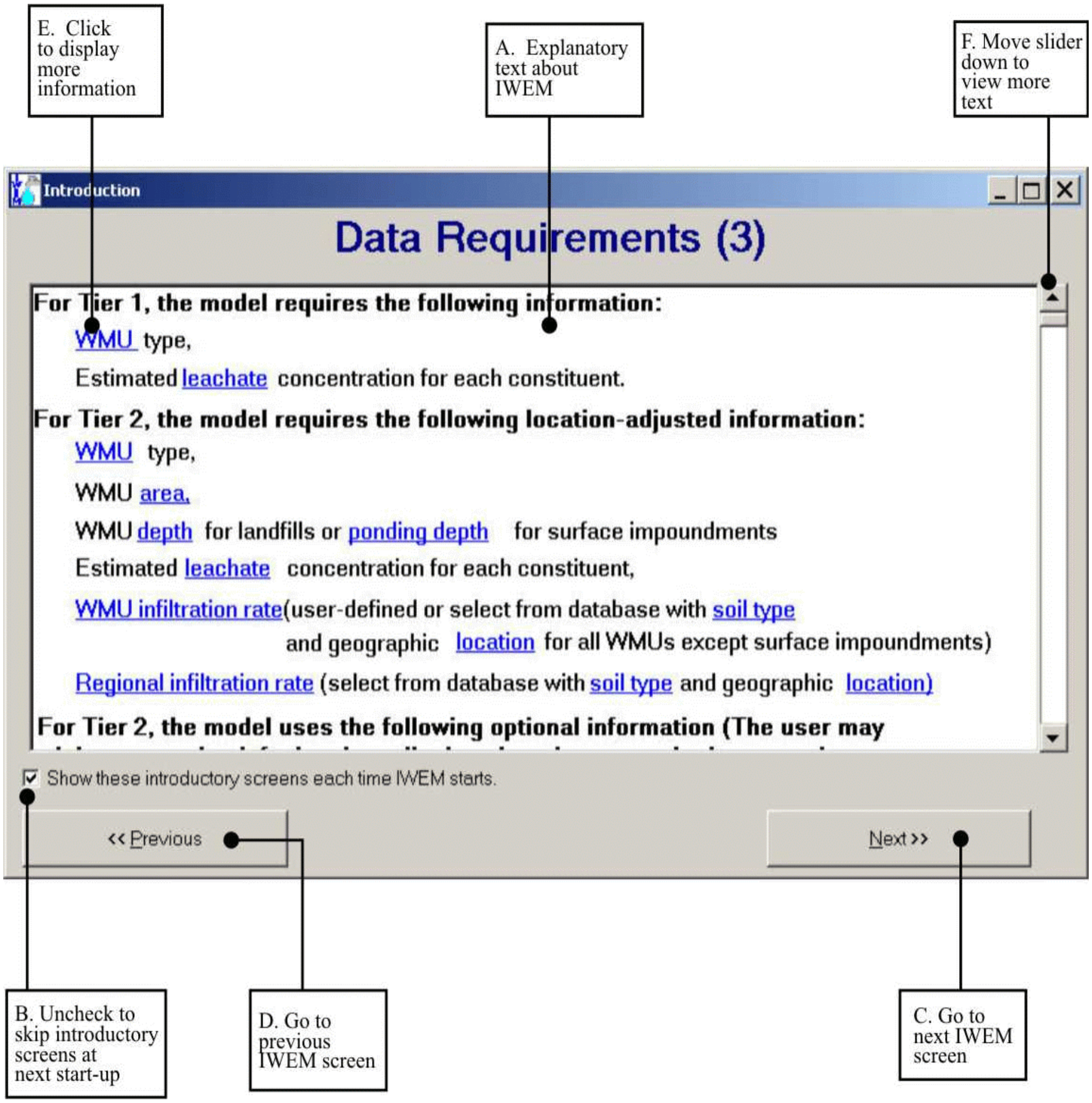


Figure 5.11 Introduction: Data Requirements (3).

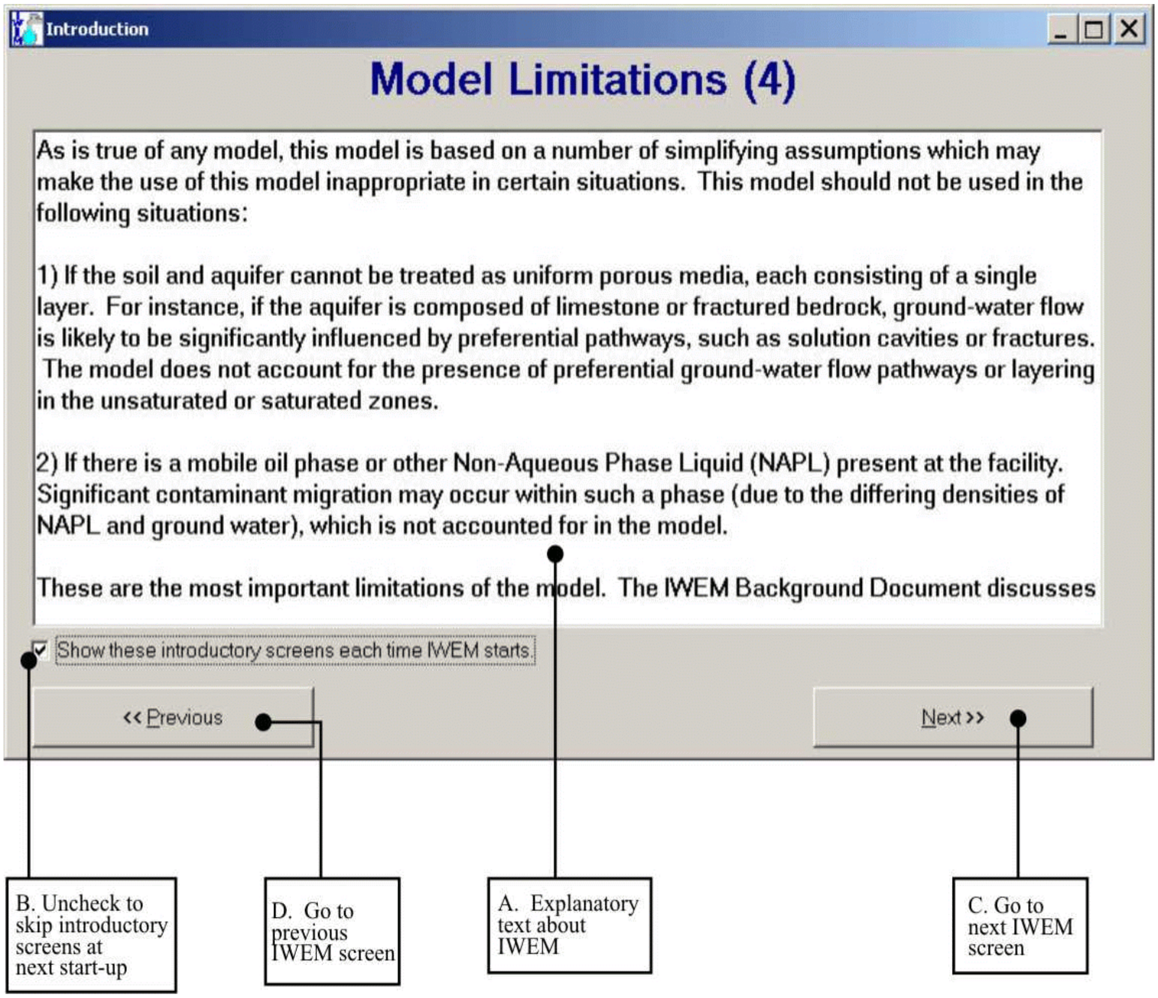


Figure 5.12 Introduction: Model Limitations (4).

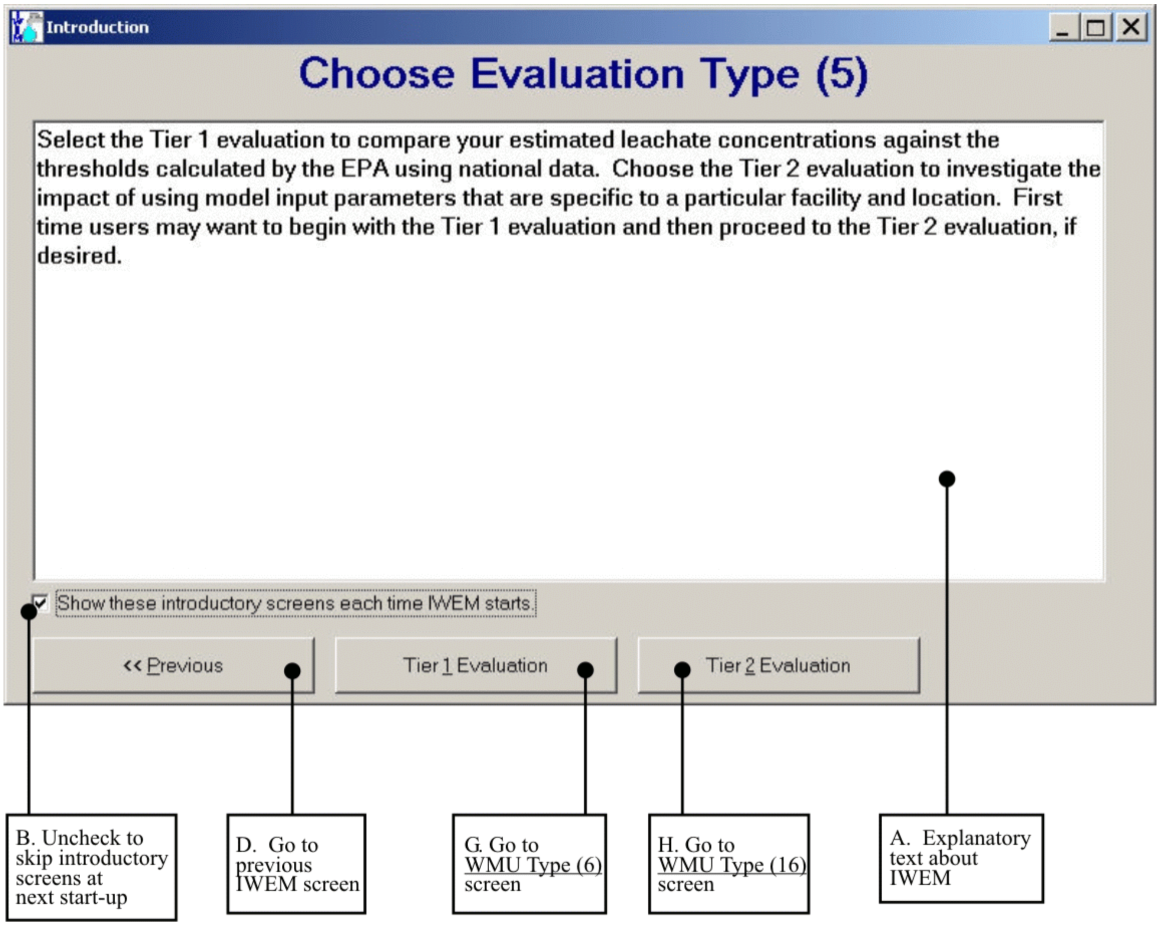
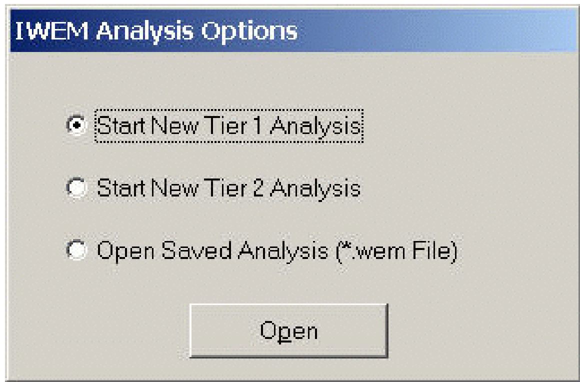


Figure 5.13 Introduction: Choose Evaluation Type (5).

B. Uncheck to Skip Introductory Screens at Next Start-up

After reading this introductory information, you can uncheck the |SHOW THESE INTRODUCTORY SCREENS EACH TIME IWEM STARTS| check-box at the bottom of the screen to prevent these screens from being displayed the next time the program is run. The introductory information can be viewed at any time by choosing |INTRODUCTION| from the |HELP| menu.

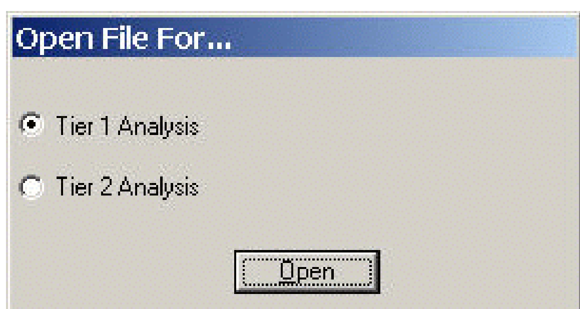
If you uncheck this check box, the next time you launch IWEM, you will see the following dialog box:



Select the |START NEW TIER 1 ANALYSIS| radio button and click the |OPEN| button to start a new Tier 1 analysis; doing so will take you directly to the <u>WMU Type (6)</u> screen – the first Tier 1 input screen.

Select the |START NEW TIER 2 ANALYSIS| radio button and click the |OPEN| button to start a new Tier 2 analysis; doing so will take you directly to the <u>WMU Type (16)</u> screen – the first Tier 2 input screen.

Select the |OPEN SAVED ANALYSIS (*.wem FILE)| radio button and click the |OPEN| button to open a previously saved IWEM analysis; doing so will launch the familiar Windows |OPEN| dialog box where you can navigate to the folder and file containing the previously saved IWEM analysis. This file will have a ".wem" file extension. After you select the appropriate file, the following dialog box will be displayed:



You can select the |TIER 1 ANALYSIS| radio button and click the |OPEN| button to open your saved analysis in Tier 1; doing so will take you directly to the <u>WMU Type (6)</u> screen – the first Tier 1 input screen. Or, you can select the |TIER 2 ANALYSIS| radio button and click the |OPEN| button to open your saved analysis in Tier 2; doing so will take you directly to the <u>WMU Type (16)</u> screen – the first Tier 2 input screen. By default, IWEM will open the file for a Tier 1 analysis.

C. Go to Next IWEM Screen

Click the |NEXT| button at the bottom right of the screen to proceed to the next screen.

D. Go to Previous IWEM Screen

Click the |PREVIOUS| button at the bottom left of the screen to go back to the previous introductory screen.

E. Click to Display More Information

Clicking on any keyword displayed in blue underlined text will display a text box containing a definition or other information about the underlined item. After reading the definition, you can click on the |OK| button at the bottom of the dialog box to close the text box and return to the <u>Data Requirements (3)</u> screen.

F. Move Slider Down to View More Text

Depending upon your monitor settings, you may need to use the scroll-bar on the far right side of these screens to display more text if the complete text does not fit on the screen all at once.

G. Go to <u>WMU Type (6)</u> screen

Click on the |TIER 1 EVALUATION| button to begin a Tier 1 analysis for your waste. Generally, you should perform the Tier 1 analysis first and then proceed on to the Tier 2 analysis, if appropriate. A Tier 1 evaluation begins at <u>WMU Type (6)</u> screen (Section 5.4).

H. Go to <u>WMU Type (16)</u> screen

Click on the |TIER 2 EVALUATION| button to begin a Tier 2 analysis for your waste. Generally, you should perform the Tier 1 analysis first and then proceed on to the Tier 2 analysis, if appropriate. However, if desired, you can proceed directly to Tier 2 by clicking this button. A Tier 2 evaluation begins at <u>WMU Type (16)</u> screen (Section 5.5).

You can also begin an evaluation by using either of these methods:

- Click on the |EVALUATION| menu and choose from |TIER 1| or |TIER 2|, or
- Click on the |T1| or |T2| toolbar buttons.

5.4 Tier 1 Evaluation

The IWEM Tier 1 analysis automates the comparison of your expected leachate concentration(s) with the Tier 1 LCTV lookup table to produce waste management recommendations for your particular waste. The IWEM Tier 1 analysis consists of four main screen groups: Tier 1 Input, Tier 1 Output (Summary), Tier 1 Output (Details), and Tier 1 Evaluation Summary. Each of the first three of these groups contains several screens.

The Tier 1 Input screen group consists of three screens:

- WMU Type (6)
- Constituent List (7)
- Leachate Concentration (8)

The Tier 1 Output (Summary) screen group consists of two screens:

- MCL Summary (9)
- HBN Summary (10)

The Tier 1 Output (Details) screen group consists of three screens:

- Results for No Liner (11) [based on MCL and HBN]
- Results for Single Liner (12) [based on MCL and HBN]
- Results for Composite Liner (13) [based on MCL and HBN]

The overall Tier 1 result is then displayed on the Tier 1 Evaluation Summary (14) screen.

The available options and data displayed on each of these screens are explained in the following sections.

5.4.1 Tier 1 Input Screen Group

5.4.1.1 Tier I Input: WMU Type (6)

This is the first input screen for a Tier 1 evaluation; you can select the WMU type and enter facility identification information on this screen, as explained below.

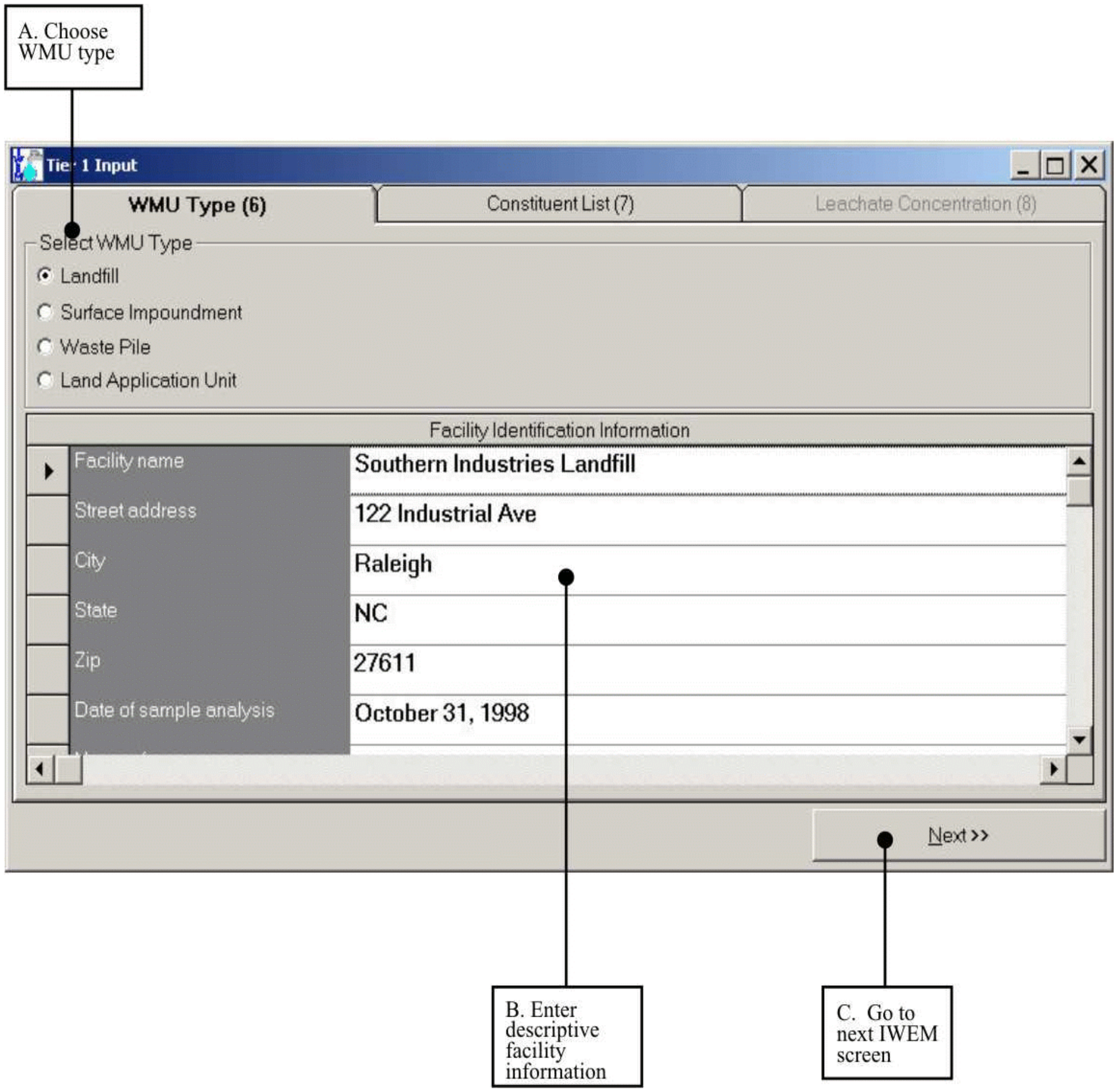


Figure 5.14 Tier 1 Input: WMU Type (6).

The features identified in Figure 5.14 are explained in more detail in the following paragraphs.

A. Choose WMU Type

First, select one of the following choices from the |SELECT WMU TYPE| option list by clicking on the appropriate option button:

- Landfill
- Surface Impoundment
- Waste Pile
- Land Application Unit

B. Enter Descriptive Facility Identification Information

Then, in the text boxes located in the lower half of the screen, enter the following information about the WMU being evaluated:

- Facility name
- Address of the WMU (street, city, state, zip)
- Date of waste constituent sample analysis
- User name (name of the person performing the liner evaluation)
- Any additional identifying information that you would like to include

All facility identification information will be included on the printed Tier 1, and if performed, Tier 2 Evaluation Reports.

C. Go to Next IWEM screen

After entering your site information, click the |NEXT| button at the bottom right of the screen to proceed to the next screen.

5.4.1.2 Tier I Input: Constituent List (7)

On this screen you can, select constituents expected in leachate by searching for the name or CAS number or by scrolling through the displayed list of IWEM constituents, as explained below.

What waste constituents can I enter in the IWEM software?

On the Constituent List (7) screen, you will find the list of waste constituents that are included in the IWEM database. This list of constituents includes 206 organics and 20 metals. These constituents are presented in Appendix A.

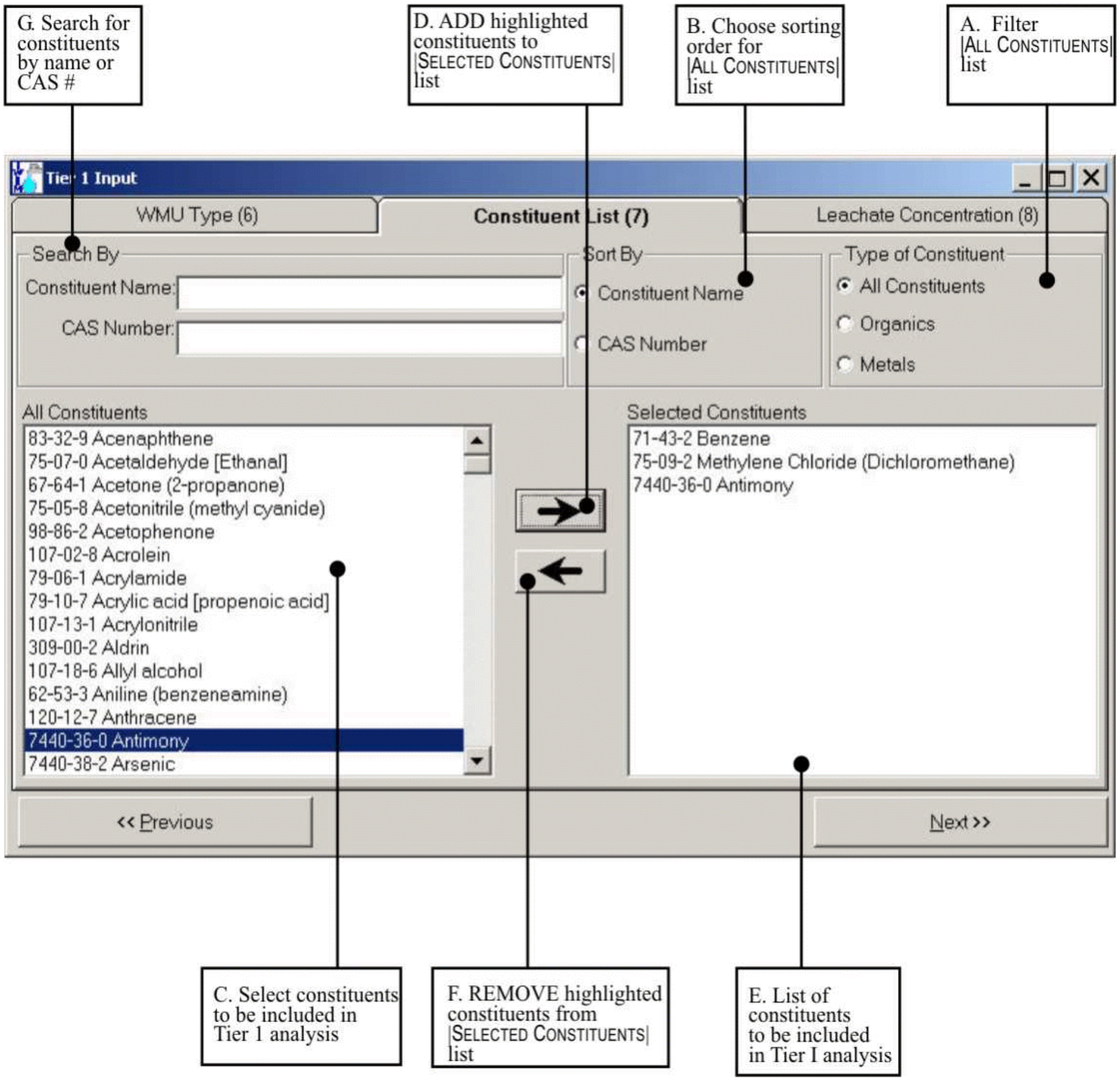


Figure 5.15 Tier 1 Input: Constituent List (7).

The features identified in Figure 5.15 are explained in more detail in the following paragraphs.

A. Filter |ALL CONSTITUENTS| *List*

You can choose to display only organics, only metals, or all constituents by clicking one of the radio buttons within the frame titled |TYPE OF CONSTITUENT|.

B. Choose Sorting Order for |ALL CONSTITUENTS| List

You can determine whether the constituents are sorted by name or by CAS number by clicking one of the radio buttons within the frame titled |SORT BY|.

C. Select Constituents to be Included in Tier 1 Analysis

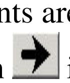
The following keyboard functions simplify the selection of more than one waste constituent:

- To add a group of constituents that are displayed sequentially in the list (that is, one after another without any non-selected constituents in the middle), click on the first desired waste constituent, press down the |SHIFT| key, and then click on the last desired waste constituent. All waste constituents listed between the first and last chosen constituents should now be highlighted.

- To add a number of constituents that not are displayed sequentially, click on the first waste constituent, and then hold down the |CONTROL| (Ctrl) key while selecting additional constituents using the mouse.

Once your selection is complete, use the |ADD| button (described below) to transfer all the highlighted constituents to your list.

D. Add Highlighted Constituents to |SELECTED CONSTITUENTS| List

Once the appropriate constituents are highlighted in the list (on the left of the screen), you can click the |ADD| button  in the center of the screen to transfer it to your list of constituents present in the leachate (on the right side of the screen). Note that a waste constituent can also be added quickly to your list by double-clicking on it in the list on the left. Likewise, multiple selections can be added using the same technique: double-clicking on your highlighted list of constituents once you have created it using the |SHIFT| or |CONTROL| keys, as described above.

E. List of Constituents to be Included in Tier 1 Analysis

After adding a constituent to your analysis, that constituent's name and CAS number will appear in the |SELECTED CONSTITUENT| listbox on the right side of the screen.

F. Remove Highlighted Constituents from |SELECTED CONSTITUENTS| *List*

Similarly, you can click the |REMOVE| button  to remove highlighted constituent(s) from your list of selected constituents. You may also use the short-cut techniques previously described in item D above (|SHIFT| and |CONTROL| keys, double-clicking) to delete constituents.

G. Search for Constituents by Name or CAS Number

As an alternative to selecting constituents by scrolling through the display list, you can search for constituents by entering their name or CAS number in the |SEARCH BY| box at the top-left of the screen. IWEM will match the name or CAS number to its database while you type and as soon as you have typed in enough information to identify one of the listed constituents, that waste constituent will be highlighted in the list. You can use the |ARROW| keys on the keyboard to move up or down the list if the highlighted constituent is not exactly the one you intended to select.

You can move through the constituent display list to select a particular constituent by using any of these methods:

To move through the list of waste constituents:

1) Use the scroll bar at the right of the displayed list

2) Use the |ARROW| keys on the keyboard (once one constituent in the list is selected)

3) Type in the constituent name or CAS number in the |SEARCH BY| text box

Once your list of waste constituents is complete, you can proceed with the Tier 1 evaluation by clicking on either the screen titled |LEACHATE CONCENTRATION| or the |NEXT| button at the bottom of the screen.

5.4.1.3 Tier I Input: Leachate Concentration (8)

On this screen, you can enter the expected leachate concentration (in milligrams per liter [mg/L]) for each selected waste constituent, as explained below. Please see Chapter 2 - Waste Characterization of the ***Guide*** for analytical procedures that can be used to determine leachate concentrations for waste constituents.

The Tier 1 Evaluation cannot be performed until an expected leachate concentration is entered for each selected waste constituent.

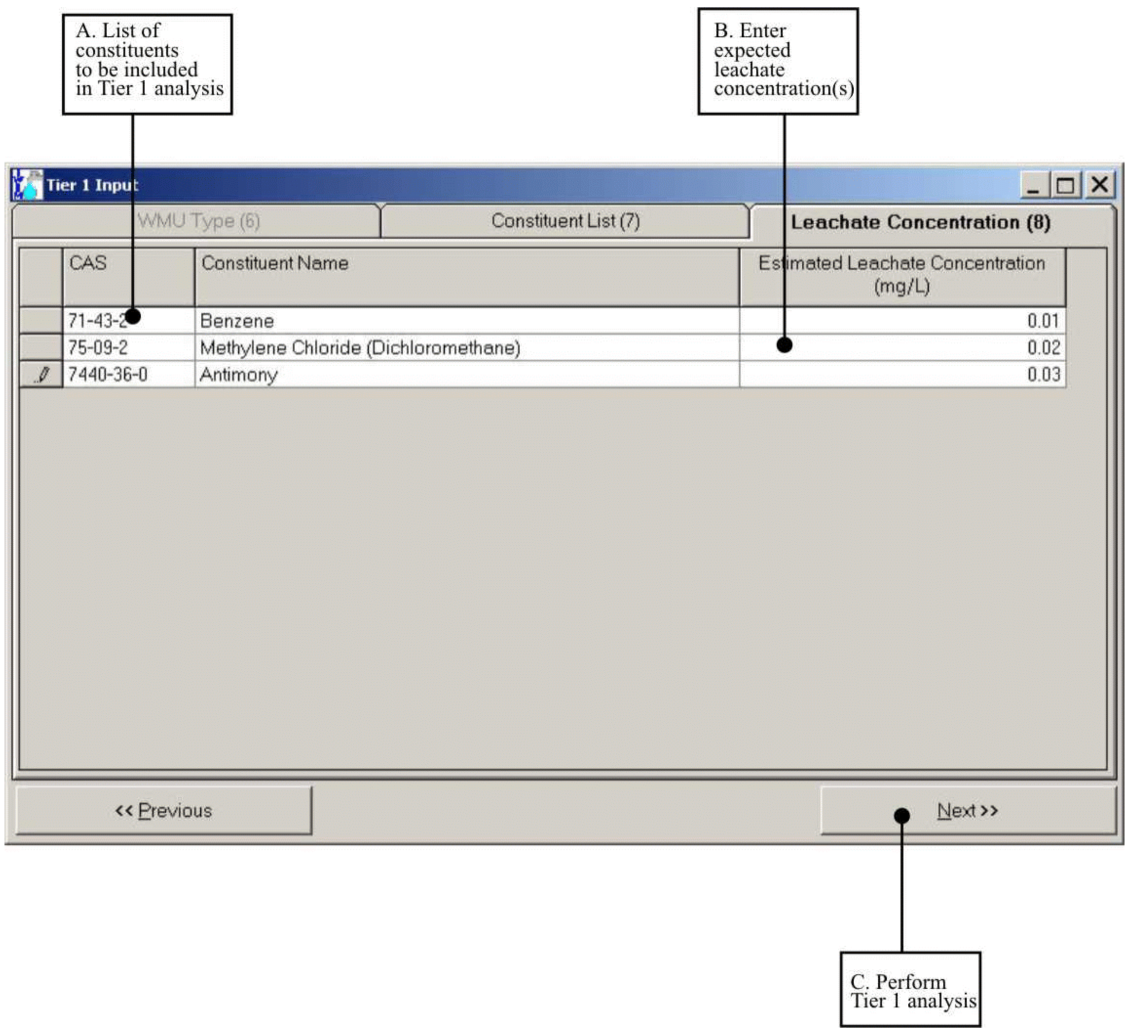


Figure 5.16 Tier 1 Input: Leachate Concentration (8).

The features identified in Figure 5.16 are explained in more detail in the following paragraphs.

A. List of Constituents to be Included in Tier 1 Analysis

The constituent names and CAS numbers for all selected waste constituents will appear in the table on this screen.

B. Enter Expected Leachate Concentration(s)

This table is similar to a spreadsheet. Using the mouse, click on the first empty cell in the |ESTIMATED LEACHATE CONCENTRATION| column, and type in your expected leachate concentration. The concentration must be entered in units of mg/L, and cannot exceed 1,000 mg/L.[1] The IWEM software will display a warning message similar to the one shown below (after the description of item C) if you enter an expected leachate concentration that exceeds the solubility of that constituent, as cited in the IWEM database. If you accidentally entered the wrong value, click the |YES| button and correct the expected leachate concentration on the <u>Leachate Concentration (8)</u> screen. If you want to proceed with the evaluation using your entered value, click the |NO| button. In this case, a similar warning message about your input leachate concentration will be included in the printed report.

After entering the expected leachate concentration for the first selected constituent, then click on the cell below, press the |TAB| key, or press the |ARROW-DOWN| key to move to the next cell and enter the next concentration. Repeat this process until you have entered expected leachate concentrations for all waste constituents. You can move up and down through the list of leachate concentration values and edit them by using the |ARROW-UP| and |ARROW-DOWN| keys on your keyboard or by using the mouse to click on the value that you want to change and entering a new concentration value.

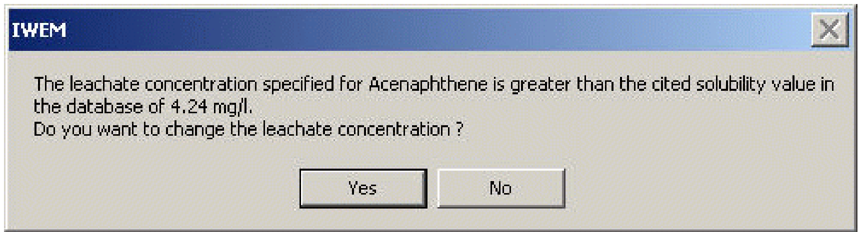
C. Perform Tier 1 Analysis

Simply click on the |NEXT| button at the bottom right of the screen to perform the Tier 1 evaluation and view your results. Before allowing you to proceed, IWEM will check to make sure that you have entered a leachate concentration for all constituents, and will compare the leachate concentration(s) to the corresponding solubility limits in the

---

[1] EPA does not expect leachate concentrations from units covered by this guidance to exceed 1,000 mg/L for a single constituent. Additionally, the fate and transport assumptions in IWEM may not be valid at high concentrations. Therefore, the EPA has designed IWEM so that the input expected leachate concentrations are not allowed to exceed 1,000 mg/L.

constituent database. If any leachate concentration(s) exceed the solubility limit, the following warning message will be displayed to alert you and to ask if you want to change the concentration value. If you select |No|, the analysis will proceed.



5.4.2 Tier I Output (Summary) Screen Group: MCL Summary and HBN Summary (9 and 10)

The IWEM Tier 1 analysis is essentially a query to an existing database of modeling results. The results of this database query are immediately presented in summary form on screens 9 and 10, as shown below in Figures 5.17 and 5.18.

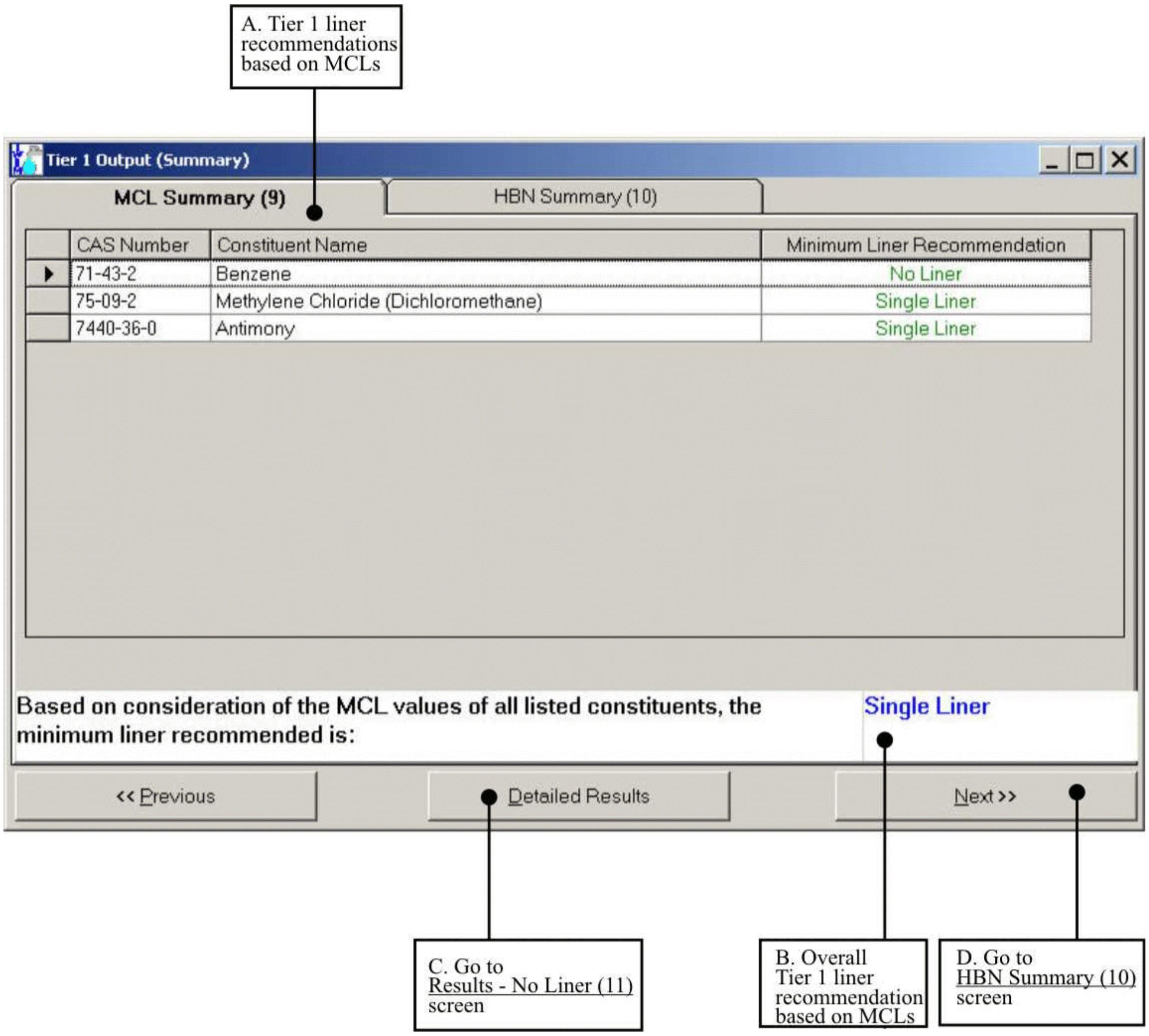


Figure 5.17 Tier 1 Output (Summary): MCL Summary (9).

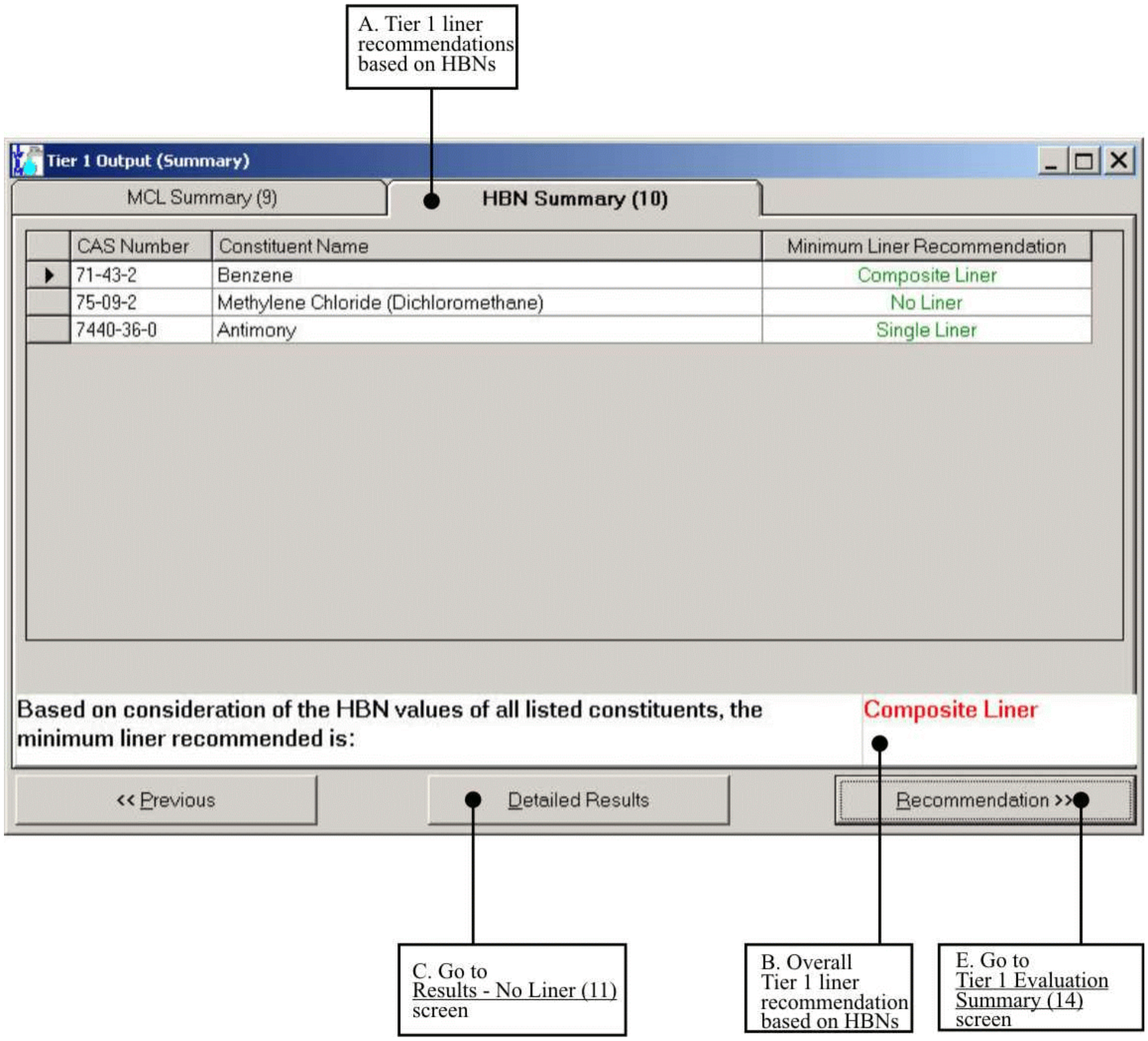


Figure 5.18 Tier 1 Output (Summary): HBN Summary (10).

The features identified in Figures 5.17 and 5.18 are explained in more detail in the following paragraphs.

A. Tier 1 Liner Recommendations Based on MCLs/HBNs

The results of the Tier 1 Evaluation are first presented on-screen in summary form. The summary results are divided into two screens: one, for LCTVs calculated based on MCLs; and one, for LCTVs calculated based on HBNs.

Not all waste constituents have both an MCL and an HBN. The MCL summary screen provides a minimum liner recommendation for each of the selected constituents that have an MCL. Likewise, the HBN screen presents a minimum liner recommendation for each of the selected constituents that have an HBN. These recommendations are based on a comparison of the expected leachate concentration for that constituent to the calculated LCTV using the constituent-specific MCL or HBN. For those constituents that have more than one HBN, the LCTV is calculated for each HBN, and the HBN that produces the lowest LCTV is used to determine the Tier 1 liner recommendation. The value and type (pathway and effect) of the controlling HBN are shown on the Detailed Results screens (11 through 13).

For each constituent in an IWEM Tier 1 evaluation, a liner recommendation that is protective is presented in green text. If the composite liner scenario is not protective, this message is presented in red text. If a constituent does not have a liner recommendation on the MCL Summary (9) screen because it does not have an MCL, this message is presented in black text.

B. Overall Tier 1 Liner Recommendation Based on MCLs/HBNs

This text box displays an overall minimum liner recommendation which is based on consideration of all waste constituents.

The overall liner recommendation may be different based upon whether HBNs or MCLs are being used. Depending upon the waste constituents being evaluated and the appropriate RGC for each, you may have to create for yourself a final list of LCTV values and minimum liner recommendations, some based on MCLs and some based on HBNs. You should obtain direction from your state regulatory authority regarding which RGC should be used for the Tier 1 evaluation of a particular waste.

C. Go to Results - No Liner (11) screen

Clicking on this button will take you to a detailed listing of the Tier 1 results, including the constituent-specific LCTVs for all evaluated liner scenarios.

D. Go to HBN Summary (10) screen

Clicking on this button will take you to minimum liner recommendations based on a comparison of expected leachate concentrations to calculated LCTVs.

E. Go to <u>Tier 1 Evaluation Summary (14)</u> screen

Clicking on this button will skip over the Tier 1 detailed results and will take you directly to the Tier 1 Evaluation Summary Screen where you can choose to view the Tier 1 report or proceed on to a Tier 2 Evaluation.

5.4.3 Tier 1 Output (Details) Screen Group: Results - No Liner, Single Clay Liner, and Composite Liner (11, 12, and 13)

Clicking the |DETAILED RESULTS| button leads you to the detailed results of the Tier 1 Evaluation. This screen group consists of the following three screens, one for each liner scenario: no liner; single clay liner; and composite liner. Each screen presents results based on MCL and HBN reference concentrations for one of the liner scenarios.

The layout of these screens is the same, the only difference is the liner scenario, which is indicated on the tab showing the screen name.

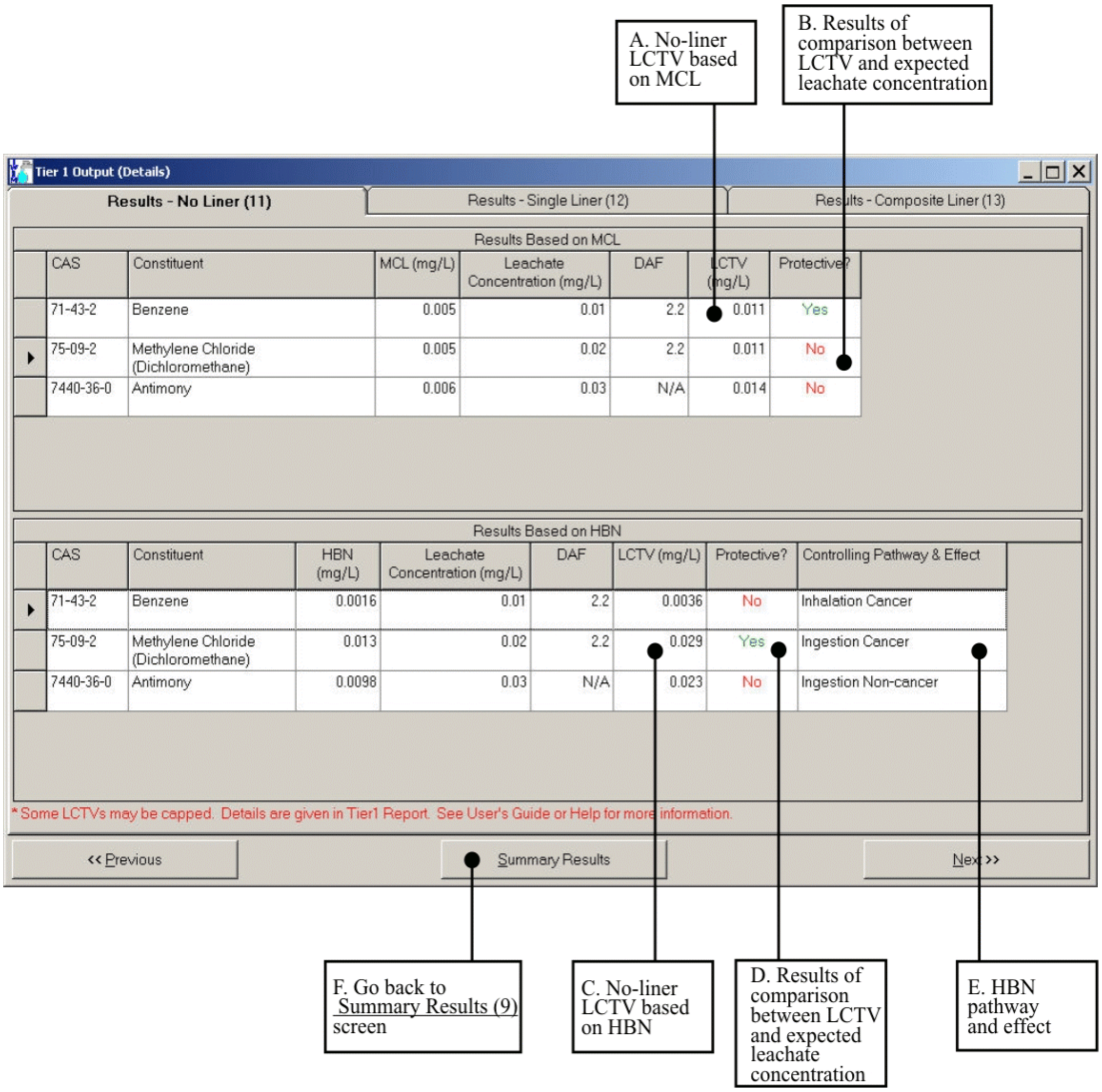


Figure 5.19 Tier 1 Output (Details): Results - No Liner (11).

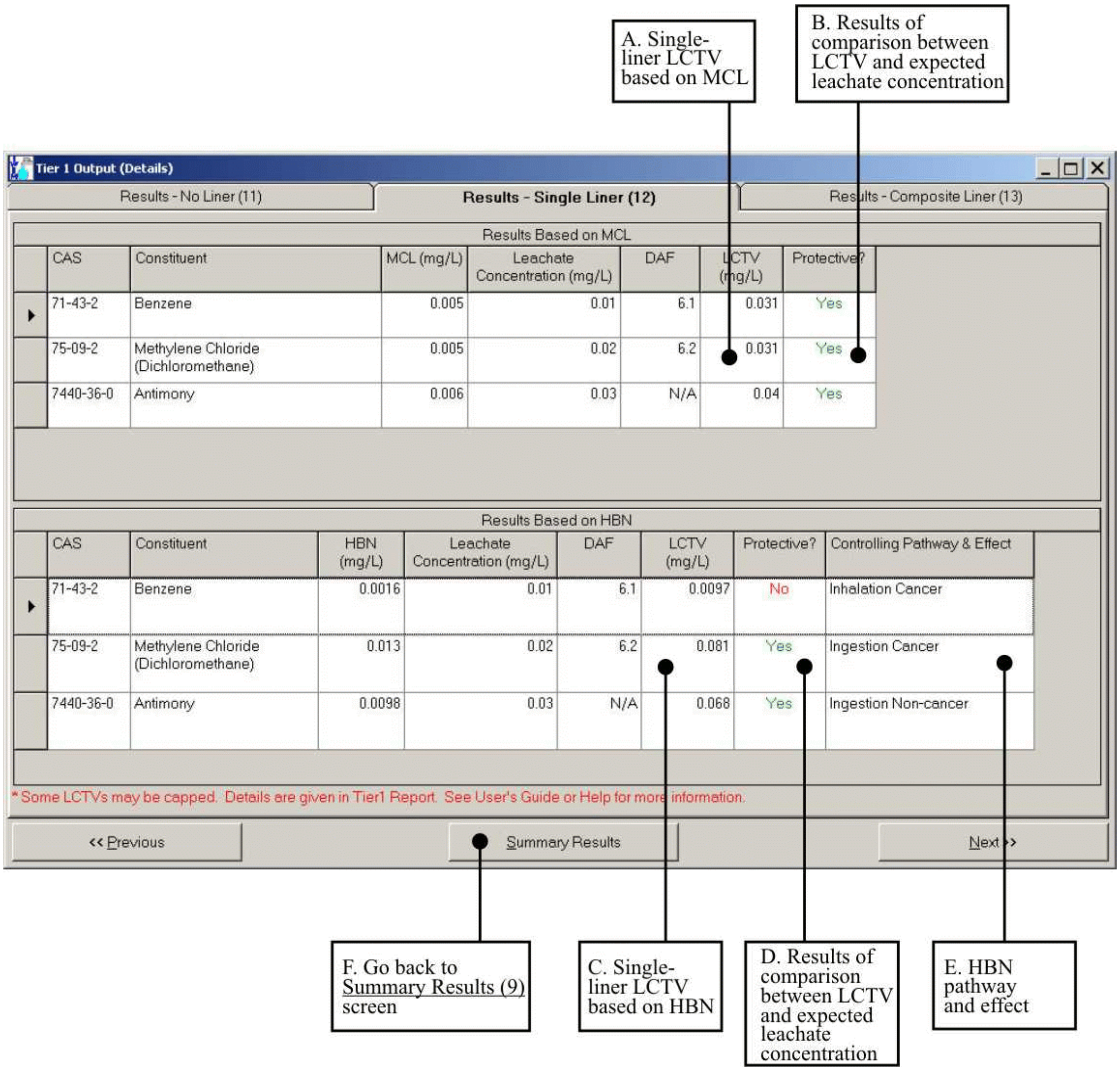


Figure 5.20 Tier 1 Output (Details): Results - Single Clay Liner (12).

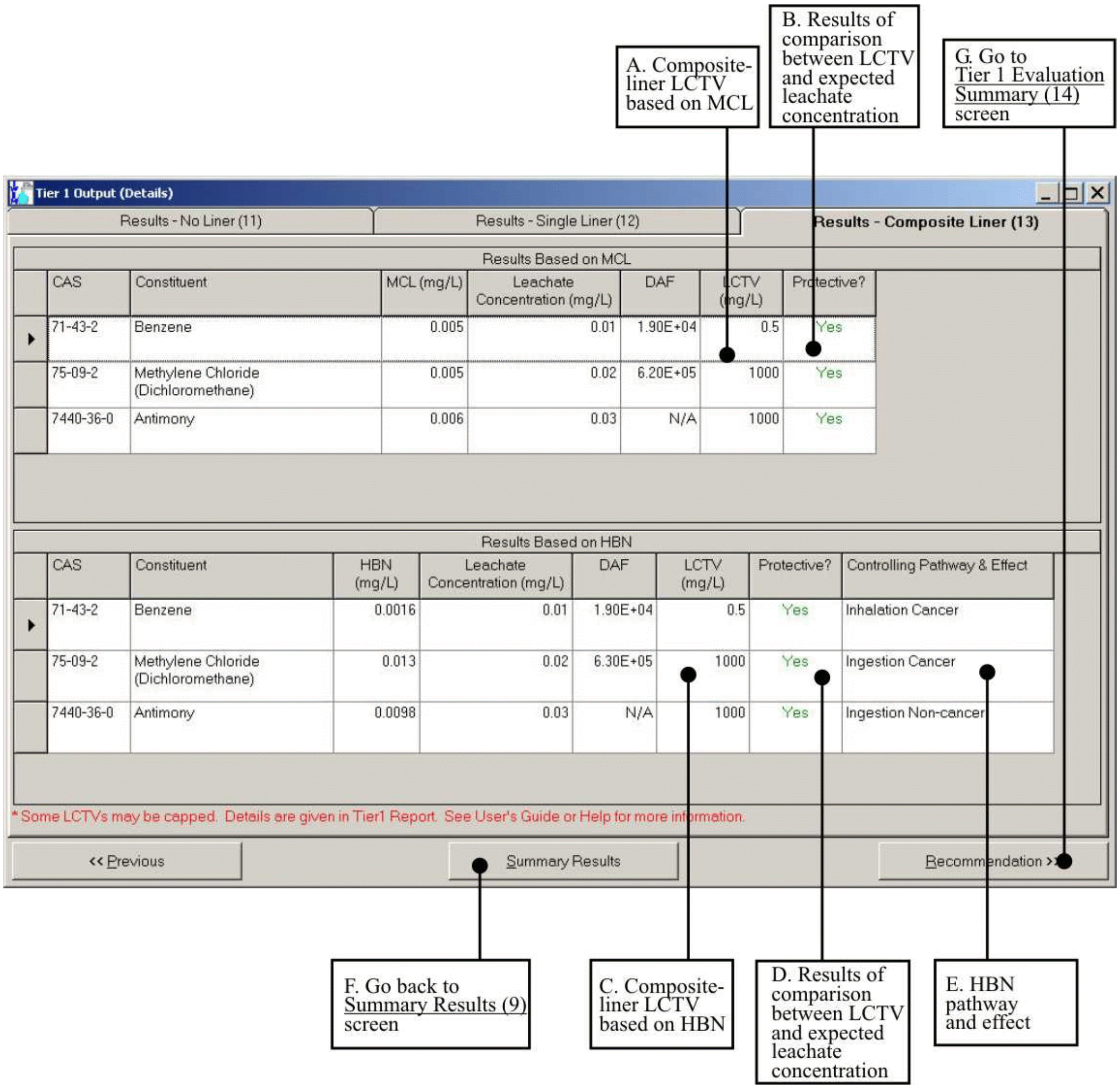


Figure 5.21 Tier 1 Output (Details): Results - Composite Liner (13).

The features identified in Figures 5.19 through 5.21 are explained in more detail in the following paragraphs.

A. Liner-Specific LCTV based on MCL

The Tier 1 constituent- and liner-specific LCTV is displayed on this screen. An LCTV is the maximum concentration of a constituent in the waste leachate that is protective of ground water. That is, if the concentration in the leachate does not exceed the LCTV, then the modeled concentration in ground water (at the modeled well) will not exceed the MCL for that constituent.

B. Results of Comparison between LCTV and Expected Leachate Concentration

The data displayed in the top window of the screen present the result on which the liner recommendation is based for each selected constituent. The last column in the table (with the header │PROTECTIVE?│) tells you whether or not the specified liner is protective of ground water for that constituent. This determination is made by comparing the entered leachate concentration with the LCTV calculated from the MCL. If the expected leachate concentration is greater than the LCTV, the liner is not recommended as being protective ("No"), whereas, if the expected leachate concentration is less than the LCTV, the liner is recommended as being protective ("Yes"). If the LCTV is not calculated for that constituent because the MCL is not available, "NA" (not applicable) is displayed in this cell.

To properly interpret the results of the Tier 1 Evaluation, you should consult with the appropriate state regulatory agency to determine which RGC should be used for each constituent of concern. For wastes with multiple constituents of concern, you may need to construct your own final list of liner recommendations, some from LCTVs based on MCLs and some from LCTVs based on HBNs.

For waste streams with multiple constituents, the most protective liner specified for any one constituent is the overall recommended liner type.

C. Liner-Specific LCTV based on HBN

The Tier 1 constituent- and liner-specific LCTV is displayed on this screen. An LCTV is the maximum concentration of a constituent in the waste leachate from a modeled WMU that is protective of ground water. That is, if the concentration in the leachate does not exceed the LCTV, then the modeled concentration in ground water (at the modeled well) will not exceed the HBN for that constituent.

D. Results of Comparison between LCTV and Expected Leachate Concentration

The data displayed in the bottom window of the screen present the liner recommendation for each selected constituent. The column with the header |PROTECTIVE?| tells you whether or not the specified liner is protective of ground water for that constituent. This determination is made by comparing the entered leachate concentration with the LCTV based on the most protective HBN. If the expected leachate concentration is greater than the LCTV, the liner is not recommended as being protective ("No"), whereas, if the expected leachate concentration is less than the LCTV, the liner is recommended as being protective ("Yes").

To properly interpret the results of the Tier 1 evaluation, you should consult with the appropriate state regulatory agency to determine which RGC should be used for each constituent of concern. For wastes with multiple constituents of concern, you may need to construct your own final list of liner recommendations, some from LCTVs based on MCLs and some from LCTVs based on HBNs.

For waste streams with multiple constituents, the most protective liner specified for any one constituent is the overall recommended liner type. For constituents that have more than one HBN, IWEM calculates the LCTV for each HBN and uses the HBN that produces the lowest LCTV to determine the Tier 1 liner recommendation.

E. HBN Pathway and Effect

The exposure pathway and health effect for the HBN that is used to calculate the LCTV, that is, the controlling HBN, is displayed in the column labeled |CONTROLLING PATHWAY & EFFECT|. IWEM accounts for direct ingestion and inhalation pathways, and carcinogenic and non-carcinogenic health effects. The |HBN| column in the table shows the value, in mg/L, of the controlling HBN.

F. Go Back to the Summary Results (9) screen

Clicking on this button will take you back to the Tier 1 MCL Summary Results (9) screen.

G. Go to Tier 1 Evaluation Summary (14) screen

Clicking on the |RECOMMENDATION| button on screen 13 will take you to the next screen, the Tier 1 Evaluation Summary screen, where you can choose to view the printable Tier 1 report, or proceed on to a Tier 2 evaluation.

5.4.4 Tier 1 Evaluation Summary Screen (14)

This screen (Figure 5.22) contains an overall summary of the Tier 1 evaluation results along with options for further (Tier 2) evaluation. You can also view or print a report of the Tier 1 evaluation by clicking on the REPORT button at the bottom of the screen.

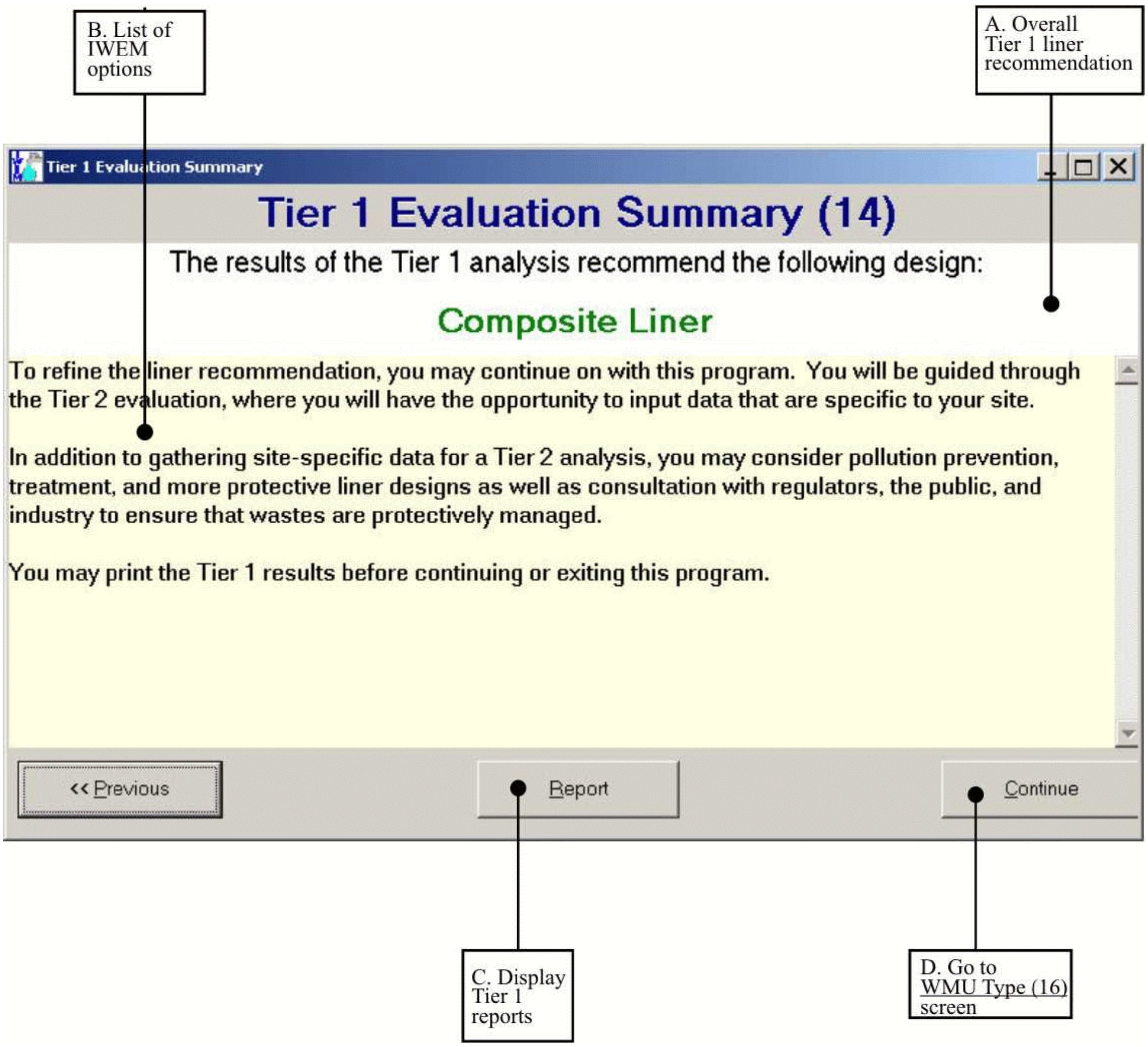


Figure 5.22 Tier 1 Evaluation Summary (14).

The features identified in Figure 5.22 are explained in more detail in the following paragraphs.

A. Overall Tier 1 Liner Recommendation

The Tier 1 liner recommendation, based on consideration of all available RGC values for each waste constituent, is displayed at the top of this screen. For landfills, surface impoundments, and waste piles the available recommendations are: "no liner," "single clay liner," "composite liner," or "not protective." For LAUs, the available recommendations are: "no liner" or "not protective." If your Tier 1 evaluation results in a recommendation of "not protective," this indicates that either the chosen WMU is not appropriate for managing your waste or you may need to continue to a Tier 2 or Tier 3 analysis to further evaluate your site.

B. List of IWEM Options

After reviewing your Tier 1 results on-screen, you can choose to continue by,

- Going back to the previous screens of the Tier 1 results by clicking on the |PREVIOUS| button,
- Viewing the Tier 1 report by clicking the |REPORT| button, or
- Beginning a Tier 2 Evaluation by clicking the |CONTINUE| button.

Or, you can choose to save your results and exit IWEM as described in Section 5.2.4 of this *User's Guide*.

C. Display Tier 1 Reports

Clicking on the |REPORT| button first displays a dialog box with the following question:

|DO YOU WANT TO SHOW THE DETAILS ?|

Choosing |NO| will display a summary version of the IWEM Tier 1 Report. This short version of the report includes the following information and data:

- Facility data entered on Screen 6
- List of selected constituents and their corresponding leachate concentrations
- Tier 1 summary results for each selected constituent, based on both MCLs and HBNs
- Tier 1 detailed results for each selected constituent, based on both MCLs and HBNs, and including an explanation of any caps or warnings that apply to the presented LCTVs

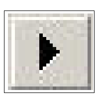
Choosing |YES| will display a complete version of the IWEM Tier 1 Report. This detailed version of the report includes the following additional information and data:

- Constituent properties and RGCs for each selected constituent, including full references for the data sources.

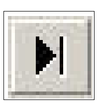
After making your choice, the selected report will be displayed on-screen. The following toolbar buttons to print, save, and scroll through the pages of the report are provided along the top of the screen:

Print the report; the |PRINT| dialog box allows you to adjust printer settings or print all or selected pages.

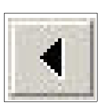
Export the report in order to save it to a file; after specifying the file type, destination type, and the pages to be included, the |CHOOSE EXPORT FILE| dialog box then appears; you can specify the file type, and then select the file name and directory. The file types in this list are dependent upon what software you have installed on your personal computer. Most users will find that the option for PDF format will produce a document-ready report.



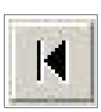
View the next page of the report.



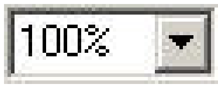
View the last page of the report.



View the previous page of the report.



View the first page of the report.



Change the display size of the report.

A Tier 1 Report Includes:

1) List of selected waste constituent(s) and constituent data
2) Minimum liner requirement based on MCLs
3) Minimum liner requirement based on HBNs
4) Data used to calculate the LCTV for each liner

An example Tier 1 report is included in this *User's Guide* in Appendix B.

D. Go to <u>WMU Type (16)</u> screen

Clicking here will take you to the Tier 2 Input screen. WMU Type, facility description information, and your list of selected Tier 1 constituents are automatically transferred to the Tier 2 analysis.

5.4.5 Exiting the IWEM software

You can exit the IWEM software by clicking on the |FILE| menu, and choosing |EXIT|. If you forget to save before trying to exit the IWEM software, a dialog box will ask if you want to save your data before exiting the software.

5.5 Tier 2 Evaluation

In a Tier 2 evaluation, IWEM analyzes available site-specific data to develop liner recommendations that are more tailored to your site conditions than the national, screening-level Tier 1 evaluations. This section of the *User's Guide* describes the Tier 2 input and results screens.

The main Tier 2 Input screen group (Figure 5.23) consists of the following screens and dialog boxes:

- WMU Type (16)
- WMU Parameters (17)
- Subsurface Parameters (18)
- Infiltration (19)
  - Climate Center List (19a)
- Constituent List (20)
  - Enter New Constituent Data (20a)
  - Add New Constituent (20b)
  - Add New Data Source (20d)
- Constituent Properties (21)
- Toxicity Standards (22)
- Input Summary (23)

After you complete the Tier 2 data inputs, IWEM will begin the Tier 2 analysis.

The Tier 2 Evaluation Run Manager (24) screen is displayed during the Tier 2 analysis. Depending upon the model inputs and the speed of your PC, a Tier 2 analysis may take anywhere from several minutes to several hours to complete.

The Tier 2 results are then presented on the Summary Results (25) screen. The Detailed Results screen for the Tier 2 Evaluation varies according to the option you chose for the infiltration rate. When using an IWEM-generated **location-based estimate of infiltration**, the Detailed Results screen for Tier 2 consists of either three screens (for landfills, surface impoundments, and waste piles) or one screen (for LAUs):

- Results – No Liner (26)
- Results – Single Clay Liner (27)
- Results – Composite Liner (28)

When using a **user-specified infiltration rate**, the Detailed Results screen for Tier 2 consists of only a single screen:

- User-Defined Liner Results (28)

The overall Tier 2 result is then displayed on the Tier 2 Evaluation Summary (29).

The available options and data displayed on each of these screens and dialog boxes are explained in the following sections.

5.5.1 Tier 2 Input Screen Group

If you begin with the Tier 1 Evaluation and choose to proceed to the Tier 2 Evaluation with the same selected constituents, then the WMU type, list of waste constituents, and the expected leachate concentrations specified in Tier 1 are automatically transferred to Tier 2. These values can also be edited in Tier 2, if desired.

5.5.1.1 Tier 2 Input: Waste Management Unit Type (16)

The first screen of the Tier 2 Input screen group, WMU Type (16), is identical to the Tier 1 WMU Type screen.

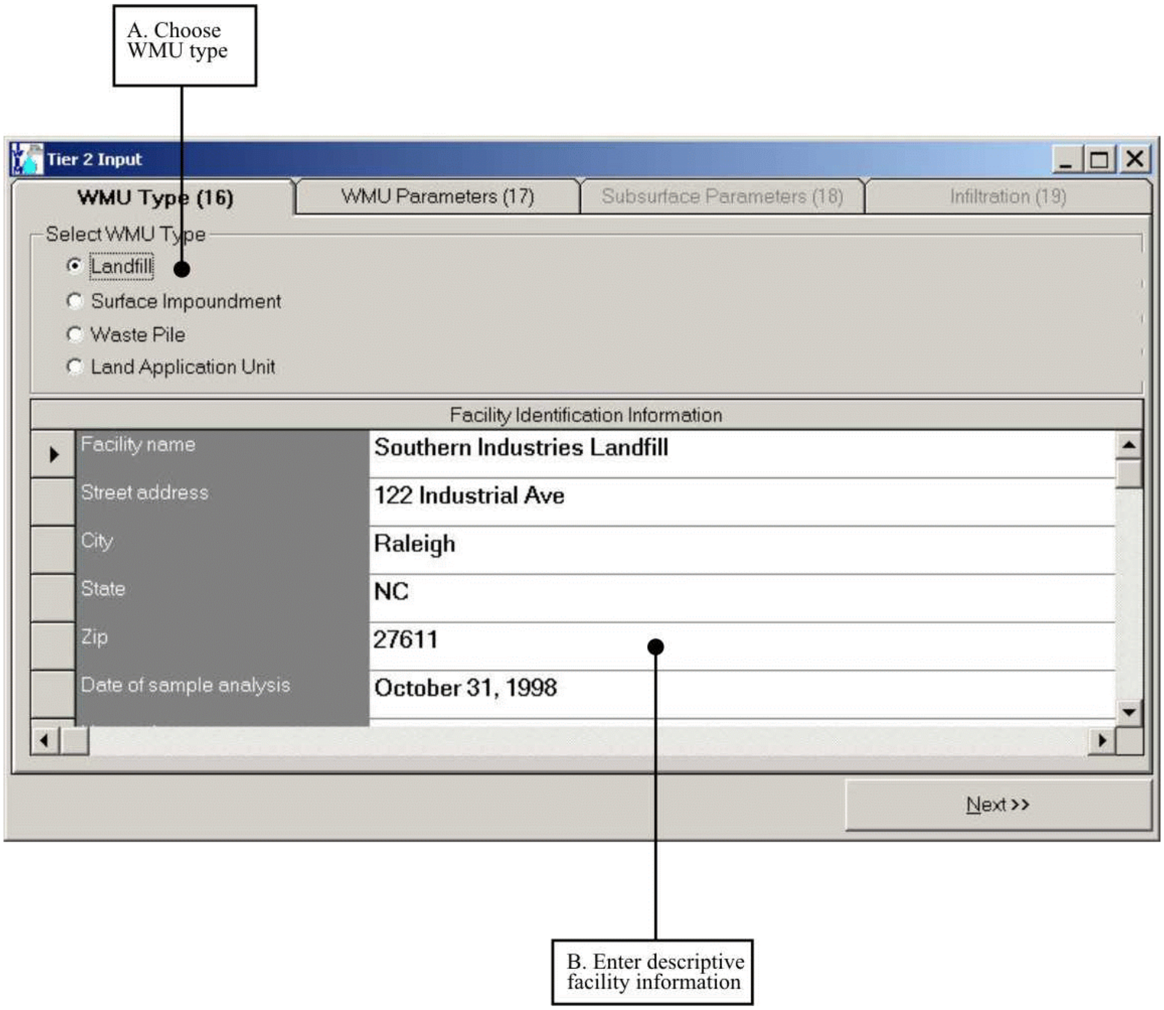


Figure 5.23 Tier 2 Input: WMU Type (16).

The features identified in Figure 5.23 are explained in more detail in the following paragraphs.

A. Choose WMU Type

First, select one of the following choices from the |SELECT WMU TYPE| option list by clicking on the appropriate radio button:

- Landfill
- Surface Impoundment
- Waste Pile
- Land Application Unit

B. Enter Descriptive Facility Information

In the text boxes located in the lower half of the screen, enter the following information about the WMU being evaluated:

- Facility name
- Address of the WMU (street, city, state, zip)
- Date of waste constituent analysis
- Your name (name of the person performing the liner evaluation)
- Any additional identifying information that you would like to include

All information entered in these text boxes will be included on the printed Tier 2 Evaluation Reports (and in the Tier 1 report, if these data were carried over from a previous Tier 1 analysis).

5.5.1.2 Tier 2 Input: WMU Parameters (17)

The Tier 2 evaluation uses site-specific WMU data to assess potential ground-water impacts. The WMU parameters are entered on the WMU Parameters (17) screen. A complete list of all WMU parameters is shown below, however, not all parameters are applicable for each WMU type. For instance, data on the WMU's operational life is used only for surface impoundments, waste piles, and LAUs. This parameter is not applicable to landfills. Some parameters are marked as (*required*). This means that you must provide a site-specific value for this parameter. If a parameter is not marked as (*required*), IWEM will use a site-specific value if you have it. If you do not have this data, IWEM gives you the option to select a default value, or distribution of values. These default values are generally the median values of the distributions of values used in Tier 1.

WMU Parameters:

- Area of the WMU *(required)*
- Distance to well
- Depth of WMU (LF only) *(required)*
- Ponding depth (SI only) *(required)*
- Operational life of WMU (WP, SI, and LAU only)
- Depth of WMU base below ground surface (LF, WP, and SI only)
- Sludge thickness (SI only)
- Distance to nearest surface water body (SI only)
- Brief explanation for each site-specific value *(required)*

For each type of WMU, the Tier 2 WMU screen looks slightly different, as shown below in Figures 5.24 through 5.27.

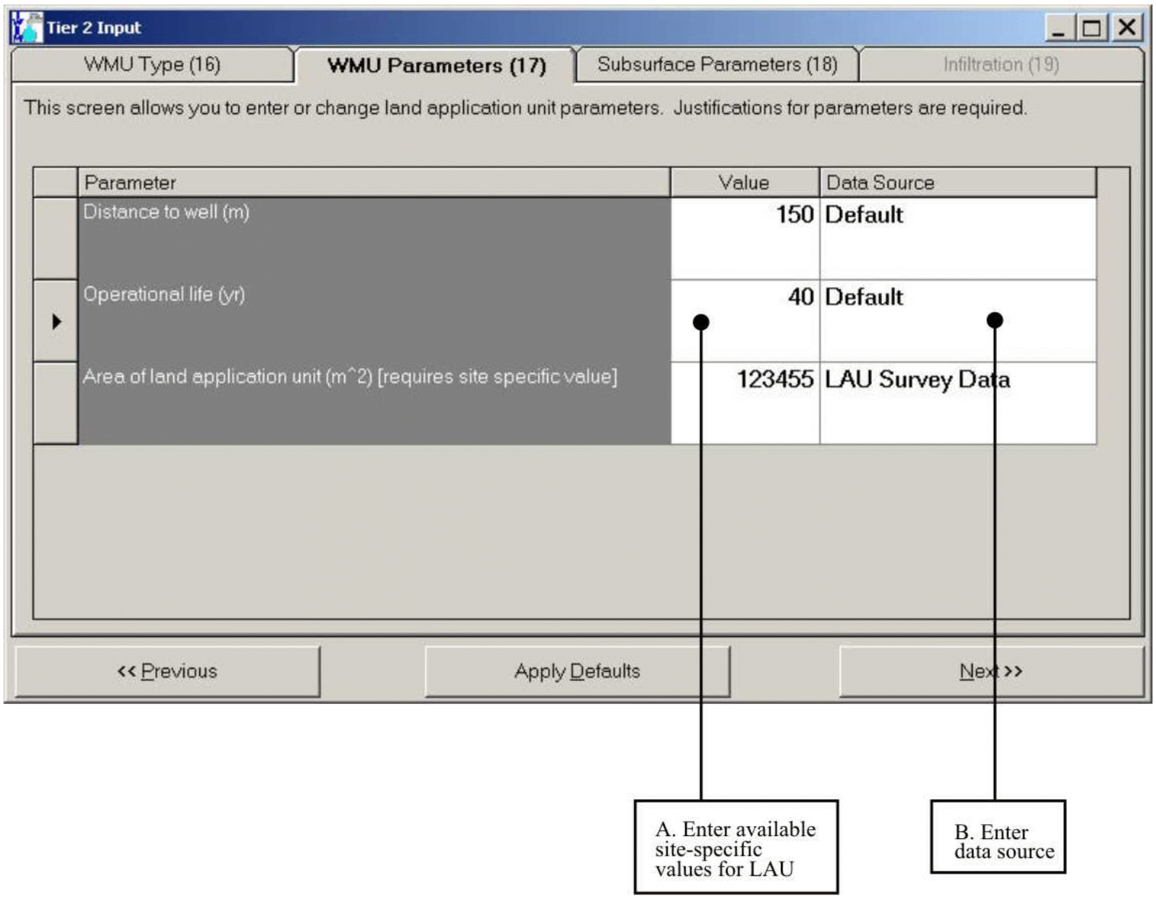


Figure 5.24 Tier 2 Input: WMU Parameters (17) for Land Application Units.

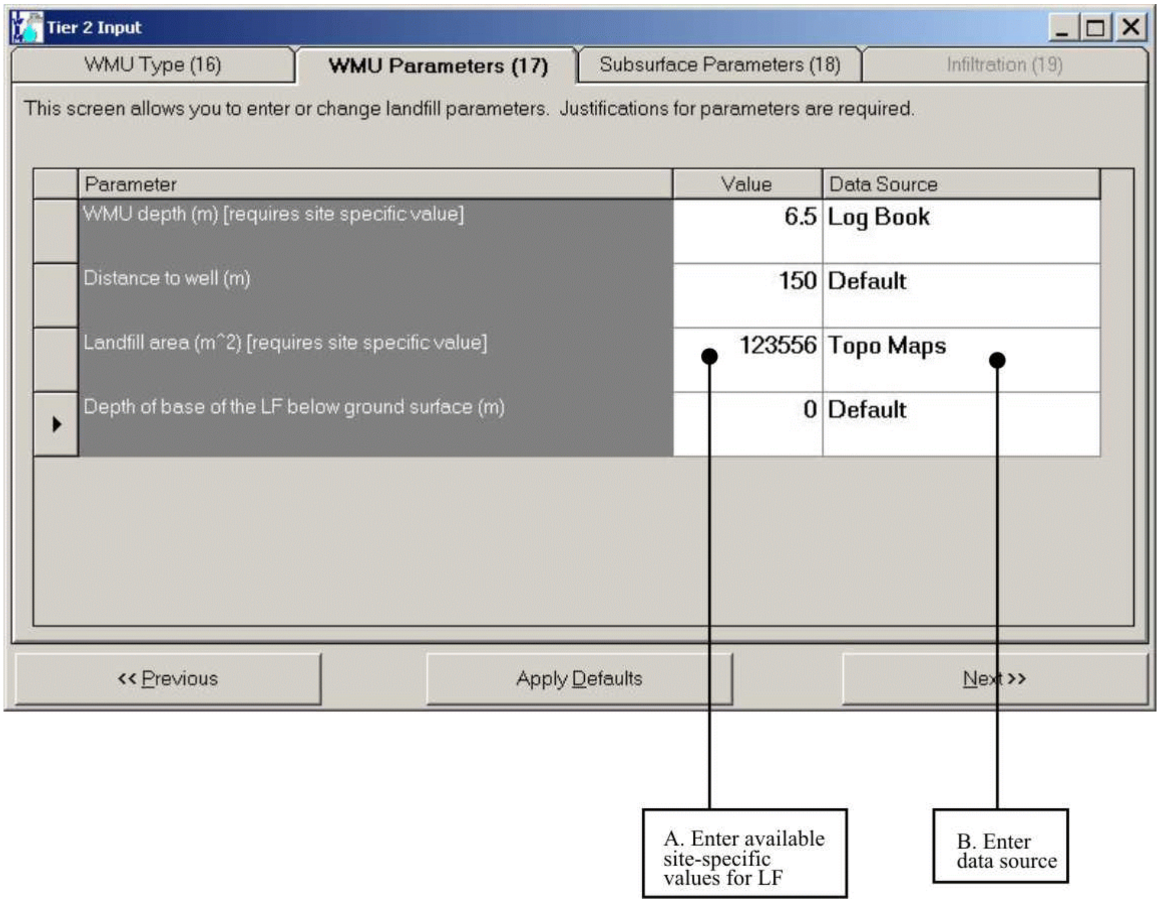


Figure 5.25 Tier 2 Input: WMU Parameters (17) for Landfills.

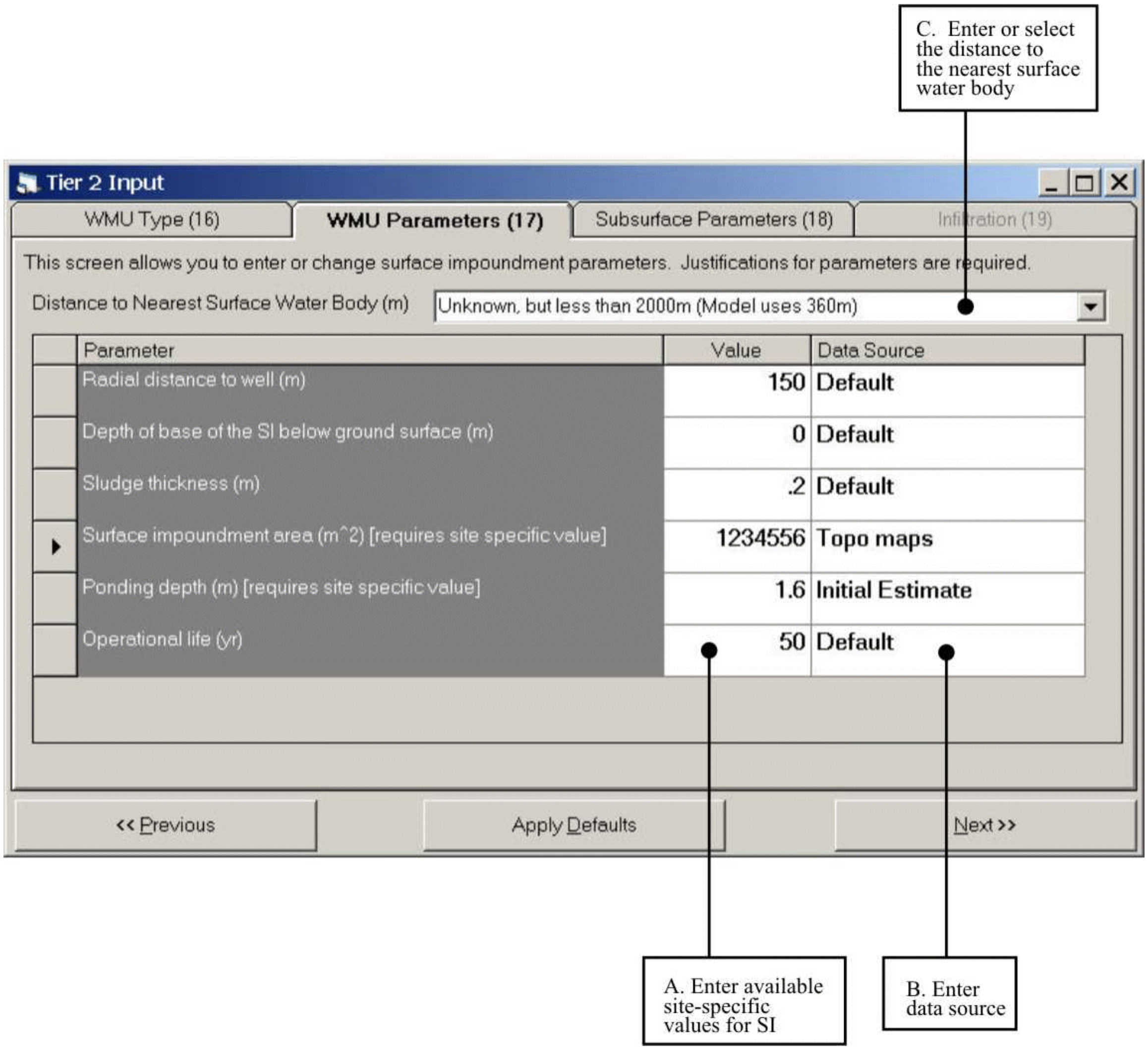


Figure 5.26 Tier 2 Input: WMU Parameters (17) for Surface Impoundments.

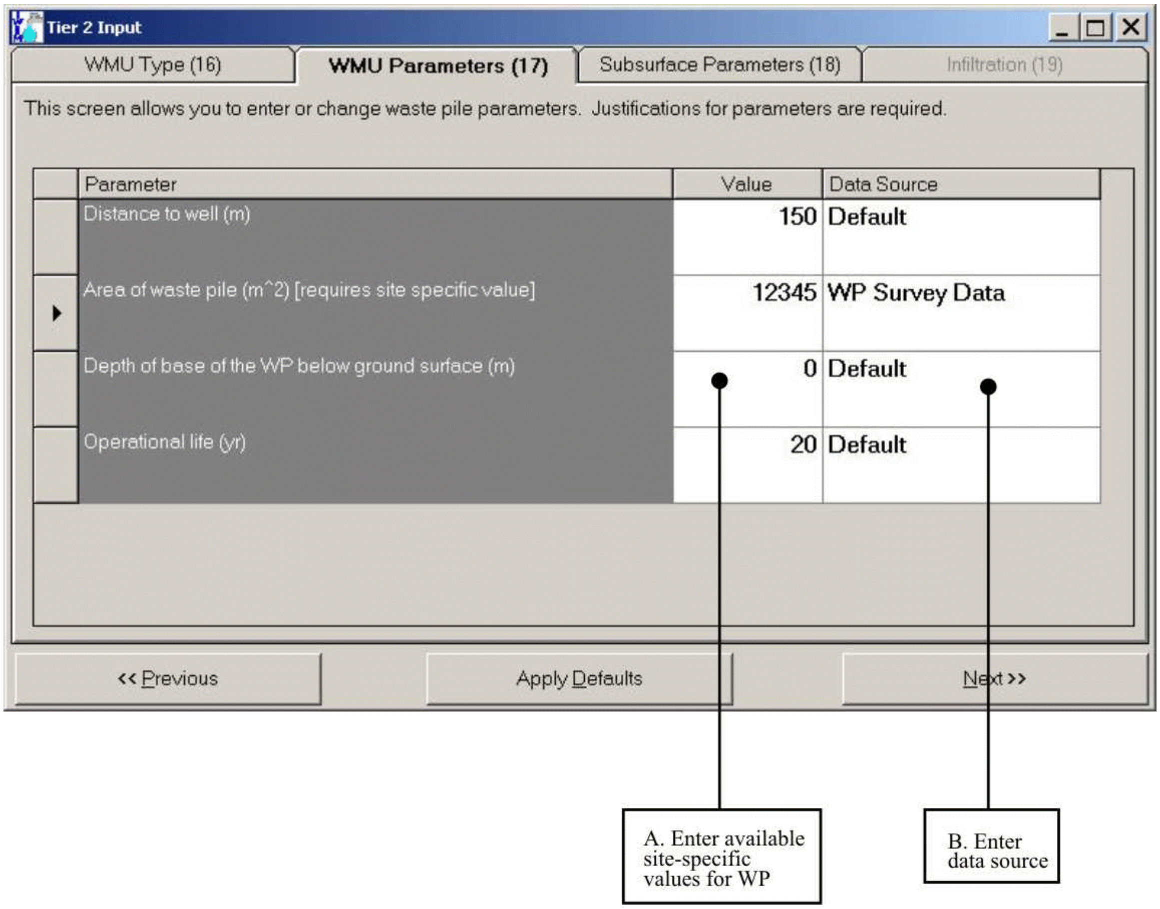


Figure 5.27 Tier 2 Input: WMU Parameters (17) for Waste Piles.

For all Tier 2 input parameters for which you enter site-specific values, remember to type in a brief justification or explanation of this value. This information is required and will be included in the printed report.

The features identified in Figure 5.24 through 5.27 are explained in more detail in the following paragraphs.

A. Enter Available Site-Specific Values

Land Application Unit (Figure 5.24)

For LAUs, site-specific values for the following parameters may be entered:

- Area of the LAU *(required)*
- Distance to nearest well *(optional; default = 150 m)*
- Operational life of the LAU *(optional; default = 40 yrs)*

Landfill (Figure 5.25)

For LFs, site-specific values for the following parameters may be entered:

- Area of the LF *(required)*
- Distance to nearest well *(optional; default = 150 m)*
- Depth of the LF *(required)*
- Depth of the LF base below ground surface *(optional; default = 0 m)*

Surface Impoundment (Figure 5.26)

For SIs, site-specific values for the following parameters may be entered:

- Area of the SI *(required)*
- Distance to nearest well *(optional; default = 150 m)*
- Ponding depth *(required)*
- Operational life of the SI *(optional; default = 50 yrs)*
- Depth of SI base below ground surface *(optional; default = 0 m)*
- Sludge thickness *(optional; default = 0.2 m)*

Waste Pile (Figure 5.27)

For WPs, site-specific values for the following parameters may be entered:

- Area of the WP *(required)*
- Distance to nearest well *(optional; default = 150 m)*
- Operational life of the WP *(optional; default = 20 yrs)*
- Depth of the WP base below ground surface *(optional; default = 0 m)*

B. Enter Data Source

For all Tier 2 input parameters for which you enter site-specific values, remember to type in a brief explanation of this value. This information is required and will be included in the printed report.

C. Enter or Select the Distance to the Nearest Surface Water Body

For a SI, you must also either enter a value for the distance to the nearest (permanent) surface water body or choose one of the default selections for this input parameter. This parameter is used in the calculation of ground-water mounding to ensure the model uses a realistic infiltration rate. If you do not know the exact distance to the nearest surface water body, select "unknown" from the drop-down list by clicking on the drop-down list control  to select an approximate distance (i.e., unknown (model uses 360 m); unknown, but less than 2,000 m; unknown, but greater than 2,000 m).

5.5.1.3 Tier 2 Input: Subsurface Parameters (18)

This screen is where you enter site-specific data that describes the subsurface environment at your site.

The subsurface parameters used in IWEM are listed below. You must select the type of subsurface environment at your site from the supplied list. Section 6.2.3.2 provides more information on the subsurface environments. If you have no hydrogeological information for your site, then "unknown" is an available choice. If your list of waste constituents includes any metals, you must also provide a value for the ambient ground-water pH. For the other subsurface parameters, you can provide a site-specific value if you have it, but IWEM will use a default value or distribution of values if you do not have this data.

Subsurface Parameters:

- Subsurface environment *(required, although "unknown" is an available choice)*
- Depth to water table
- Aquifer thickness
- Regional hydraulic gradient
- Aquifer hydraulic conductivity
- Ground-water pH *(required only if a metal is included in the waste constituents)*

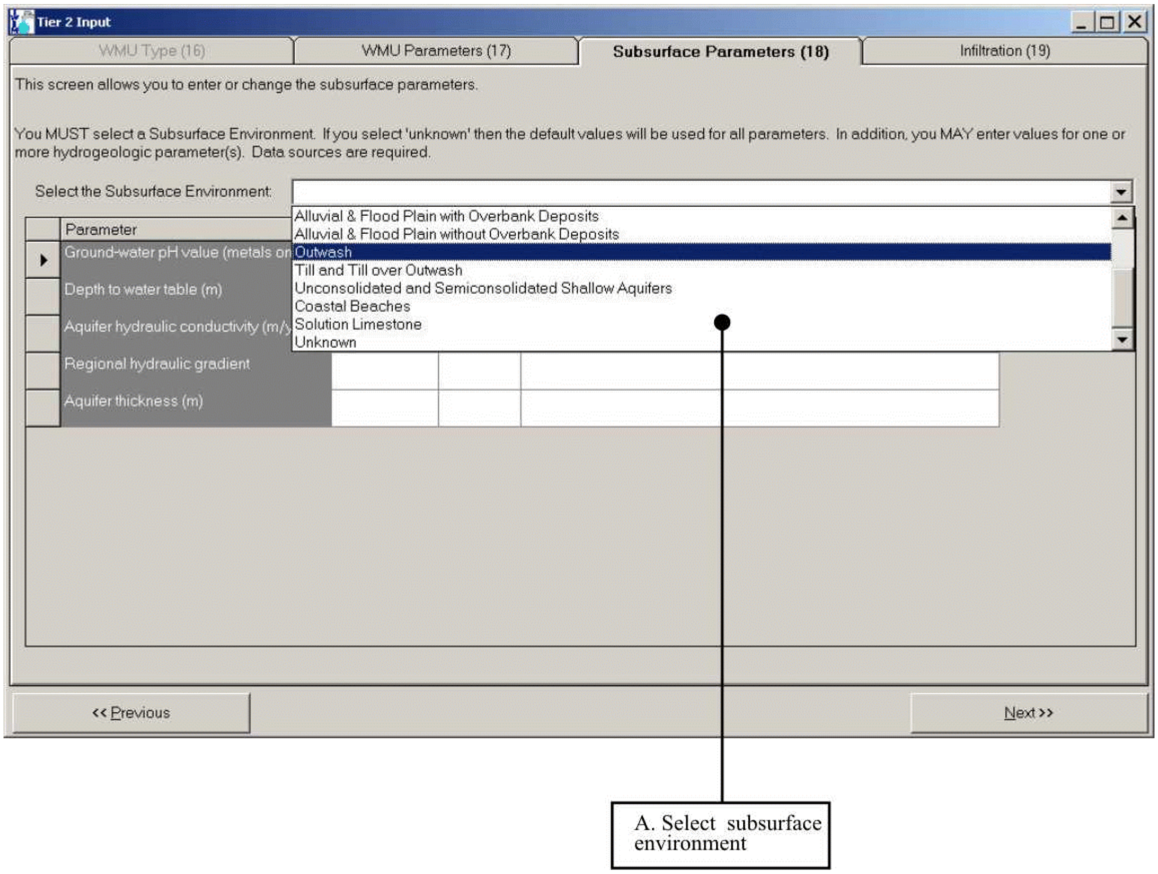


Figure 5.28 Tier 2 Input: Subsurface Parameters (18) - Selecting Subsurface Environment.

The features identified in Figure 5.28 are explained in more detail in the following paragraph.

A. Select Subsurface Environment

IWEM includes twelve different types of subsurface environments that represent different hydrogeological settings. If you do not know what type of environment is appropriate for your site, select "unknown." In effect, the "unknown" subsurface environment is an average of the twelve known environments. You **must** select one of the available subsurface environments. Figure 5.29 presents an example of what this screen will look like if you choose one of the available subsurface environments (the screen appears only slightly different if you set the subsurface environment to "unknown").

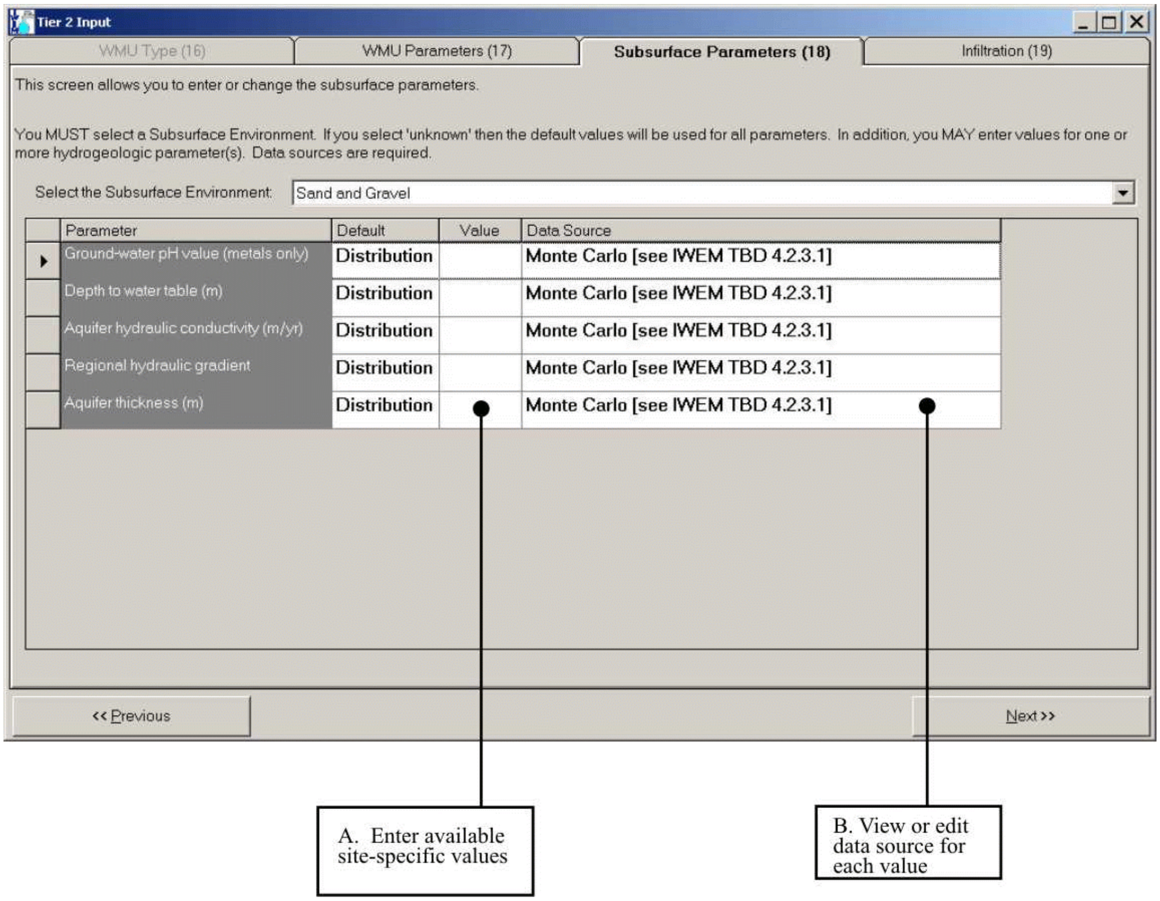


Figure 5.29 Tier 2 Input: Subsurface Parameters (18) - Entering Values of Subsurface Parameters.

The features identified in Figure 5.29 are explained in more detail in the following paragraphs.

A. Enter Available Site-Specific Values

If you select one of the twelve subsurface environments, then screen 18's appearance will be similar to that shown in Figure 5.29. You may enter values for any subsurface parameters for which you have site-specific data. However, you may enter data for only some (but not all) of the parameters and continue with the Tier 2 analysis. In this case, a distribution of parameter values that corresponds to the specified subsurface environment will be used to generate values for any parameter for which you do not enter a site-specific value. The word "Distribution" displayed in the default value column and the phrase "Monte Carlo [see IWEM TBD 4.2.3.1]" in the data source column indicate that IWEM will randomly select values for this parameter from the appropriate distribution during the Tier 2 analysis process. The distributions reflect the range of values that each parameter can have.

If you do not know the type of subsurface environment beneath your WMU, then you can select the "unknown" subsurface environment. For the unknown subsurface environment, a default value (the one displayed in the default value column) will be used for any input parameter for which you do not enter a site-specific value; that is, the value displayed on the screen will be input to the model as a constant value (no distribution of values is used). Each default value corresponds to the mean value of the available data for that parameter from all twelve subsurface environments. This value is representative of a national average. You may enter values for subsurface parameters that you have site-specific data for. However, if you are lacking data for one or more of the requested parameters for your site, you can still perform a Tier 2 analysis. In this case, the default (displayed) value will be used. The displayed value in the data source column and the phrase "Default [see IWEM TBD 4.2.3.1]" in the data source column indicate that IWEM will use the displayed default value for this input parameter in the Tier 2 analysis.

The subsurface parameters for which you can enter site-specific values are:

- Ground-water pH
- Depth to water table
- Aquifer hydraulic conductivity
- Regional hydraulic gradient
- Aquifer thickness

A site-specific value for ground-water pH is only required if the modeled waste constituents include metals; this parameter is not needed as a user-input for modeling organic constituents.

B. View or Edit Data Source for Each Value

If you select one of the twelve subsurface environments, then for any Tier 2 input parameter that you enter as a site-specific value, you must document the data source or explain the value used. IWEM provides a default data source for all optional data. The default data source is "Monte Carlo [see IWEM TBD 4.2.3.1]" as a reminder that a distribution of values (rather than a single, constant value) is being used for this parameter. All data sources or explanations for default or user-specified data are included in the printed Tier 2 report.

If you select the unknown subsurface environment, then for any Tier 2 input parameter that you enter as a site-specific value, you must document the data source or explain the value used. IWEM provides a data source for all default data. For the "unknown" subsurface environment, the default data source is "Default [see IWEM TBD 4.2.3.1]" as a reminder that a single, constant value (rather than a distribution of values)

> The information provided on screens 17 and 18 completely describes the WMU setting as required by IWEM. When you click |NEXT| on screen 18, IWEM will check your inputs to evaluate whether the setting you have described is physically possible and consistent with the EPACMTP model.
>
> IWEM verifies that:
>
> - the bottom of LFs and WPs are above the water table; and
> - the elevation of ponded water in a SI is higher than the water table elevation.
>
> If you do not specify the depth to ground water, IWEM will postpone this evaluation until screen 19 has been completed. IWEM will notify you if either of the above conditions is violated with a message box informing you of your options. If none of the suggested options is consistent with the conditions at your site, IWEM is not appropriate for your site, and you should consider a Tier 3 analysis. Consult Section 2.3 of this *User's Guide*, or the *IWEM Technical Background Document* (U.S. EPA, 2002c) for more information on the assumptions built into the EPACMTP model which may make it unsuitable for a particular site.

is being used for this parameter. All data sources or explanations for default or user-specified data are included in the printed Tier 2 report.

5.5.1.4 Tier 2 Input: Infiltration (19)

On screen 19 (Figure 5.30), you enter or select the infiltration rate that IWEM will use in modeling your site. The first selection is whether you have site-specific infiltration data, or wish to use IWEM default data if you do not have site-specific data.

In IWEM, infiltration refers to the liquid (leachate) that infiltrates to the subsurface directly below a WMU; recharge refers to the natural precipitation that infiltrates to the subsurface outside the footprint of the WMU.

Choose one of the following options for specifying infiltration rate:

- |YES, I HAVE SITE-SPECIFIC INFILTRATION| (*i.e.*, a measured, modeled, or calculated value);

- |NO, I DO NOT HAVE SITE-SPECIFIC INFILTRATION| (the model will estimate values for you based on the selected soil type (or waste type permeability, for WPs) and geographic location of the WMU site).

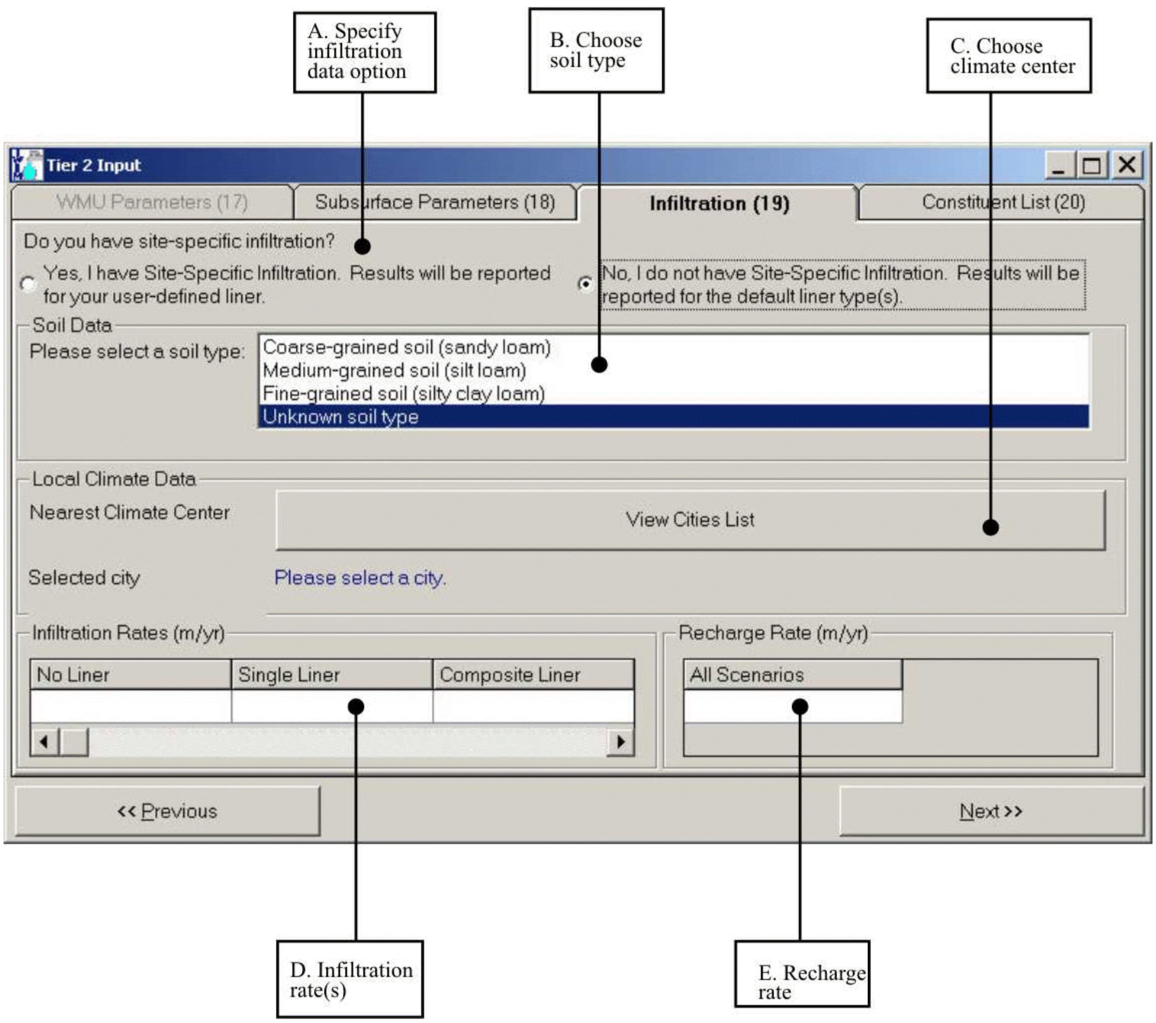


Figure 5.30 Tier 2 Input: Infiltration (19) - Initial Appearance.

At its initial appearance (with the NO, I DO NOT HAVE SITE-SPECIFIC INFILTRATION radio button selected by default), screen 19 will generally appear like Figure 5.30 (although this screen can be slightly different depending upon the selected WMU type).

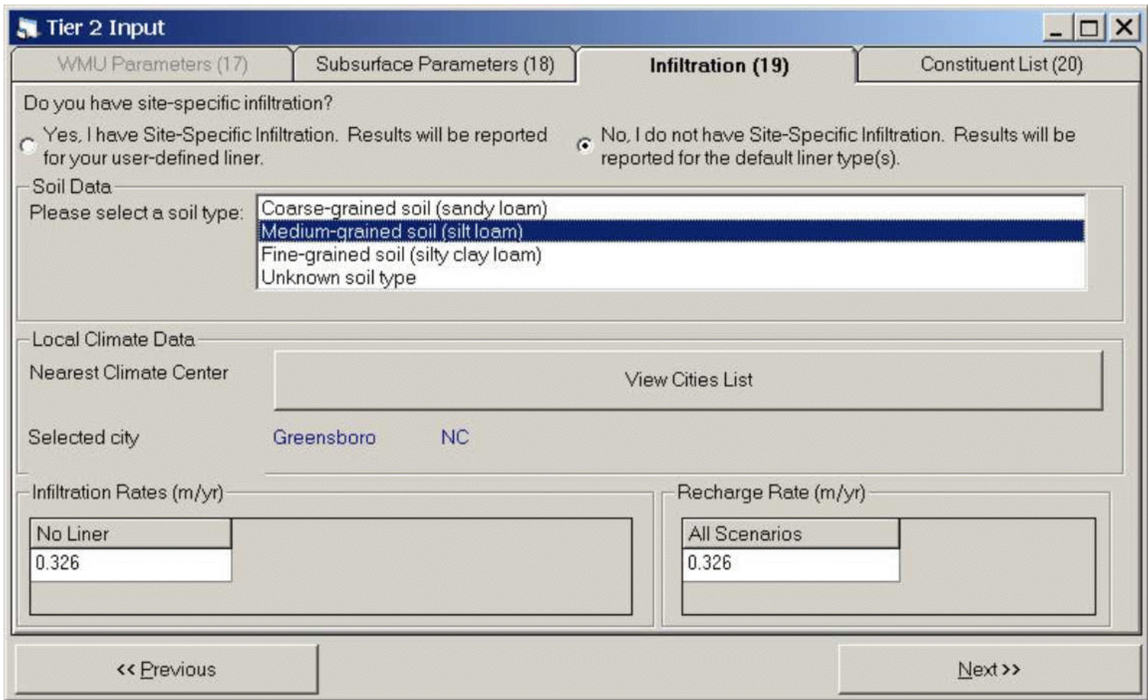


Figure 5.31 Tier 2 Input: Infiltration (19) - Land Application Unit.

If you do not have a site-specific value for infiltration, once you have selected a soil type (or waste type permeability, for waste piles) and climate center, screen 19 will appear like one of the screens presented in Figures 5.31 through 5.34 depending on the WMU type you have selected.

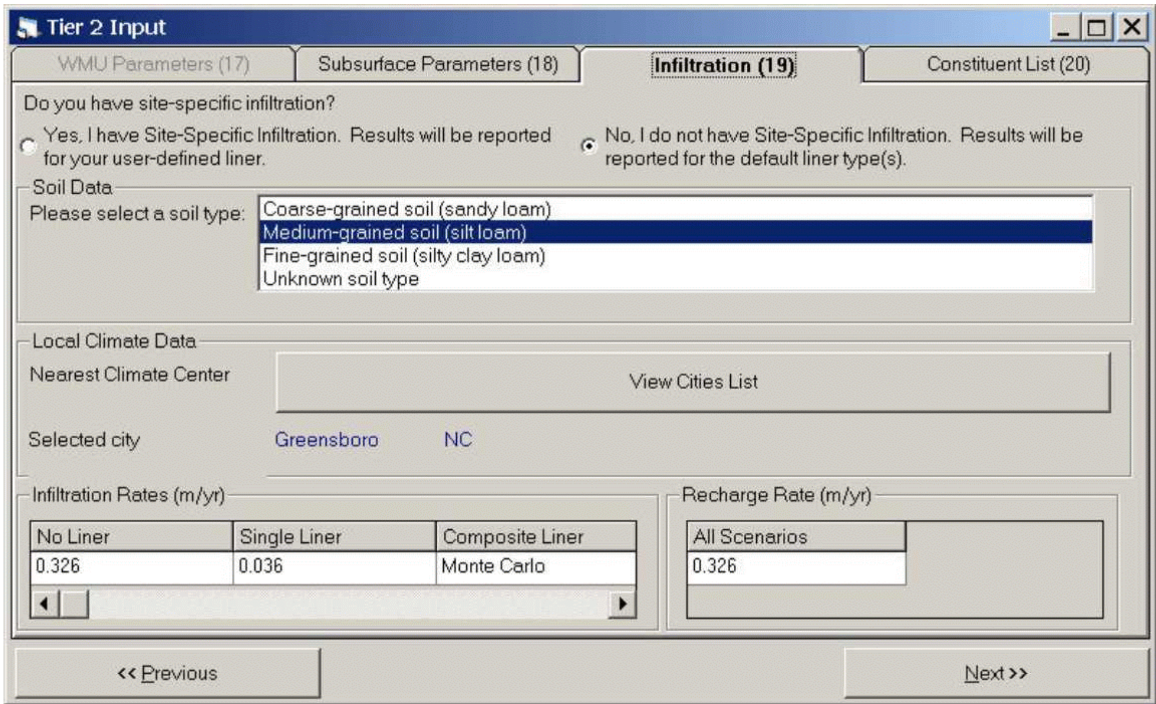


Figure 5.32 Tier 2 Input: Infiltration (19) - Landfill.

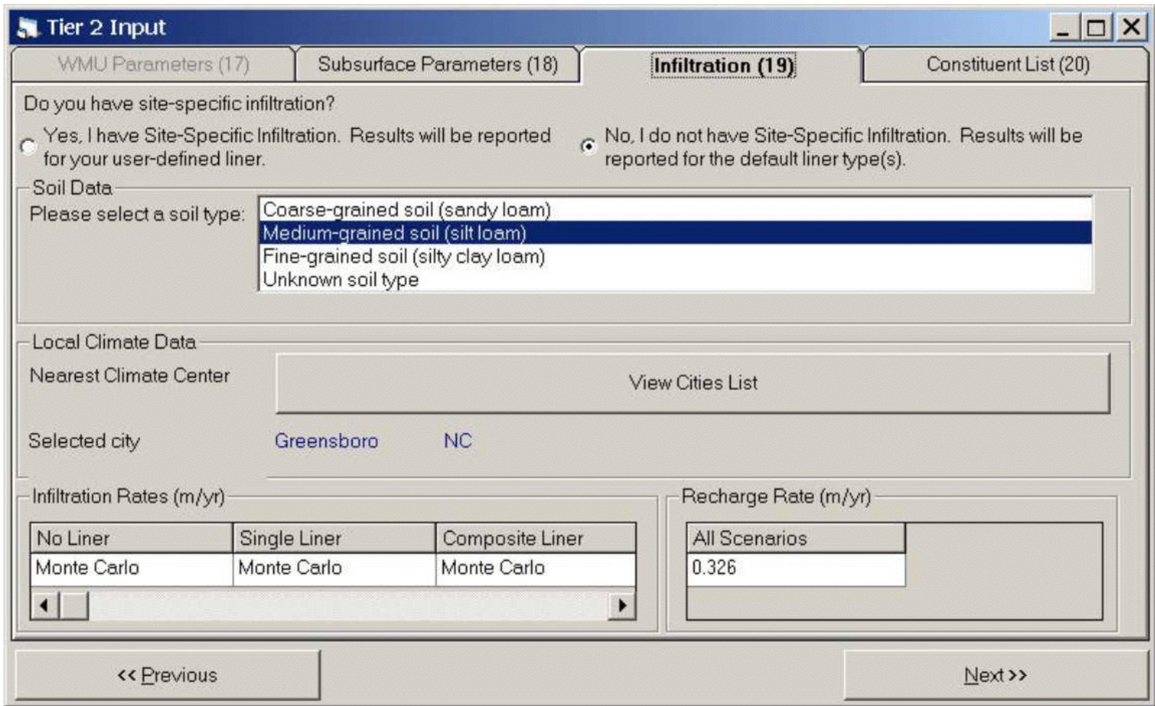


Figure 5.33 Tier 2 Input: Infiltration (19) - Surface Impoundment.

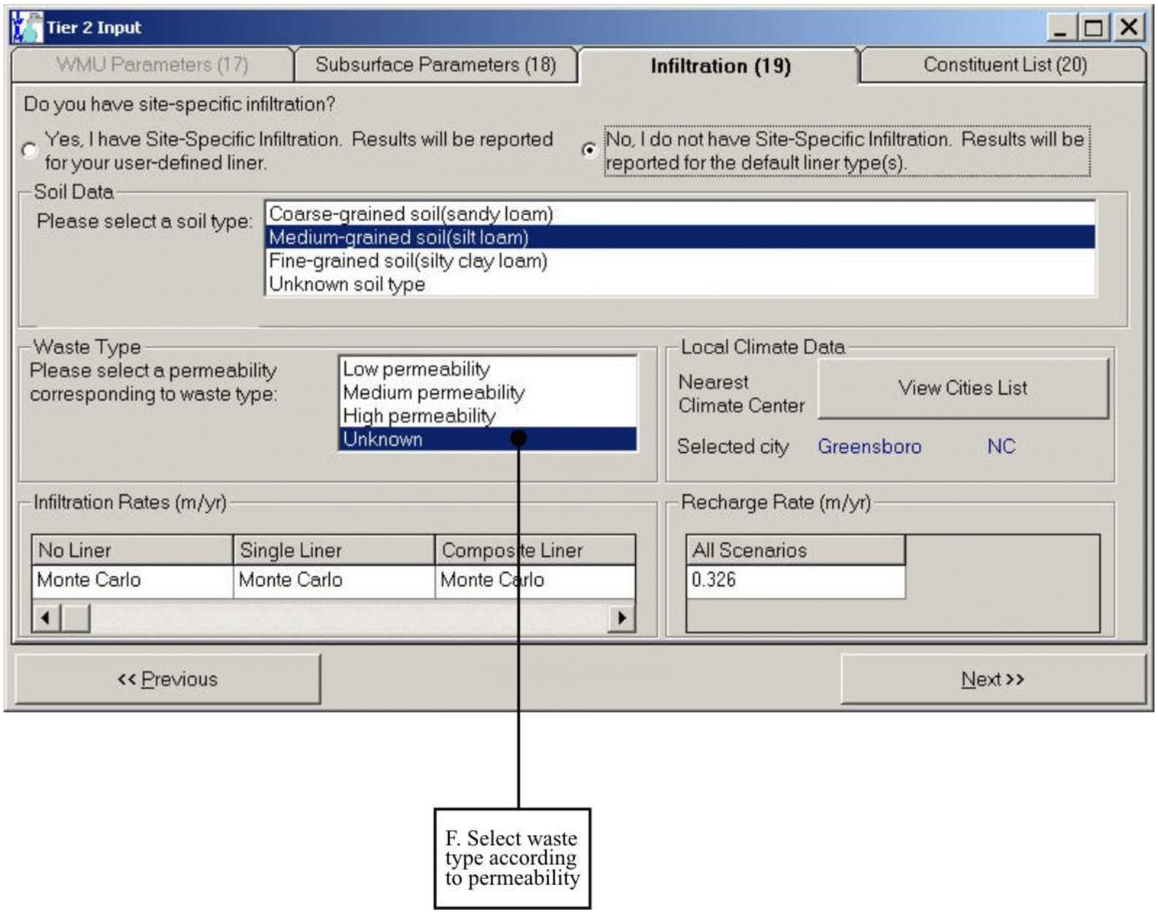


Figure 5.34 Tier 2 Input: Infiltration (19) - Waste Pile.

The features identified in Figures 5.30 through 5.34 are explained in more detail in the following paragraphs.

A. Specify Infiltration Data Option

Displayed at the top of screen 19 is the following question:

"Do you have a site-specific value for infiltration rate?"

Select one of the two available options:

- | YES, I HAVE A SITE-SPECIFIC INFILTRATION RATE |, or
- | NO, I DO NOT HAVE A SITE-SPECIFIC INFILTRATION RATE |

If you choose |NO|, the Tier 2 evaluation will be performed for the default liner type(s). There are three liner types for landfills, surface impoundments, and waste piles (no liner, single clay liner, and composite liner). IWEM will evaluate only the no-liner scenario for land application units because engineered liners are not usually used at this type of facility.

If you choose |YES|, the Infiltration Screen will appear as in Figure 5.36 and the Tier 2 evaluation will be performed for your specified WMU infiltration rate. This liner scenario is referred to as a "user-defined liner". This is the appropriate option to choose if you know the infiltration rate for your particular liner design.

The final result of a Tier 2 analysis is a recommended minimum liner design that is protective for all the selected constituents in your waste. When you specify a site-specific infiltration rate, IWEM will evaluate a "user-defined liner" scenario for protectiveness; otherwise, IWEM will evaluate all appropriate default liner scenarios.

B. Choose Soil Type

Regardless of whether or not you have a site-specific value for infiltration, you need to specify the soil type and geographic location of the WMU so that the model can generate a recharge rate for your site. Additionally, if you do not have a site-specific value for infiltration, the specified soil type and geographic location are used to estimate the infiltration rate for your site for the standard liner scenarios for landfills, land application units, and waste piles (infiltration rates for surface impoundments are a function of the ponding depth).

First, select the appropriate soil type from the choices shown in the |SOIL DATA| dialog box:

- Coarse-grained soil (sandy loam)
- Medium-grained soil (silt loam)
- Fine-grained soil (silty clay loam)
- Unknown soil type

If you choose one of the three default soil types, the Tier 2 Monte Carlo process will randomly assign values for the required soil-related input parameters according to probability distributions that are appropriate for the specified soil type. If you choose "unknown soil type" (the default selection), the Tier 2 Monte Carlo process will randomly select one of the three possible soil types in accordance with their nationwide frequency of occurrence. For more details, please see Section 4.2.3.2 of the *IWEM Technical Background Document* (U.S. EPA, 2002c).

C. Choose Climate Center

For unlined units, except SIs, and for single clay-lined LFs and WPs, infiltration and recharge rates for representative regions and locations, or "climate centers," around the country have been calculated based on meteorological data and soil type. By choosing the climate center that is representative of the modeled WMU site, you can use the infiltration and recharge rate(s) for this climate center as an estimate of the rate(s) expected at your site.

In many cases, selecting the climate center that is closest to your site will provide the best estimate of infiltration rate. A map of the IWEM climate centers is presented in Figure 6.4 of Section 6.2.3.3 of this document. You should, however, verify that the overall climate conditions at the selected climate station are representative of your site. Section 4.2.2 of the *IWEM Technical Background Document* (U.S. EPA, 2002c) provides a detailed discussion of how the infiltration rates were developed. To choose a climate center, click on the |VIEW CITIES LIST| button. The dialog box shown in Figure 5.35 will appear.

D. Infiltration Rate(s)

If you do not have a site-specific infiltration rate (see Figures 5.31 through 5.34), once you have selected a soil type and the nearest climate center, the model will estimate the infiltration rates for each of three standard liner scenarios (no liner, single clay liner, and composite liner) for your WMU site (note that only the no-liner scenario is evaluated for LAUs). The resulting value(s) are listed in the table at the bottom left of the infiltration screen.

E. Recharge Rate

Once you have selected a soil type and the appropriate climate center, the model will estimate the recharge rate for your WMU site. The resulting value is listed in the table at the bottom right of the infiltration screen.

F. Select Waste Type According to Permeability

For a WP, you must also specify the waste type permeability (this value is used in determining the no-liner and single clay-liner infiltration rate). There are three choices for waste permeability: high (4.1×10^{-2} centimeters per second [cm/sec]), medium (4.1×10^{-3} cm/sec), and low (5.0×10^{-5} cm/sec). These values are representative of wastes commonly disposed in WPs.

To choose a climate center to provide default recharge and infiltration data, click on the |VIEW CITIES LIST| button on the Infiltration (19) screen. The dialog box shown below in Figure 5.35 will then be displayed.

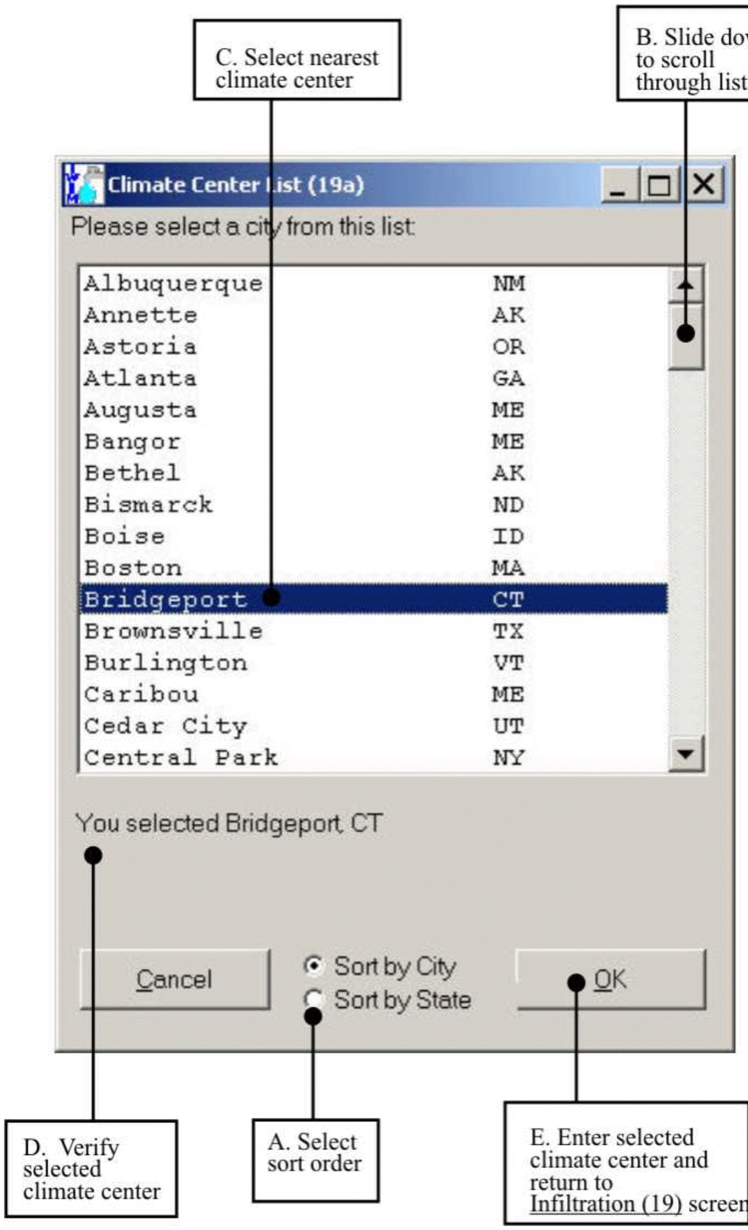


Figure 5.35 Tier 2 Input: Climate Center List (19a).

The features identified in Figure 5.35 are explained in more detail in the following paragraphs.

A. Select Sort Order

You can sort the climate centers alphabetically by city or by state by choosing one of the |SORT BY| options.

B. Slide Down to Scroll through List

You can view the entire list using the |ARROW| keys on the keyboard or by manipulating the scroll bar to the right of the list.

C. Select Nearest Climate Center

Select a climate center by using the |ARROW| keys to highlight an entry, or by a single click on the entry with your mouse.

D. Verify Selected Climate Center

You can verify that the correct climate center is selected by looking at the city name printed at the bottom of this dialog box.

E. Enter Selected Climate Center and Return to Infiltration (19) screen

Clicking on the |OK| button or double-clicking on the highlighted entry will enter your selection and return you to the Infiltration (19) screen.

If you choose the |YES, I HAVE SITE-SPECIFIC INFILTRATION| option at the top of the Infiltration (19) screen, then this screen will appear as shown in Figure 5.36.

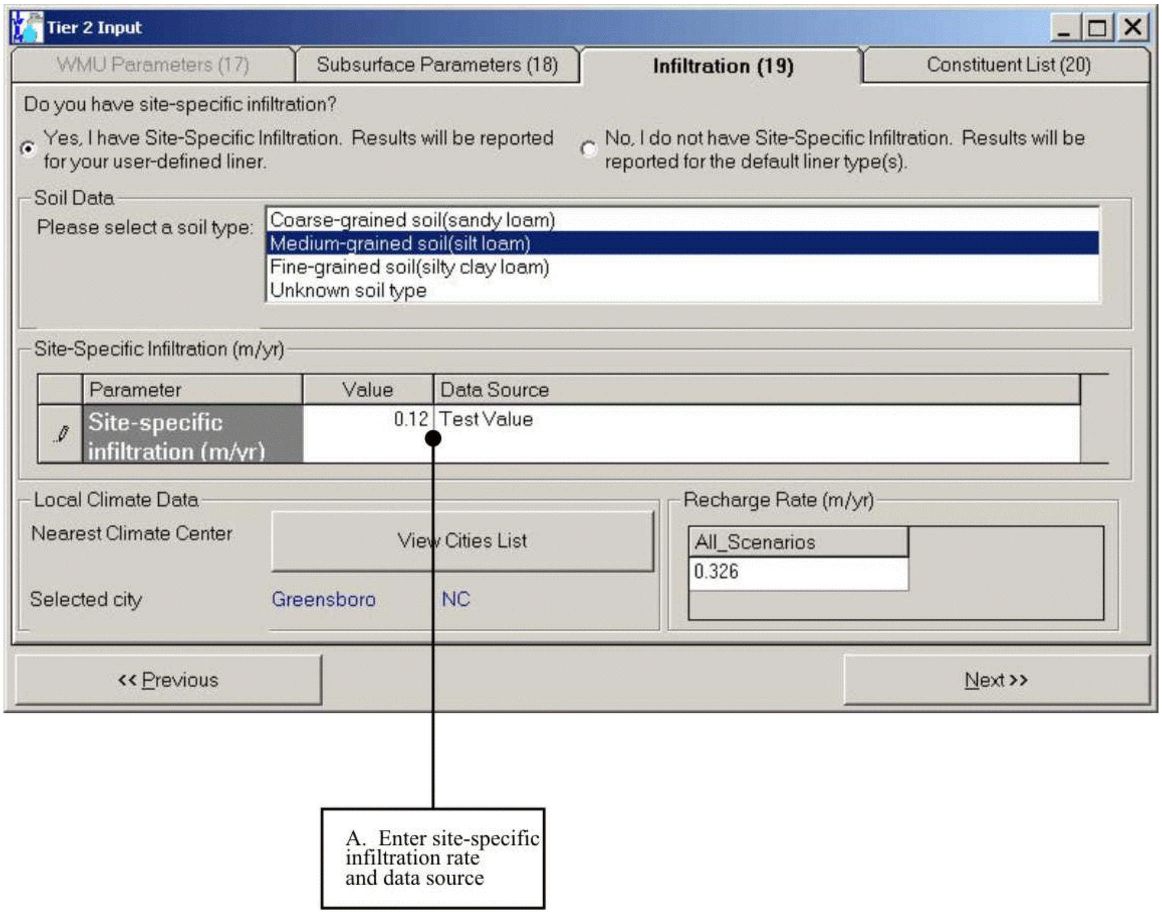


Figure 5.36 Tier 2 Input: Infiltration (19) - Site Specific Infiltration.

The features identified in Figure 5.36 are explained in more detail in the following paragraphs.

A. Enter Site-Specific Infiltration Rate and Data Source

Enter your site-specific infiltration rate and provide a brief explanation of the data source for your value in the |DATA SOURCE| cell. Both the value and your explanation will be included in the printed Tier 2 report.

5.5.1.5 Probabilistic Screening Module

The EPACMTP model used in IWEM to simulate ground-water fate and transport incorporates certain constraints to ensure that the parameter values that are selected in the

Tier 2 Monte Carlo process will represent physically realistic WMU settings. These constraints are:

1. The base of a LF or WP must be above the water table,
   or,
   The elevation of ponded water in a SI must be higher than the water table elevation; and

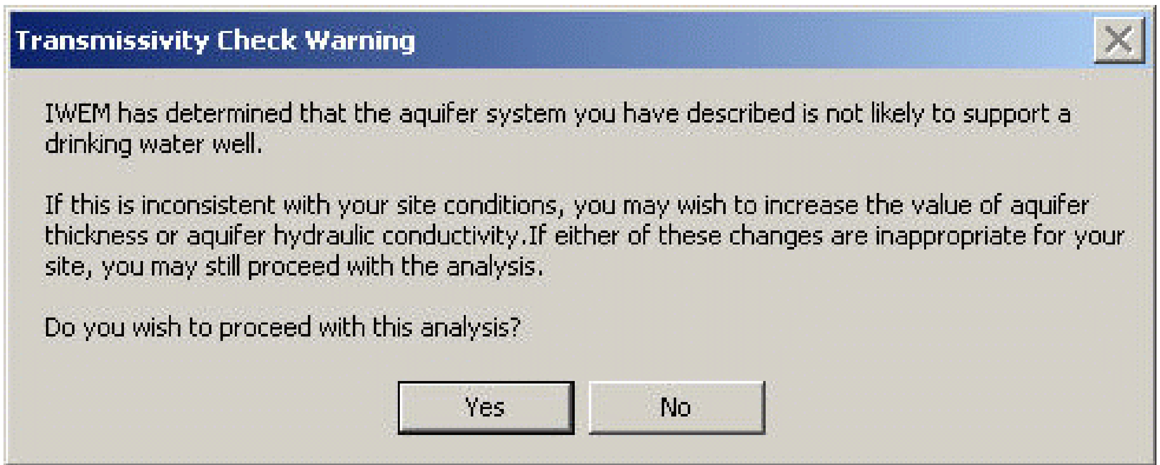
2. Infiltration- and recharge-induced mounding of the water table cannot rise above the ground surface.

If either one of these constraints is violated, the model will not run. Given the range of parameter values that may be generated in the Monte Carlo process, in combination with user-specified site-specific values, it is possible that the simulation model might encounter a scenario where a constraint is frequently violated, and the model is unable to complete the Monte Carlo simulation process.

IWEM screens your Tier 2 input values and parameter distributions prior to performing the EPACMTP Monte Carlo simulation to ensure that an adequate number of Monte Carlo realizations can be conducted. The Probabilistic Screening module of IWEM examines your inputs to determine if you have provided complete and valid information. If you specify a constant value for every parameter on screens 17 through 19, the screener will determine the magnitude of water table mounding (that is, IWEM will evaluate the constraints on hydraulic connections between the WMU and the water table). If the screening is successful, IWEM will take you to screen 20, otherwise a message box will alert you to the most violated constraint and suggest potential remedies. If all proposed remedies are inconsistent with site conditions, then IWEM is not appropriate for your site and a Tier 3 analysis should be considered.

If you do not provide site-specific values for all possible Tier 2 inputs, the screener will generate values for the missing input parameters according to their appropriate distributions, and then evaluate the constraints. The screening process usually takes ten or twenty seconds to complete, but can take up to a minute or two. A progress bar, like the one displayed below, is updated during the screening process.

As part of the screening process, IWEM will check that the aquifer that will be modeled has a sufficiently high transmissivity to supply enough water to a domestic drinking water well. A low transmissivity value corresponds to a combination of a low hydraulic conductivity in the saturated zone and a small saturated thickness. If this situation is encountered, IWEM will display a warning message dialog box like the one shown below which asks if you want to continue. If you click |OK|, IWEM will continue with the input parameters you provided.



5.5.1.6 <u>Tier 2 Input: Constituent List (20)</u>

This is where you select the constituents that are present in the waste, and enter their leachate concentration. You can select constituents in several ways. You can:

- Search by Constituent Name or CAS Number, or
- Scroll through the list of IWEM constituents, using display and sort options.

If you performed a Tier 2 evaluation immediately after a Tier 1 evaluation, the waste constituents selected in Tier 1 are automatically transferred to Tier 2 and the Tier 1 leachate concentrations are also imported. If you are starting a Tier 2 evaluation and need to enter waste constituents, follow the steps described here.

The <u>Constituent List (20)</u> screen for Tier 2 is nearly identical to the Tier 1 <u>Constituent List (7)</u> screen, and the options and controls on this screen work exactly the same as the ones on the Screen 7. You can choose to include in your Tier 2 analysis any of the 206 organic constituents and 20 metal constituents included in the IWEM database (see Appendix A). However, unlike Tier 1, in Tier 2 you can also add constituents to the IWEM list.

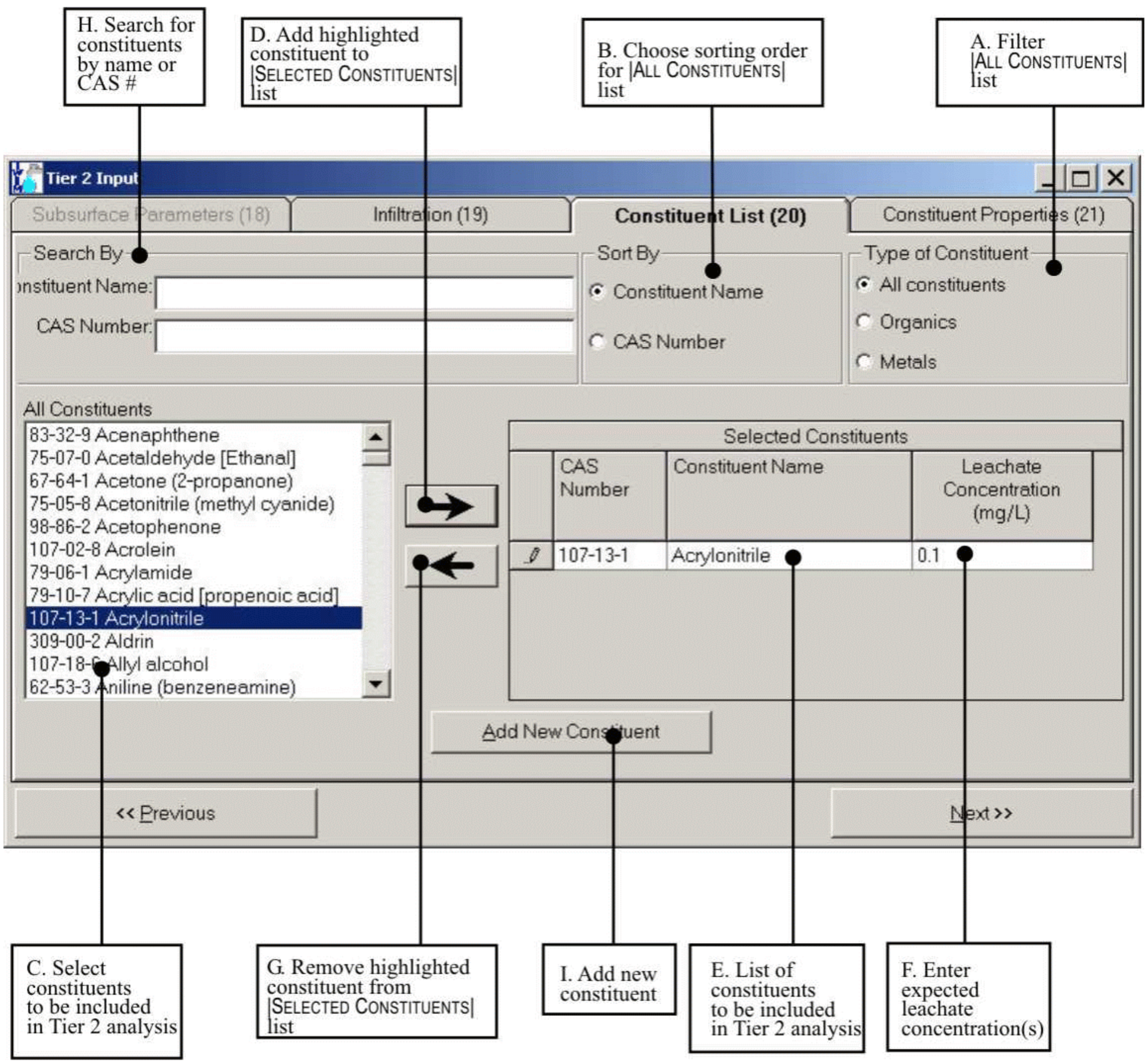


Figure 5.37 Tier 2 Input: Constituent List (20).

The features identified in Figure 5.37 are explained in more detail in the following paragraphs.

A. Filter |ALL CONSTITUENTS| *List*

You can choose to display only organic constituents, only metals, or a combined list of all constituents by clicking one of the radio buttons under |TYPE OF CONSTITUENT|.

B. Choose Sorting Order for |ALL CONSTITUENTS| *List*

You can determine whether the constituents are sorted by name or by CAS number by clicking one of the |SORT BY| radio buttons.

C. Select Constituents to be Included in Tier 2 Analysis

To move through the list of waste constituents:

1) Use the scroll bar at the right of the display window

2) Use the |ARROW| keys on the keyboard (once one constituent in the list is selected)

3) Type in the constituent name or CAS number in the |SEARCH BY| box

You can select constituents by using one of these methods:

- To add an individual constituent, select that constituent by clicking on its name.

- To add multiple constituents that are listed in contiguous order (that is, one after another without any non-selected constituents in the middle), click on the first waste constituent, press down the |SHIFT| key, and then click on the last waste constituent. All waste constituents listed between the first and last chosen constituents should now be highlighted.

- To add multiple constituents that are not in contiguous order, click on the first waste constituent, and then hold down the |CTRL| key while selecting additional constituents using the mouse.

Once your selection is complete, use the |ADD| button (described below) to transfer all the highlighted constituents to your list.

D. Add Highlighted Constituent(s) to |SELECTED CONSTITUENTS| ***List***

Once the appropriate constituents are highlighted in the list (on the left of the screen), you can click the |ADD|  button in the center of the screen to transfer it to your list of leachate constituents (on the right side of the screen). Note that a waste constituent can also be added directly to your list by double-clicking on it in the list on the left.

E. List of Constituents to be Included in Tier 2 Analysis

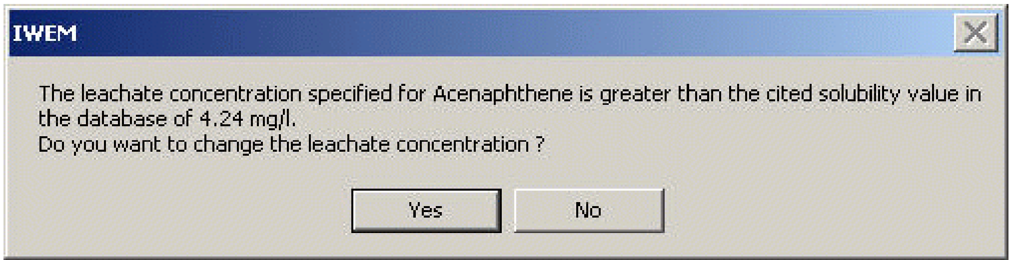
Once you have successfully added a constituent to your analysis, that constituent's name and CAS number will appear in the |SELECTED CONSTITUENTS| window on the right side of the screen.

If any of the selected waste constituents hydrolyze into toxic daughter products, the daughter products are automatically added to the Tier 2 evaluation. You can modify constituent properties and toxicity standards of the daughter product(s) in the upcoming screens.

F. Enter Expected Leachate Concentrations

For each waste constituent in the |SELECTED CONSTITUENTS| list, you must enter your expected leachate concentration in mg/L. This value cannot exceed 1,000 mg/L. Consult Chapter 2-Characterizing Waste in the ***Guide*** (U.S. EPA, 2002d) for analytical procedures that can be used to determine expected leachate concentrations for waste constituents. Because the expected leachate concentrations of daughter products are controlled by the leachate concentration of the parent constituent, the daughter product leachate concentrations are not IWEM inputs.

The IWEM software will display a warning message similar to the one shown below if you enter an expected leachate concentration that exceeds the solubility of that constituent, as cited in the IWEM database. If you accidentally entered the wrong value, click the |YES| button and correct the expected leachate concentration on the <u>Leachate Concentration (8)</u> screen. If you want to proceed with the evaluation using your entered value, click the |NO| button. In this case, a similar warning message about your input leachate concentration will be included in the printed report.



The Tier 2 Evaluation cannot be performed until the expected leachate concentration is entered for each selected waste constituent.

G. Remove Highlighted Constituent from |SELECTED CONSTITUENTS| List

Analogous to the |ADD| button, you can click the |REMOVE|  button to delete a highlighted constituent from the your list of selected constituents.

H. Search for Constituents by Name or CAS #

Type the name or the CAS number in the |SEARCH BY| window to select a particular constituent on the IWEM list. As soon as you have typed in enough information to identify the constituent, it will be highlighted in the constituent window on the left of the screen. You can then use the |ARROW| keys on the keyboard to move up or down in the list if the highlighted constituent is not exactly the one you intended to select.

I. Add New Constituent

To add a new waste constituent, click on the |ADD NEW CONSTITUENT| button at the bottom of the Constituent List. The message box shown below in Figure 5.38 will appear:

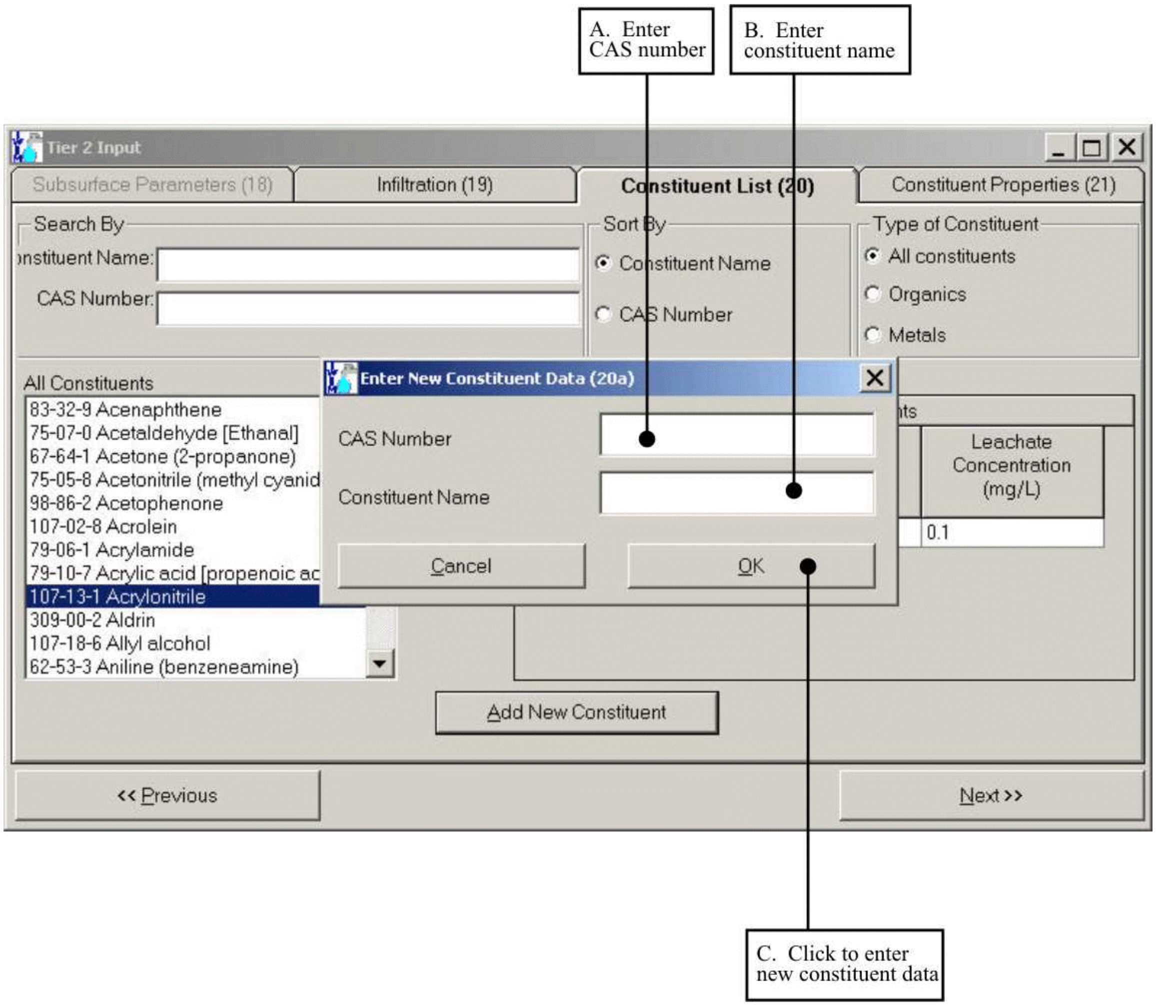


Figure 5.38 Tier 2 Input: Enter New Constituent Data (20a).

The features identified in Figure 5.38 are explained in more detail in the following paragraphs.

A. Enter CAS Number

The CAS number of a new constituent must be entered and it must be a number that is not already in use by one of the IWEM constituents. If a CAS number is not available or you do not know the number for a new constituent, any number can be used here, as long as it is a unique number between 50,000 and 999,999,999.

B. Enter Constituent Name

The constituent name must be entered and it must be a name that is not already in use by one of the constituents in the IWEM database.

C. Click to Enter New Constituent Data

After you click |OK|, a new entry in the database will be created for your new constituent, and screen 20b (Figure 5.39) will appear.

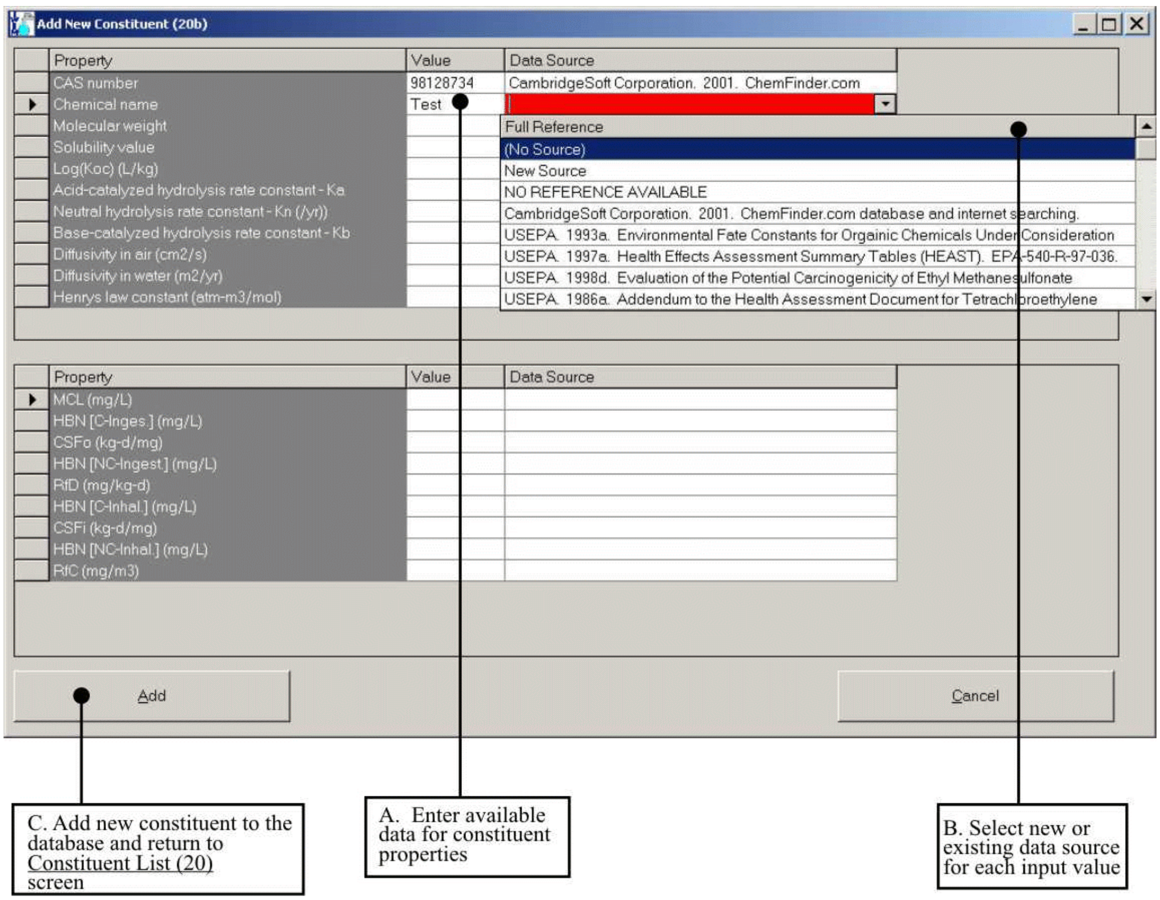


Figure 5.39 Tier 2 Input: New Constituent Data (20b).

The features identified in Figure 5.39 are explained in more detail in the following paragraphs.

A. Enter Available Data for Constituent Properties

You can provide the following constituent physical-chemical data as optional inputs. In addition, you can provide a "User-defined RGC" later on, in screen 22.

- Molecular weight
- Solubility
- Log K_{oc}
- Acid-catalyzed hydrolysis rate constant
- Neutral hydrolysis rate constant
- Base-catalyzed hydrolysis rate constant
- Diffusivity in air
- Diffusivity in water
- Henry's Law constant
- MCL (Maximum Contaminant Levels)
- HBN (Non-carcinogenic-Ingestion)
- HBN (Carcinogenic-Ingestion)
- HBN (Non-carcinogenic-Inhalation)
- HBN (Carcinogenic-Inhalation)

If you do not enter a value for the physical-chemical parameters, a default value of zero will be used for each of these parameters. However, for each constituent at least one non-zero RGC value must be entered (either an MCL, or an HBN). If you enter an HBN RGC, you must also enter its corresponding toxicity value (listed in the column next to each HBN). IWEM assumes a 30-year exposure duration for cancer HBNs and 7-year exposure duration for non-cancer HBNs.

B. Select Type of Data Source for Each Input Value

For each constituent property value that you enter, you must specify the source of the data. Clicking in the |DATA SOURCE| field after entering your data will display the drop-down list control . Click on this control to reveal the drop-down list shown in Figure 5.39. You can select from the current list of references in the IWEM database, or you can choose |NEW SOURCE| to enter a bibliographic reference that is not included in the IWEM database (see Figure 5.40).

C. Add New Constituent to the Database and Return to the Constituent List (20) screen

After entering the available data and selecting or entering a reference for each value, click the |ADD| button to update the list of IWEM constituents. Once you have done this, a message box will appear asking if you want to include this newly added constituent in your Tier 2 analysis. Even if you decide not to use the new constituent in your current analysis, the new constituent will be permanently added to the IWEM database.

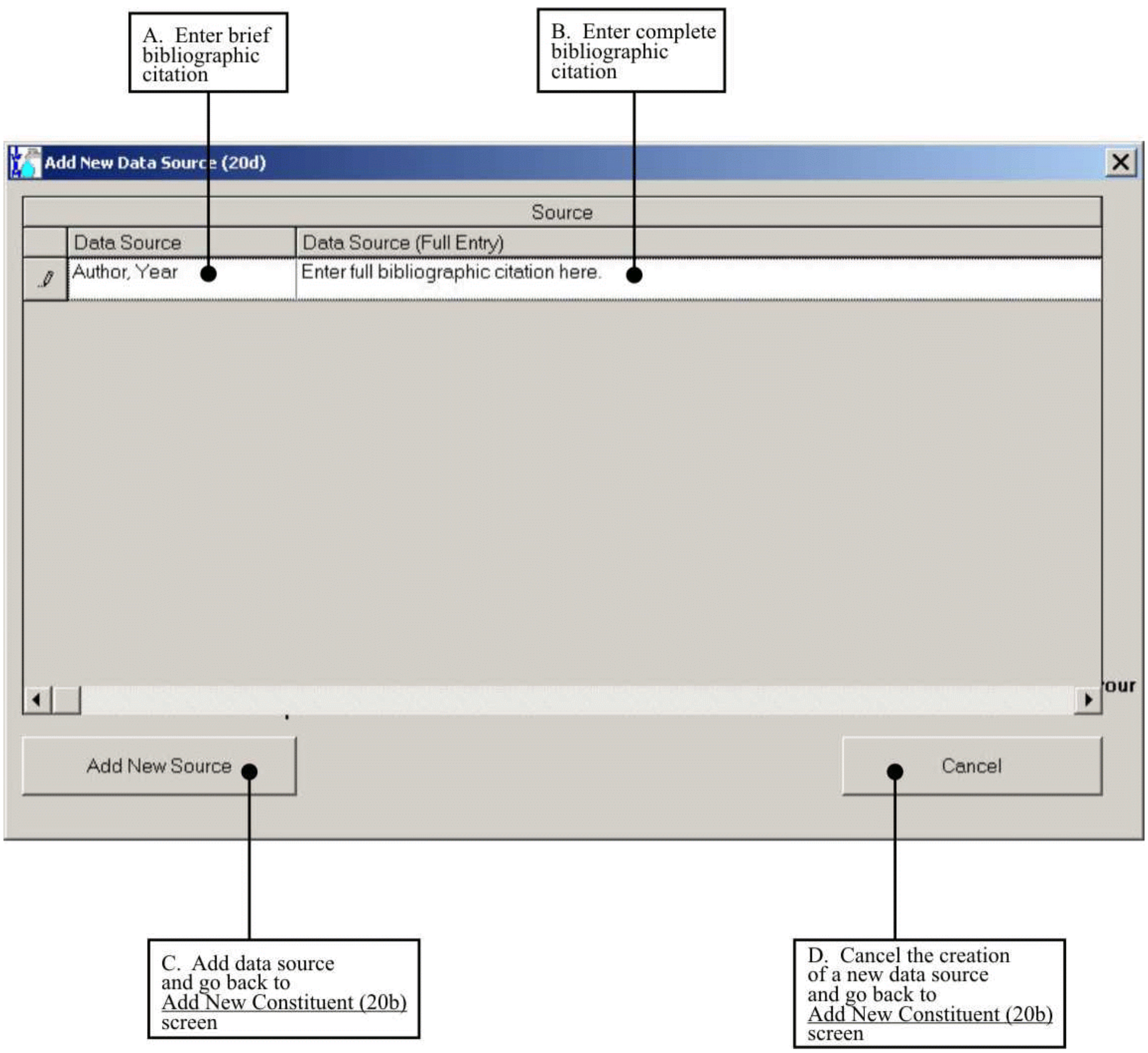


Figure 5.40 Tier 2 Input: Add New Data Source (20d).

The features identified in Figure 5.40 are explained in more detail in the following paragraphs.

A. Enter Brief Bibliographic Citation

If you choose |NEW SOURCE| on dialog box 20b, the dialog box shown in Figure 5.40 will appear. Enter a brief bibliographic citation in this field, in the form of "Author, Year." IWEM uses this information to index all citations, and therefore, this entry must not duplicate an existing reference in the IWEM database.

B. Enter Complete Bibliographic Citation

Enter a complete bibliographic citation in this field. You can use the existing references in the IWEM database as a guide for formatting your newly added citation.

C. Add Data Source and Go Back to Add New Constituent (20b) screen

Click the |ADD NEW SOURCE| button to enter this citation into the IWEM database and return to dialog box 20b.

D. Cancel and Go Back to Add New Constituent (20b) screen

Check the |CANCEL| button if you do not wish to use the new bibliographic citation. This will return you to dialog box 20b.

5.5.1.7 Tier 2 Input: Constituent Properties (21)

On this screen, you can modify constituent sorption and degradation parameters. For each selected waste constituent, IWEM will display default values that are stored in its database. These values will be used in the Tier 2 analysis, unless you override them with user-supplied values. For all constituents, you can enter a value for the soil-water partition coefficient (k_d). For organic constituents, you can also enter an overall first-order degradation rate.

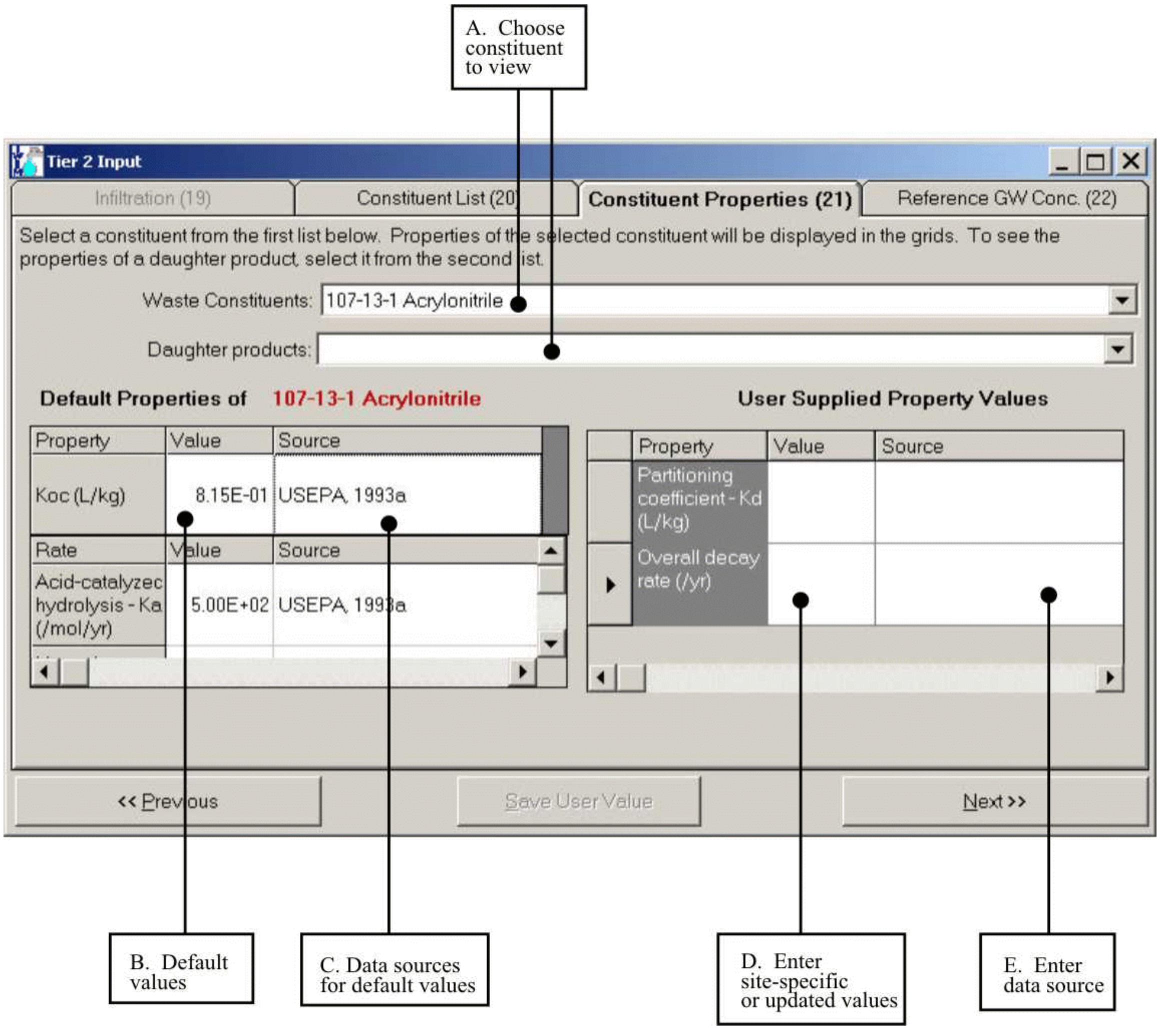


Figure 5.41 Tier 2 Input: Constituent Properties (21).

The features identified in Figure 5.41 are explained in more detail in the following paragraphs.

A. Choose Constituent to View

Select a constituent and/or daughter product from the drop-down lists at the top of the screen. To view the properties for a waste constituent, click on the drop-down list control at the right edge of the |WASTE CONSTITUENTS| listbox. To view the constituent properties for a constituent that is produced by hydrolysis of one of your entered constituents, click on the drop-down list control at the right edge of the |DAUGHTER PRODUCTS| listbox. If the |DAUGHTER PRODUCTS| box is blank, it means that the currently displayed waste constituent has no hydrolysis daughter products. Then use the mouse or the |ARROW| keys to scroll through the list of constituents until the desired constituent is highlighted. Left click on the mouse or hit the |ENTER| key to make your selection.

B. Default Values

The constituent properties and their default values for the selected waste constituent are listed in the table on the left side of the screen.

C. Data Sources for Default Values

The data source for each default parameter value of the selected waste constituent is listed in the "Data Source" field.

D. Enter Site-Specific or Updated Values

For each constituent, IWEM assigns default values for K_{OC} (k_d for metals) and hydrolysis rate constants (for organics only) (see constituent list in Appendix A); however, you can enter and use site-specific values for k_d (organics and metals) and overall decay rate (organics only) if these data are available. To enter site-specific values, just type them into the table on the right side of the screen.

By default, IWEM accounts for degradation from constituent hydrolysis only. IWEM calculates the hydrolysis rate from constituent-specific values for the acid-catalyzed (k_a), neutral (k_n) and base-catalyzed (k_b) hydrolysis rate constants. Biodegradation can also be an important process. However, biodegradation rates can vary greatly from site to site. You should only increase the overall decay rate above the value corresponding to the hydrolysis rate constants if there is clear evidence of biodegradation occurring at a site. For organics, the calculation of the overall decay rate from the hydrolysis rate constants and the calculation of k_d from K_{oc} is given in Sections 4.2.4.1 and 4.2.4.3 of the *IWEM Technical Background Document* (U.S. EPA, 2002c).

E. Enter Data Source

For each Tier 2 input parameter for which you enter a site-specific value, remember to type in a brief explanation of this value. This information is required and will be included in the printed report.

Once your list of waste constituents and expected leachate concentrations is complete, click on the │NEXT│ button to specify RGC values to be used in the Tier 2 evaluation.

5.5.1.8 Tier 2 Input: Reference Ground-Water Concentrations (22)

In screen 22, you select which RGC is to be used to evaluate each waste constituent in the Tier 2 analysis. You can select RGCs (MCLs and HBNs) that are in the IWEM database, or you can supply a user-defined RGC. The following options are available:

- Maximum Contaminant Level (MCL)
- Health-Based Number (HBN)
- User-defined standard (this can be any value and is generally determined by your state regulatory authority)
- Compare to all available standards

The features identified in Figure 5.42 are explained in more detail in the following paragraphs.

A. Select Constituent

On the row for the desired constituent, click in the cell on the far left of the table to display a small arrow indicating which constituent is selected. Once a constituent is selected, the available toxicity standards are displayed on the bottom half of this screen.

B. Select Standard(s) to Apply

Once a constituent listed at the top of the screen is selected, the available ground-water standards (and RGC values) are displayed at the bottom. Using the radio buttons, click on the appropriate standard to use in your Tier 2 analysis. If a constituent has more than one standard, you should consult with the appropriate state regulatory agency to determine which RGC should be used. If none of the default choices are appropriate for your analysis, you can enter a new RGC value and associated exposure duration (see items C and D, below). Additionally, if you choose the last option, │COMPARE TO ALL AVAILABLE STANDARDS│, then the IWEM model will use the most stringent standard to determine the Tier 2 liner recommendation.

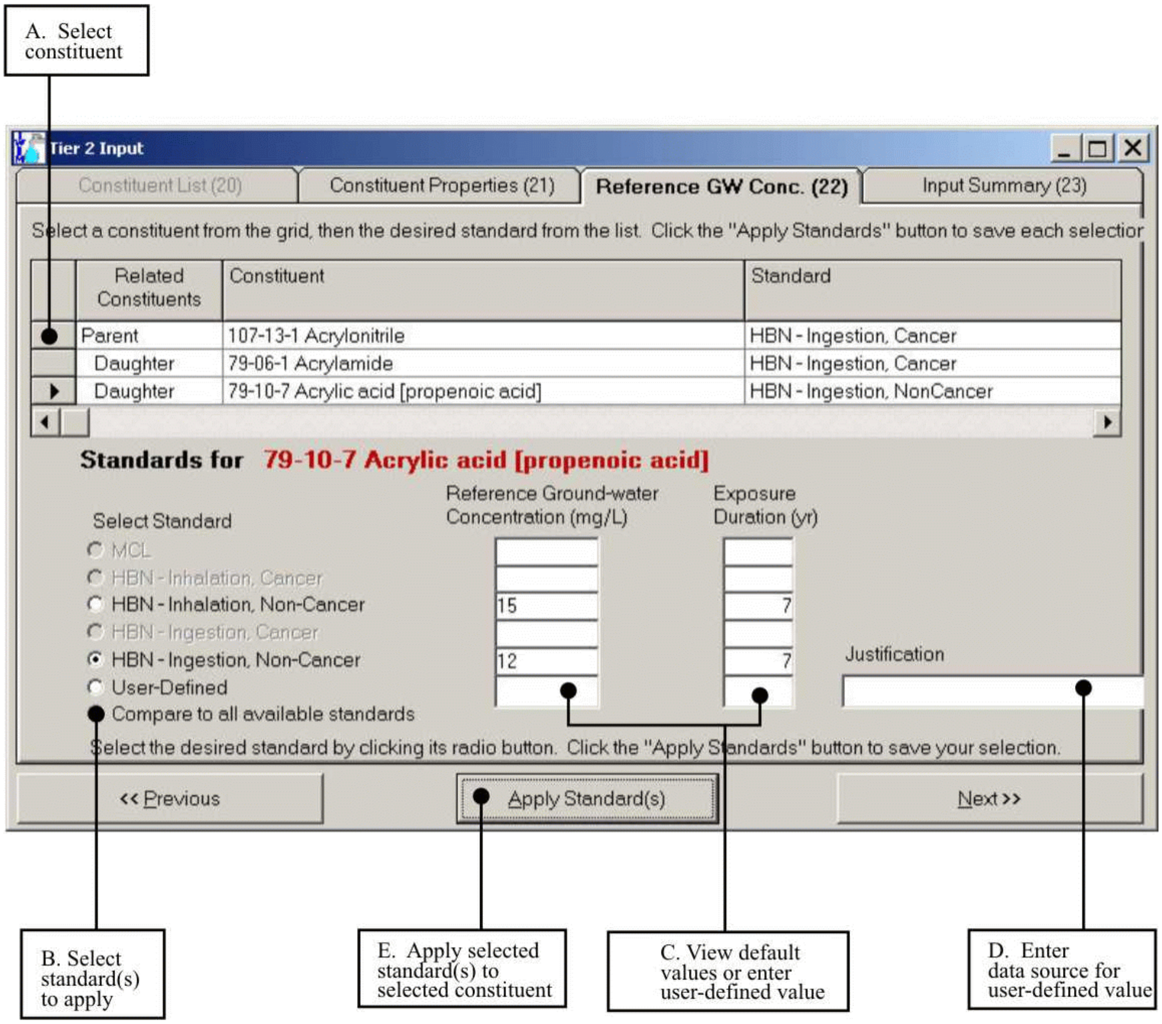


Figure 5.42 Tier 2 Input: Reference Ground-Water Concentrations (22).

C. View Default Values or Enter User-Defined Value

These textboxes display the RGC values in the IWEM database; and in the case of the user-defined RGC, this is where you enter the appropriate RGC value and its associated exposure duration. In the IWEM model, the exposure duration corresponds to the time interval over which the average ground-water concentration is calculated. Consult with the appropriate state regulatory agency for additional guidance on entering your own RGC value and exposure duration.

D. Enter Data Source for User-Defined Value

If you enter a user-specified RGC for any constituent, be sure to provide a brief explanation of this value in the |JUSTIFICATION| textbox.

E. Apply Selected Standard(s) to Selected Constituent

After you have chosen the appropriate standard(s) for the selected constituent, click on the |APPLY STANDARDS| button to input your choice. After you have done so, your selection will be displayed in the |STANDARD| column in the table at the top of the screen.

5.5.1.9 Tier 2 Input: Input Summary (23)

This screen displays a summary of the input data for your Tier 2 analysis. You cannot enter or edit data on the Input Summary screen; rather, its purpose is to consolidate into one place all the data you have already entered for the Tier 2 Evaluation. If you notice that you have entered any data incorrectly, use the |PREVIOUS| button or click on the desired screen tab to go back to the appropriate screen on the Tier 2 Input Screen.

The input summary screen has three sections containing data on: 1) constituent properties; 2) source and unsaturated zone; and 3) saturated zone. Each section has a scroll bar which can be used to view information that does not fit on the screen.

The features identified in Figure 5.43 are explained in more detail in the following paragraphs.

A. Identification of Constituent as Either a Parent or a Toxic Daughter

The first section contains a table of the selected waste constituents, listing their CAS number, name, expected leachate concentration, the type and value of the selected RGC, and fate parameters (log K_{OC}, k_d, hydrolysis rate constants, and/or overall decay rate). The entry in the "Related Constituents" column on the left side of the screen indicates whether the constituent is present in the waste ("parent") or whether it is included because it is a daughter product of a waste constituent ("daughter"). In the latter case, the parent constituent is listed immediately above the daughter.

B. Summary of Constituent Properties

For your reference, the constituent-specific properties for each waste constituent in the Tier 2 analysis are displayed in the table at the top of the screen.

C. Verify Tier 2 Input Values

The bottom section of this screen consists of two tables that present the selected values for the WMU and subsurface parameters. To the left, the selected values for the WMU (source) and unsaturated zone parameters are displayed. To the right, the selected values for the saturated zone parameters are listed. Note that each table has a scroll bar on the right-hand side which can be used to view information which does not fit on the screen.

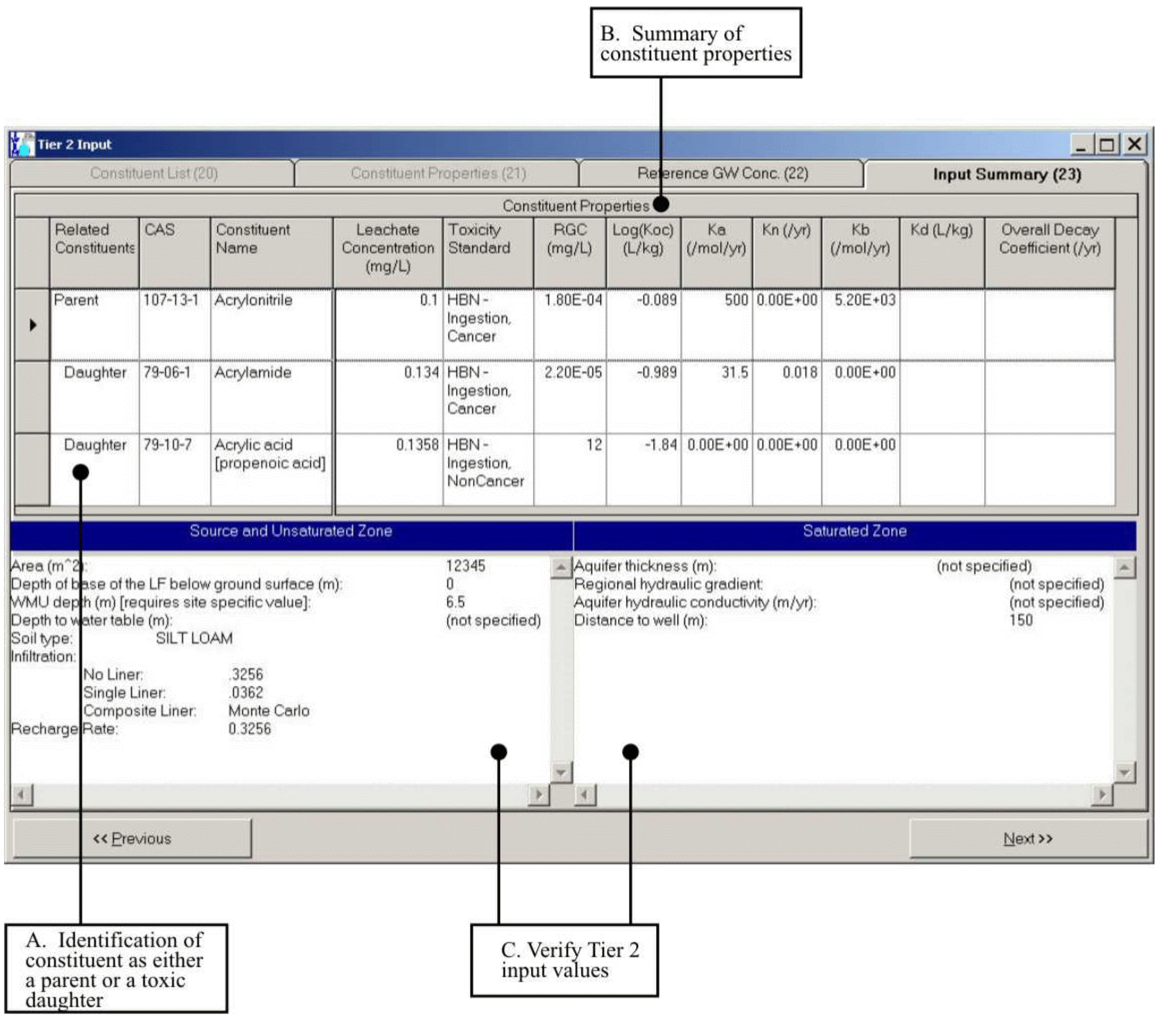


Figure 5.43 Tier 2 Input: Input Summary (23).

5.5.2 Tier 2 Evaluation: Run Manager (24)

After you have verified that all Tier 2 inputs are correct, click the |NEXT| button on the Input Summary screen (23) to perform the Tier 2 evaluation. The Tier 2 Run Manager (Screen 24) will be displayed.

In a Tier 2 evaluation, after you click on the |START EPACMTP| button, the ground-water model is automatically executed for each waste constituent for each applicable liner scenario using the chosen waste constituent-specific and site-specific inputs. Any toxic daughter products produced by hydrolysis of the selected constituents are also evaluated. Each combination of constituent and liner scenario requires one probabilistic Monte Carlo modeling run consisting of 10,000 model realizations. Depending upon model inputs and the speed of your personal computer, each modeling run may take from several minutes to several hours. For this reason, we have developed a Run Manager dialog box which displays the current status of your modeling analysis; this way, you will know that the model is working and how much progress has been made at any given point in time.

The following sequence of screen images (Figures 5.44 through 5.46) demonstrate how the Tier 2 Run Manager and the EPACMTP dialog box help you track the progress of your Tier 2 modeling analysis.

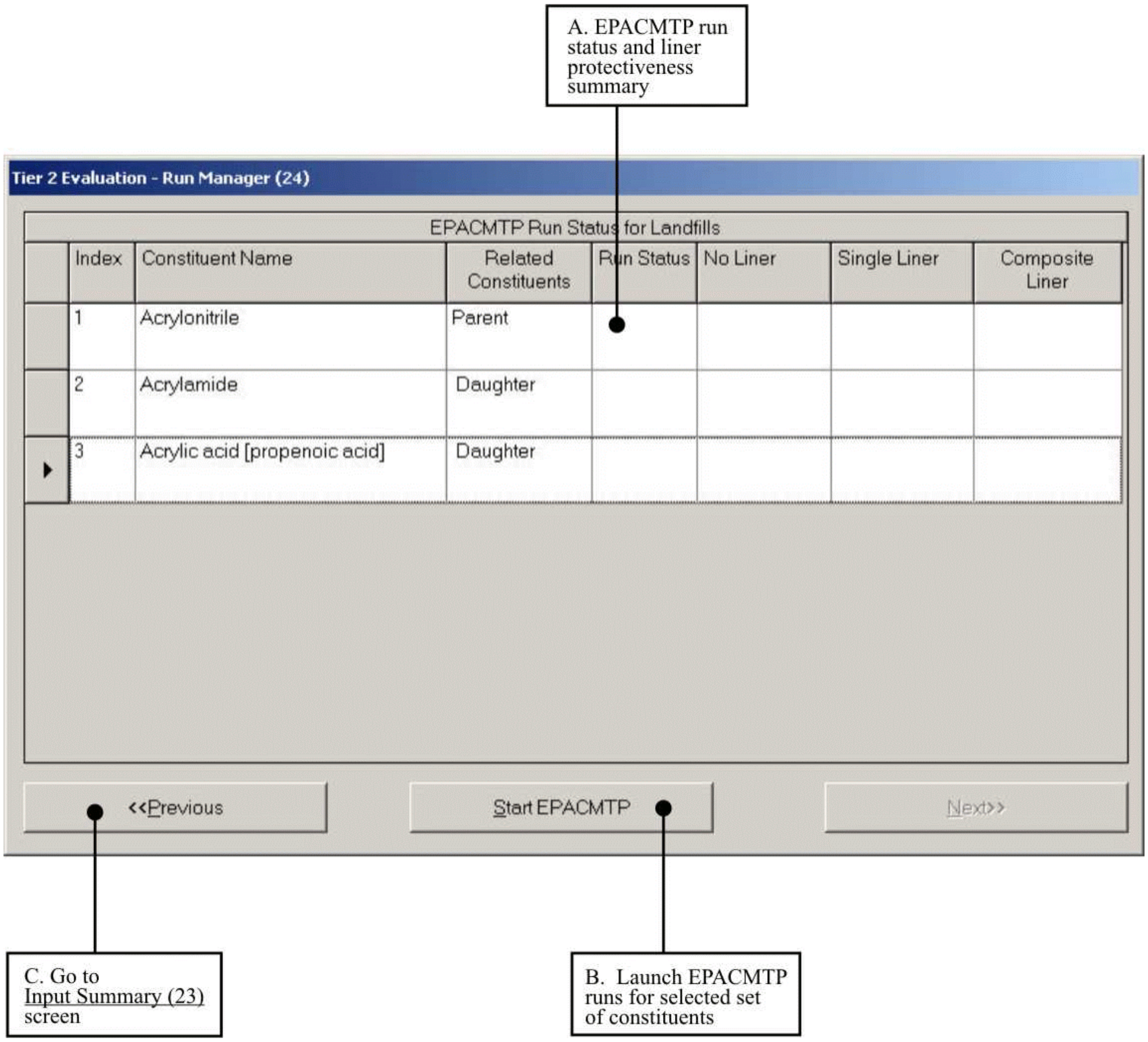


Figure 5.44 Tier 2 Evaluation: Run Manager (24) - Appearance Before Launching EPACMTP Runs.

The features identified in Figure 5.44 are explained in more detail in the following paragraphs.

Figure 5.44 shows a summary table listing all the constituents and liner scenarios in a typical Tier 2 analysis prior to launching the first EPACMTP run. During an EPACMTP run, a dialog box is displayed (Figure 5.45), allowing you to track the progress of the model's execution. The summary table shown in the background (Figure 5.46) keeps you informed of the overall progress of the Tier 2 analysis. The EPACMTP runs proceed from the first to the last selected constituent. For each constituent, EPACMTP runs are sequentially launched for the no-liner, single clay-liner, and composite-liner scenarios until a protective scenario is found. That is, if the single clay-liner scenario is determined to be protective for a given constituent, the composite-liner scenario for that constituent is not modeled. For the LAU or user-defined liner/ infiltration scenarios, only one scenario per constituent is evaluated. During EPACMTP model execution, the message "Running" appears in the table cell corresponding to the current constituent and liner scenario. After the completion of a run, the results are analyzed by IWEM to determine whether the liner scenario is protective for the current constituent. An up-to-date summary of the results is displayed in the summary table as shown in Figure 5.46.

A. EPACMTP Run Status and Liner Protectiveness Summary

This summary table shows the current status of the analysis. For each waste constituent, you can see whether the required modeling is in progress or has been completed. In addition, this table will tell you whether or not each liner scenario is protective of ground water.

B. Launch EPACMTP Runs for Selected Set of Constituents

Click on the |START EPACMTP| button to launch the required EPACMTP runs for the selected set of waste constituents. During an EPACMTP model run, the dialog box shown below in Figure 5.45 appears on-screen and displays the status of the current model run, including estimated time to completion.

C. Go to Input Summary (23) screen

You can click the |PREVIOUS| button at the bottom left of the screen to go back to the Tier 2 Input Summary (23)screen.

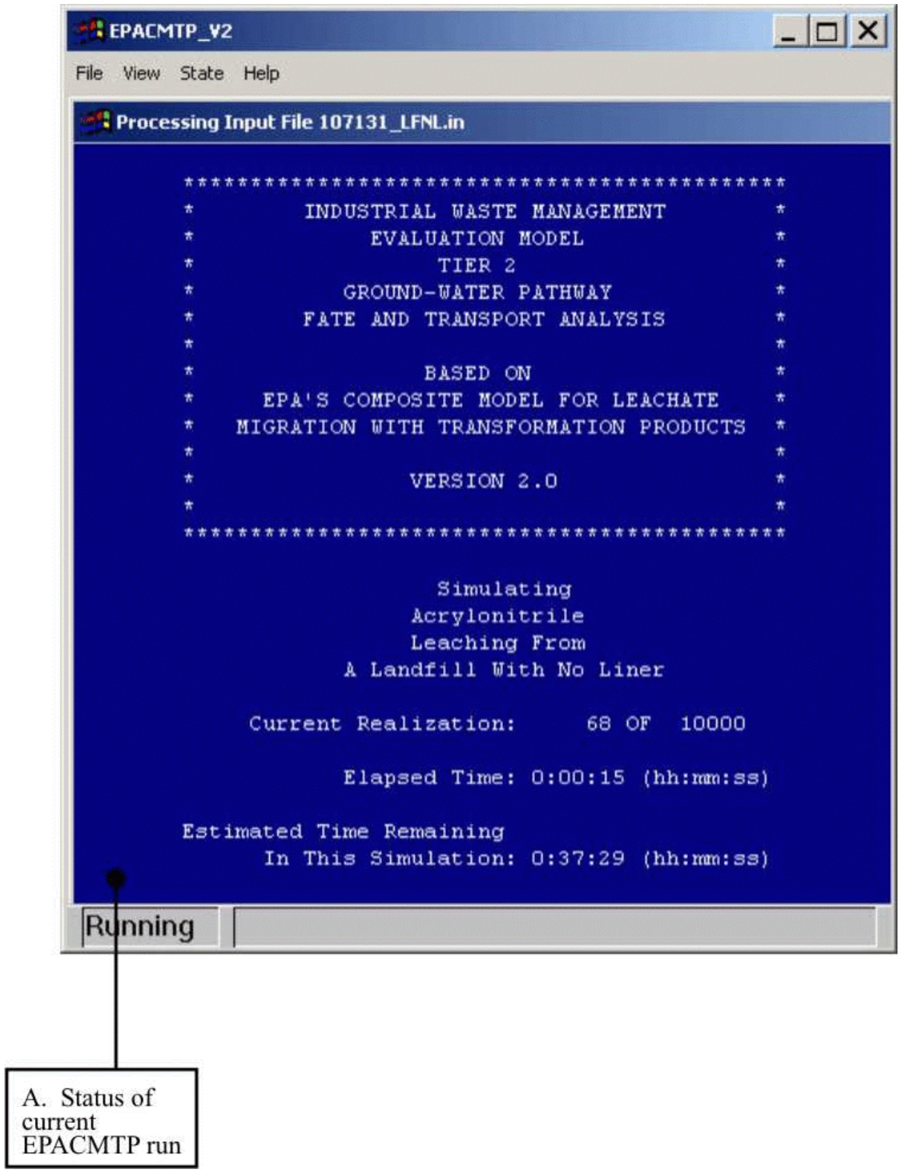


Figure 5.45 Tier 2 Evaluation: Run Manager (24) - EPACMTP Dialog Box Displayed During Model Execution.

A. Status of Current EPACMTP Run

A Run Manager dialog box will be displayed during each EPACMTP run to help you monitor the model's progress in real time. Note that the information displayed on this screen includes: constituent name, WMU type and liner scenario, current realization number, time elapsed, and estimated time remaining.

The summary table displayed on the Run Manager (24) screen, presented below in Figure 5.46, shows you the overall progress of the Tier 2 analysis – the liner recommendation for each completed EPACMTP model run and which (if any) model runs have not yet begun.

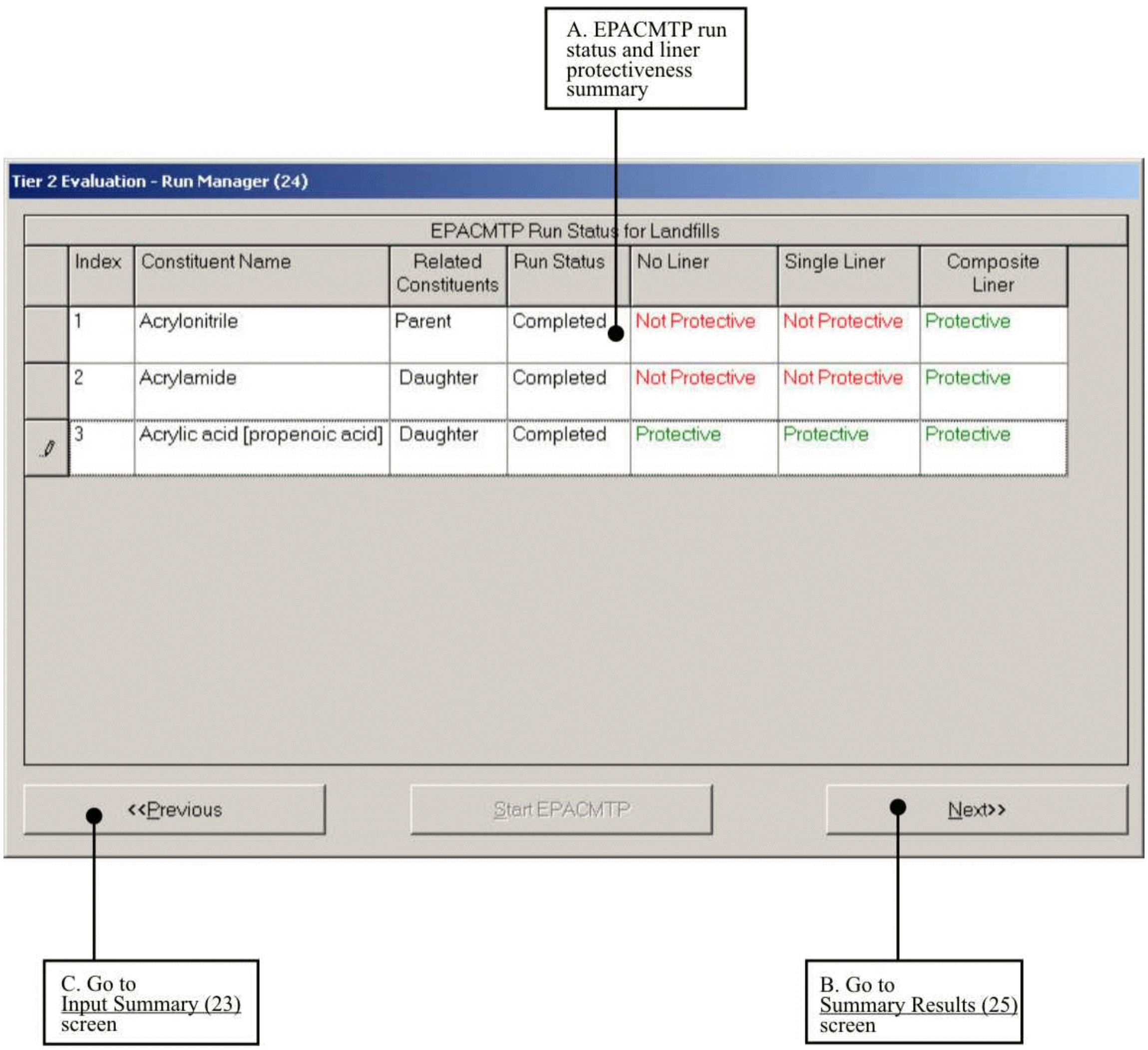


Figure 5.46 Tier 2 Evaluation: Run Manager (24) - Status and Liner Protectiveness Summary.

The features identified in Figure 5.46 are explained in more detail in the following paragraphs.

A. EPACMTP Run Status and Liner Protectiveness Summary

This summary table shows the current status of the analysis. For each waste constituent, you can see whether the required modeling is in progress or has been completed. In addition, this table will tell you whether or not each liner scenario is protective of ground water.

B. Go to Summary Results (25) screen

You can click on the |NEXT| button at the bottom right of the screen to proceed to the brief listing of the Tier 2 results that is presented on the Summary Results (25) screen.

C. Go to Input Summary (23) screen

You can click the |PREVIOUS| button at the bottom left of the screen to go back to the Tier 2 Input Summary (23) screen.

5.5.3 Tier 2 Evaluation Summary: Summary Results Screen (Screen 25)

The presentation of the liner recommendation for the Tier 2 evaluation is determined by which option you chose to specify the infiltration rate (either a location-based estimate or a user-specified value) and your WMU type. But whichever infiltration option you choose, the results are divided into two sets: summary results and detailed results. The first set of results is a summary which reports a liner recommendation for each individual waste constituent and the overall liner recommendation that is protective for all constituents. The second set of results, the detailed results, present the data upon which the liner evaluation is based. For each waste constituent, the expected leachate concentration, the DAF, the Tier 2 LCTV, specified RGC type and value, and the resulting 90^{th} percentile ground-water concentration calculated by EPACMTP are listed. These detailed results allow you to understand how the liner design recommendations were developed.

The results of the Tier 2 Evaluation are first presented on-screen in a summary form. The Summary Results screen provides a liner design recommendation for each of the selected constituents which are listed by name and CAS number. The recommendation is based on a comparison of the resulting 90^{th} percentile ground-water concentration and the specified RGC. If the ground-water concentration does not exceed the specified RGC, then the evaluated liner scenario is protective for that constituent. If the ground-water concentration exceeds the specified RGC, then the evaluated liner scenario is not protective for that constituent. Only the no-liner soil scenario is evaluated for LAUs. In this case, if the no-liner scenario is not protective of ground water, then land application of the modeled waste is not recommended at the site.

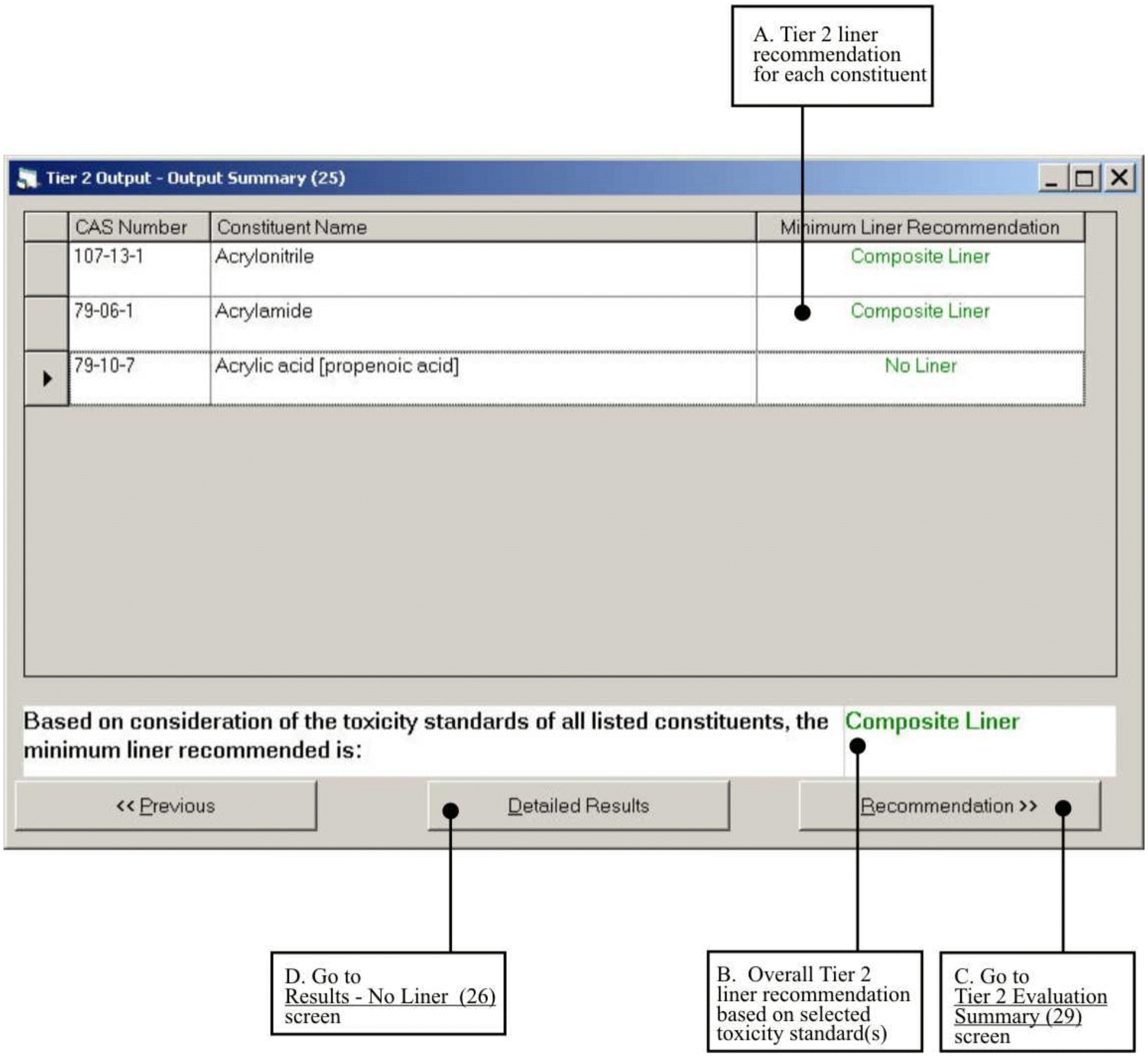


Figure 5.47 Tier 2 Output (Summary): Summary Results (25).

The features identified in Figure 5.47 are explained in more detail in the following paragraphs.

A. Tier 2 Liner Recommendation for Each Constituent

If you evaluated a landfill, waste pile, or surface impoundment and used a location-based estimate of the infiltration rate, the liner recommendation is the minimum recommended liner of the three types that are evaluated (no liner, single clay liner, and composite liner). If you evaluated a LAU and used a location-based estimate of the infiltration rate, the resulting recommendation is whether or not land application of this waste at this site will be protective of ground-water.

If you entered a site-specific infiltration rate (for any type of WMU), then the liner recommendation is whether or not the modeled liner type is recommended as being protective of ground water.

For a Tier 2 evaluation, the no-liner, single clay-liner, and composite-liner recommendations are displayed in green text. If the composite liner is not protective, then this message is displayed in red text. If the liner recommendation is "Not Applicable," then this message is displayed in black text.

B. Overall Tier 2 Liner Recommendation Based on Selected Toxicity Standard(s)

The bottom of the screen displays an overall liner recommendation which is based on consideration of all waste constituents (and their daughter products).

If EPACMTP predicts that the 90th percentile values of ground-water well concentration for all constituents under the no-liner scenario are below their respective RGCs, then IWEM will recommend that no liner is needed to protect groundwater. If the modeled ground-water concentration of any constituent under the no-liner scenario is higher than its RGC, then at least a single clay liner is recommended (or in the case of LAUs, land application is not recommended). If the predicted ground-water concentration of any constituent exceeds the RGC under the composite liner scenario, then consider pollution prevention, treatment, and more protective liner designs, as well as consultation among regulators, the public, and industry to ensure such wastes are protectively managed. See Chapter 4 of the ***Guide*** (U.S. EPA, 2002d) for further information.

For waste streams with multiple constituents, the least stringent liner design that is protective for all constituents is the overall recommended liner design.

C. Go to <u>Tier 2 Evaluation Summary (29)</u> screen

Clicking on the |RECOMMENDATION| button will take you to the Tier 2 Evaluation Summary screen where you can choose to view the Tier 2 report or save your analysis and exit the IWEM software.

D. Go to <u>Results - No Liner (26)</u> screen

Clicking on the |DETAILED RESULTS| button will take you to a detailed listing of the Tier 2 results, including the constituent-specific modeling results for all evaluated liner scenarios.

5.5.4 Tier 2 Output (Details) Screen Group (26, 27, and 28)

The detailed results table for each evaluated liner type presents the data on which the liner recommendation are based. For each waste constituent, this information includes the expected leachate concentration, the DAF, the Tier 2 LCTV, the specified RGC type and value, the resulting 90^{th} percentile ground-water concentration, and text explaining whether or not the liner is recommended as being protective of ground water. These detailed results allow you to understand how the liner design recommendations were developed.

If you directly enter a value for infiltration (for any of the four types of WMUs), EPACMTP will use this value of the infiltration rate in its fate and transport simulation, and IWEM will then compare the predicted ground-water well concentration to each constituent's RGC. In this case, the detailed results will consist of only one screen, rather than the three that are shown below in Figures 5.48 through 5.50.

Also, for a Tier 2 analysis of a LAU, only the no-liner scenario is evaluated since engineered liners are not typically used at this type of facility. In this case, the detailed results will consist of only one screen.

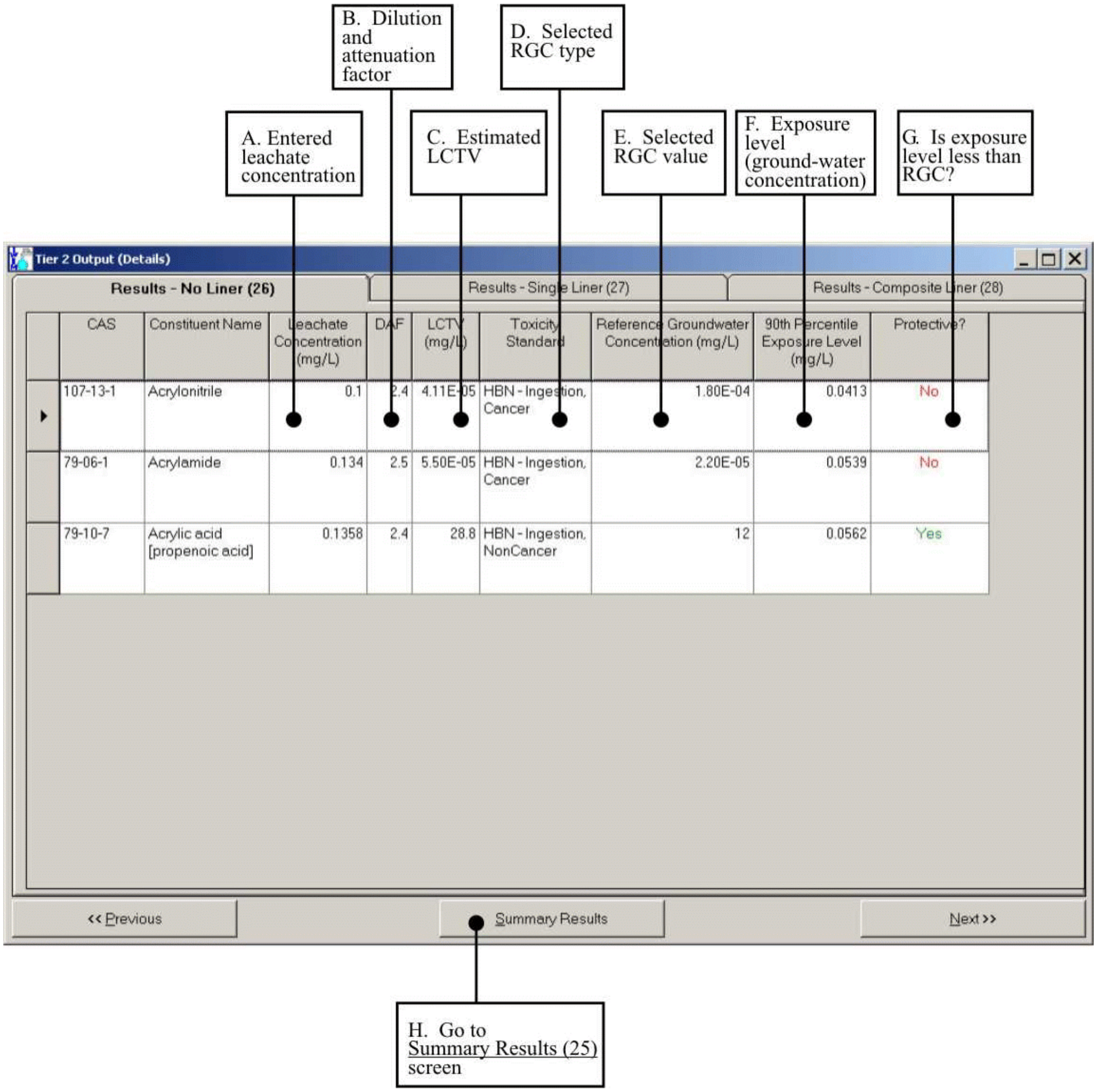


Figure 5.48 Tier 2 Output (Details): Results-No Liner (26).

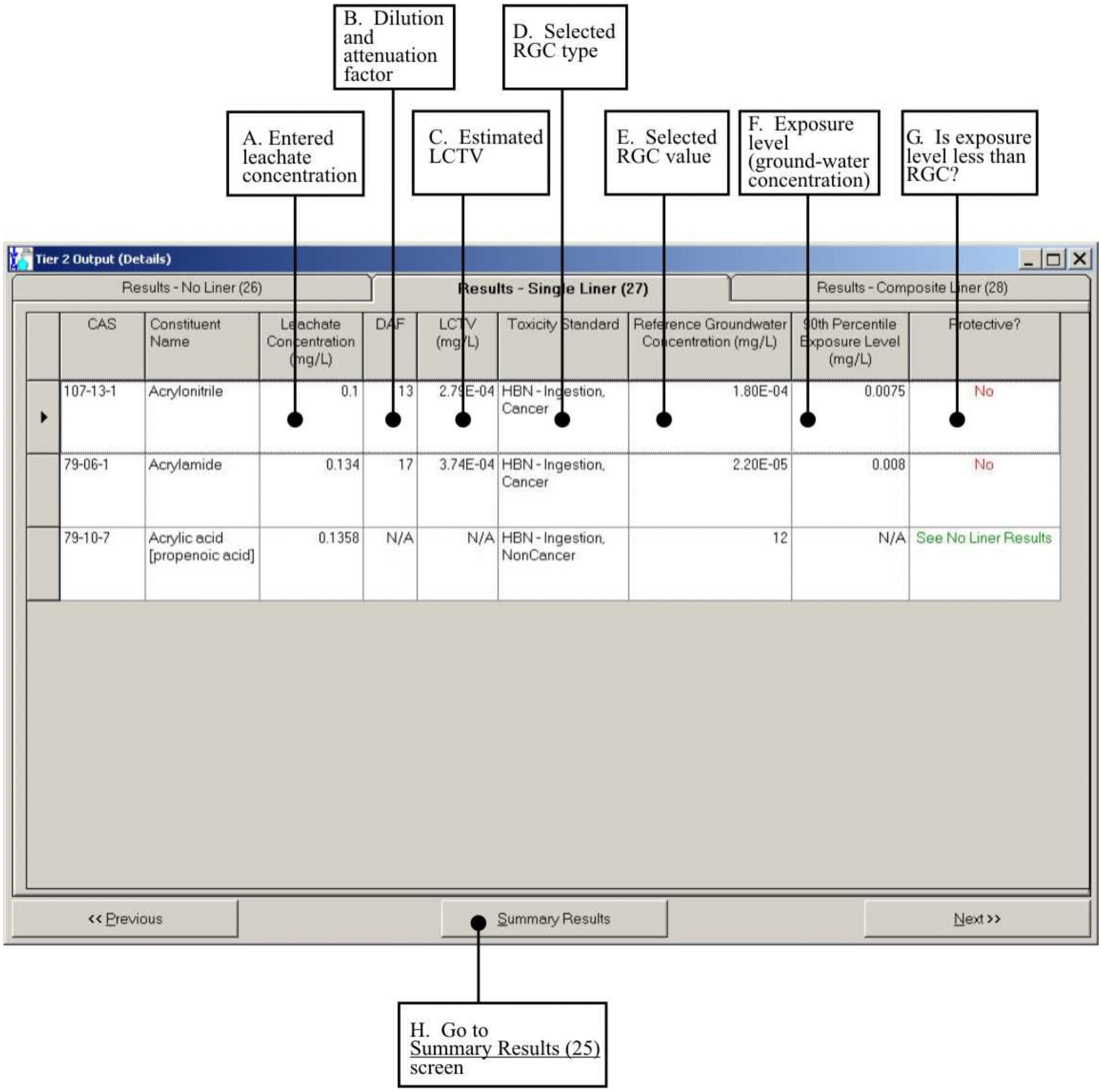


Figure 5.49 Tier 2 Output (Details): Results-Single Liner (27).

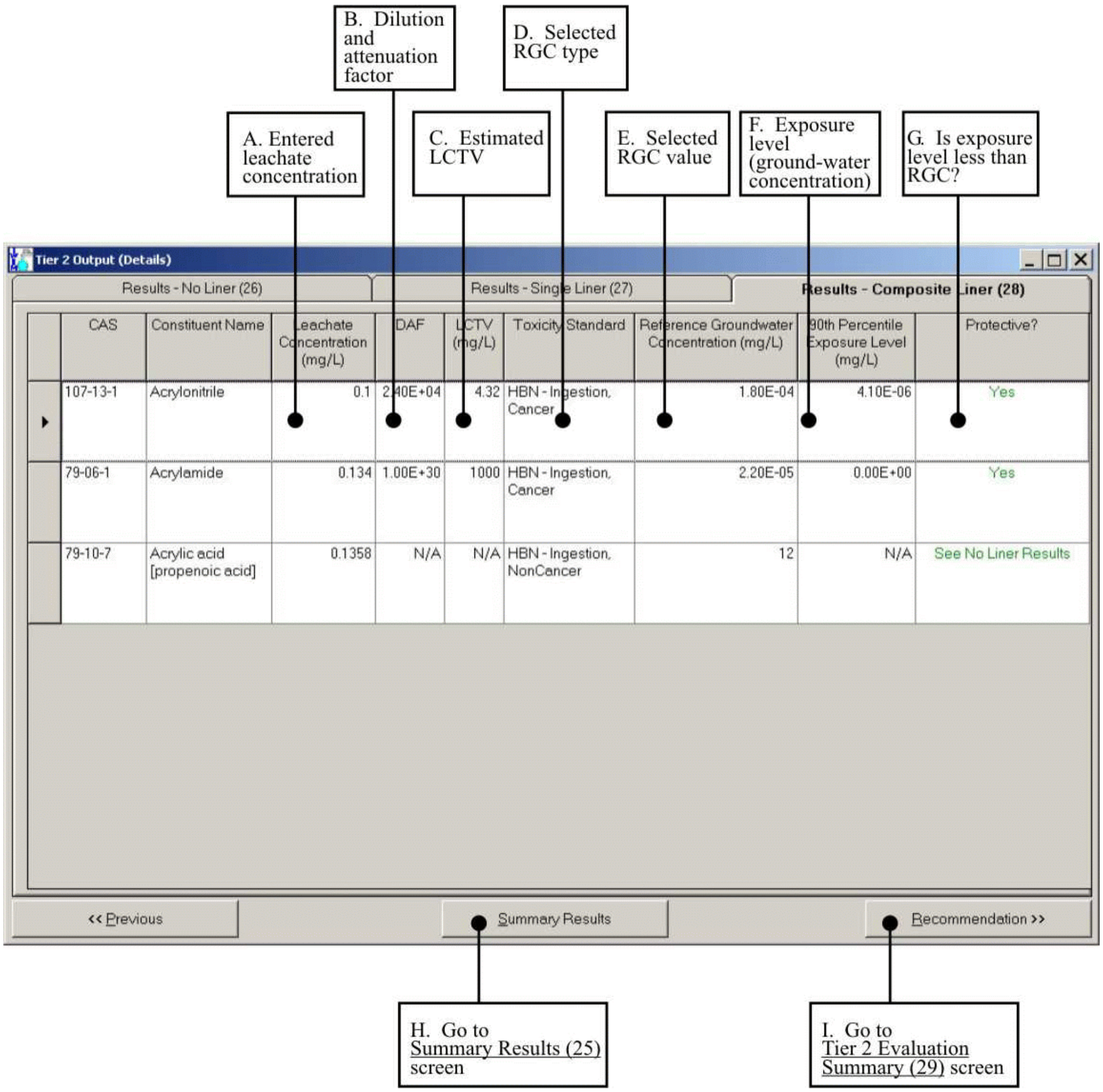


Figure 5.50 Tier 2 Output (Details): Results-Composite Liner (28).

The features identified in Figures 5.48 through 5.50 are explained below.

A. Entered Leachate Concentration

The entered leachate concentration for each constituent is displayed in the third column. This is the value that was used by IWEM in the EPACMTP ground-water fate and transport modeling.

B. Dilution and Attenuation Factor

This column shows the 90th percentile value of the ground-water DAF calculated by EPACMTP. DAF values are capped at 1×10^{30}.

C. Estimated LCTV

The constituent- and liner-specific Tier 2 LCTV is also displayed on this screen. The LCTV for organics is calculated as follows:

$$LCTV = DAF \times RGC$$

where:

LCTV	=	leachate concentration threshold value (mg/L)
DAF	=	dilution-attenuation factor (EPACMTP model output) (dimensionless)
RGC	=	reference ground-water concentration (MCL, HBN, or user-specified value) (mg/L)

In Tier 2, the LCTV for metal constituents is an estimated value due to the non-linear nature of metals adsorption (that is, for metals the DAF is not constant across all leachate concentrations, as it is for organics). For this reason, an adjustment factor of 0.85 is used to estimate the LCTVs for metals in order to ensure adequate protection of the ground water. The Tier 2 LCTV for metals is calculated as follows:

$$LCTV = DAF \times RGC \times 0.85$$

D. Selected RGC Type

The selected RGC type is displayed in this table for your reference. In addition to regulatory MCLs, four types of HBNs can be evaluated in the IWEM software, covering the direct ingestion and inhalation pathways, and carcinogenic and non-carcinogenic health effects. However, if the existing values in the IWEM software are not appropriate for your analysis, you may enter your own RGC to be used in the Tier 2 analysis. In any case, the specified RGC type and value are displayed for each waste constituent.

E. Selected RGC Value

The selected RGC value is also displayed in this table for your reference. Note that is value may be an MCL, an HBN, or a user-defined value.

F. Exposure Level (Ground-water Concentration)

In order to determine whether or not this liner scenario is protective for a given constituent, the resulting 90th percentile ground-water concentration is compared with the specified RGC. If the ground-water concentration does not exceed the specified RGC, then the evaluated liner is protective for that constituent. If the ground-water concentration exceeds the specified RGC, then the evaluated liner is not protective for that constituent.

G. Is the Exposure Level Less than the RGC?

The result of the comparison between the modeled 90th percentile exposure level (ground-water concentration) and the specified RGC is displayed at the far right of this table.

If the 90th percentile exposure level does not exceed the specified RGC, then the evaluated liner is protective for that constituent and the text in the last column of this table will read |YES| for that constituent.

If the 90th percentile exposure level exceeds the specified RGC, then the evaluated liner is not protective for that constituent and the text in the last column of this table will read |NO| for that constituent.

H. Go to <u>Summary Results (25)</u> Screen

Clicking on the |RESULTS SUMMARY| button will take you back to the Tier 2 <u>Summary Results (25)</u> screen.

I. Go to <u>Tier 2 Evaluation Summary (29)</u> Screen

Clicking on the |RECOMMENDATION| button will take you to the next screen, the Tier 2 <u>Evaluation Summary (29)</u> screen where you can choose to view the Tier 2 report or save your analysis and exit the IWEM software.

5.5.5 Tier 2 Evaluation Summary (29)

The <u>Tier 2 Evaluation Summary</u> screen identifies the overall Tier 2 liner recommendations and lists the available options within the IWEM software.

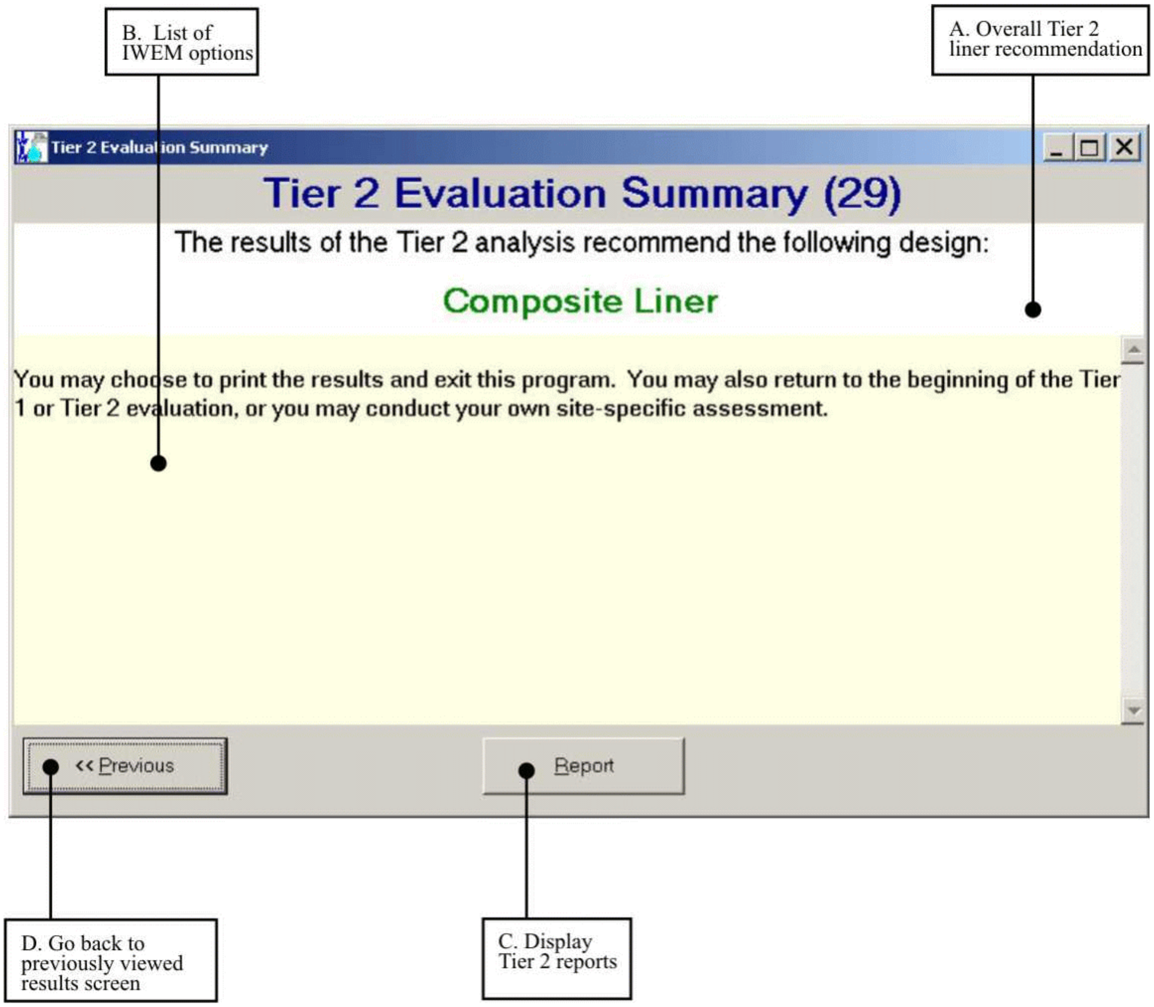


Figure 5.51 Tier 2 Evaluation Summary (29).

The features identified in Figure 5.51 are explained in more detail in the following paragraphs.

A. Overall Tier 2 Liner Recommendation

The Tier 2 liner recommendation is displayed at the top of this screen. For landfills, surface impoundments, and waste piles that were modeled using a location-based estimate of the infiltration rate, the available recommendations are: no-liner, single clay-liner, composite-liner, and not protective. For LAUs that were modeled using a location-based estimate of the infiltration rate, the available recommendations are: no-liner and not protective. If you entered a user-specified value for the infiltration rate, the available recommendations are: protective and not protective. If your Tier 2 evaluation results in a recommendation of "not protective", then the chosen WMU for managing the waste may not be appropriate at the selected site. In this case, consider pollution prevention, treatment, and more protective liner designs, as well as consultation among regulators, the public, and industry to ensure such wastes are protectively managed. See Chapter 4 of the ***Guide*** (U.S. EPA, 2002d) for further information.

B. List of IWEM Options

After reviewing your Tier 2 results on-screen, you have several options to continue within the IWEM software:

- Go back to the previous screens of the Tier 2 results by clicking on the |PREVIOUS| button.

- View the Tier 2 report by clicking the |REPORT| button.

At this point, you can also choose to save your results, exit the IWEM software, or conduct a Tier 3 Evaluation. For more information about Tier 3 Evaluations, see Chapter 7A (Protecting Ground Water - Assessing Risk) of the ***Guide***.

There are several ways to save the Tier 2 Evaluation:

- Click on the |FILE| menu and choose |SAVE| or |SAVE AS|. A dialog box will then open which prompts you for the filename and directory location, as appropriate. Once you have provided a filename, the tool will save two files, automatically applying the "wem" and "mdb" extensions for you. The combination of these two files completely describes the data you have entered and any model-generated results. Please note that you cannot save any files to the cd-rom, so you must specify a directory on your hard-drive or a floppy disk to save the file.

- Click on the |SAVE| button on the toolbar. If you are editing a previously saved evaluation, the file will be automatically updated. If you have created a new evaluation, the |SAVE AS| dialog box will open, as described above.

Note that IWEM will not allow you to save both model inputs and results at a point where the inputs do not correspond to the model-generated results. If you do choose to save your work in a situation like this, only the inputs will be saved; that is, when you later open up this file, you will have to perform either the Tier 1 or Tier 2 evaluation to create the corresponding results. Once you have completed an evaluation you should save it under an appropriate file name. If you want to start a new evaluation by editing an existing IWEM file, you should first save the new evaluation under a different name to avoid losing the results of your original evaluation.

You can exit the IWEM software by clicking on the |File| menu, and choosing |Exit|. If you forget to save before trying to exit the IWEM software, a dialog box will ask if you want to save your data before exiting the software.

You can open a previously saved IWEM analysis by clicking on any one of the following options:

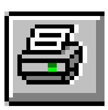
- |Open| button on the Tool Bar
- |File|Open| selection from the Menu Bar
- |Open Saved Analysis (*.WEM File)| radio button from the |IWEM Analysis Options| dialog box (see Item B in Section 5.3)

Once the |Open| dialog box is displayed, highlight the appropriate file and click the |Open| button to open the desired file. You will then see a dialog box in which you can specify what type of analysis you want to perform – Tier 1 or Tier 2.

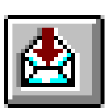
C. Display Tier 2 Reports

Clicking on the |Report| button displays the IWEM Tier 2 Report.

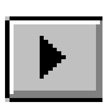
Once the Tier 2 report is displayed on-screen, you can then use the following toolbar buttons to print, save, and scroll through the pages of the report:



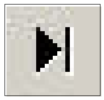
Print the report; the |Print| dialog box then appears where you can adjust printer setting or choose to print selected pages.

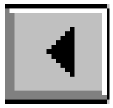


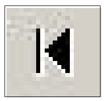
Export the report in order to save it to a file; after specifying the file type, destination type, and the pages to be included, the |Choose Export File| dialog box then appears; you can specify the file type, and then select the file name and directory. The file types in this list are dependent upon what software you have installed on your PC. Most users will find that the option for PDF format will produce a document-ready report.



View the next page of the report


View the last page of the report.


View the previous page of the report


View the first page of the report.

Change the display size of the report.

Tier 2 Report Includes:

- WMU facility data entered on screen 16
- List of selected constituents and their corresponding leachable concentrations entered on screen 20
- List of Tier 2 input values and explanations of user-input data, as summarized on screen 23
- Tier 2 summary results for each selected constituent, based on the user-specified RGC for each constituent
- Tier 2 detailed results for each selected constituent, based on the user-specified RGC for each constituent, and including an explanation of any appropriate caps or warnings about the presented results
- Constituent properties and RGCs for each selected constituent, including full references for the data sources

An example Tier 2 report is included in this *User's Guide* in Appendix B.

D. Go Back to Previously Viewed Tier 2 Results

Click on the |PREVIOUS| button to return to the Tier 2 results that were previously displayed. That is, if you navigated directly to the Tier 2 Evaluation Summary (29) screen from the Summary Results (25) screen, then screen 25 is the screen you will return to. However, if you viewed the detailed results before navigating to the Tier 2 Evaluation Summary (29) screen, then clicking the |PREVIOUS| button will return you to the Results-Composite Liner (28) screen.

6.0 Understanding Your IWEM Input Values

This section of the *User's Guide* will assist you in understanding the WMU, waste constituent and other fate and transport data that IWEM uses to evaluate whether a liner design is protective.

Broadly speaking, there are three main categories of input values:

- WMU data,
- Waste constituent data, and
- Location-specific climate and hydrogeological data.

A Tier 1 analysis requires only a few key inputs. A Tier 2 analysis, which is designed to provide a more accurate evaluation, requires you to provide additional site-specific input data. Section 6.1 describes basic inputs that are common to both Tier 1 and Tier 2 evaluations. Section 6.2 describes the additional inputs for a Tier 2 evaluation.

The *IWEM Technical Background Document (TBD)* provides additional detail on the Tier 1 and Tier 2 input values. To assist you in cross-referencing the discussion on each input parameter to the corresponding section(s) of the TBD, specific references to the TBD are provided for each IWEM input. The references are indicated pictorially as follows:


Section x.y.z

TBD

6.1 Parameters Common to Both Tier 1 and Tier 2 Evaluations

The common parameters are:

1) <u>WMU type</u>,

2) <u>Constituent(s) of concern</u> that are present in the WMU, and

3) <u>Leachate concentration</u> (in mg/L) of each constituent.

6.1.1 WMU Type

Section 3.1; 4.2.1
TBD

IWEM address four different types of WMUs. Each of the four unit types reflects waste management practices that are likely to occur at industrial Subtitle D facilities. The WMU can be a landfill, a waste pile, a surface impoundment, or a land application unit. The latter is also sometimes called a land treatment unit. Figure 6.1 presents schematic diagrams of the different types of WMU's modeled in IWEM.

Landfill. Landfills are facilities for the final disposal of solid waste on land. IWEM considers closed landfills with an earthen cover and either no-liner, a single clay liner, or a composite, clay-geomembrane liner. IWEM assumes there is no leachate collection system. The release of waste constituents into the soil and ground water underneath the landfill is caused by dissolution and leaching of the constituents due to precipitation which percolates through the landfill. The type of liner that is present controls, to a large extent, the amount of leachate which is released from the unit. Because the landfill is closed, the concentration of the waste constituents will diminish with time due to depletion of landfill wastes. The leachate concentration value that is used as an input is the expected initial leachate concentration when the waste is 'fresh'.

Surface Impoundment. A surface impoundment is a WMU which is designed to hold liquid waste or wastes containing free liquid. Surface impoundments may be either ground level or below ground level flow-through units. They may be unlined, or they may have a single clay liner or a composite clay-geomembrane liner. Release of leachate is driven by the ponding of water in the impoundment, which creates a hydraulic head gradient across the barrier underneath the unit. In Tier 1, IWEM uses a national distribution of values for surface impoundment operational life. In Tier 2, you can enter a site-specific value. The Tier 2 default is 50 years.

Waste Pile. Waste piles are typically used as temporary storage or treatment units for solid wastes. Due to their temporary nature, they will not typically be covered. IWEM does consider liners to be present, similar to landfills. In Tier 1 analyses, IWEM assumes that waste piles have a fixed operational life of 20 years, after which the waste pile is removed. In Tier 2, you can provide a site-specific value for the operational life. The default value is 20 years. After the operational period, IWEM assumes the waste pile is removed.

Land Application Unit. Land application units (or land treatment units) are areas of land receiving regular applications of waste which can be either tilled directly into the soil or sprayed onto the soil and subsequently tilled into the soil. IWEM models the leaching of wastes after they have been tilled with soil.

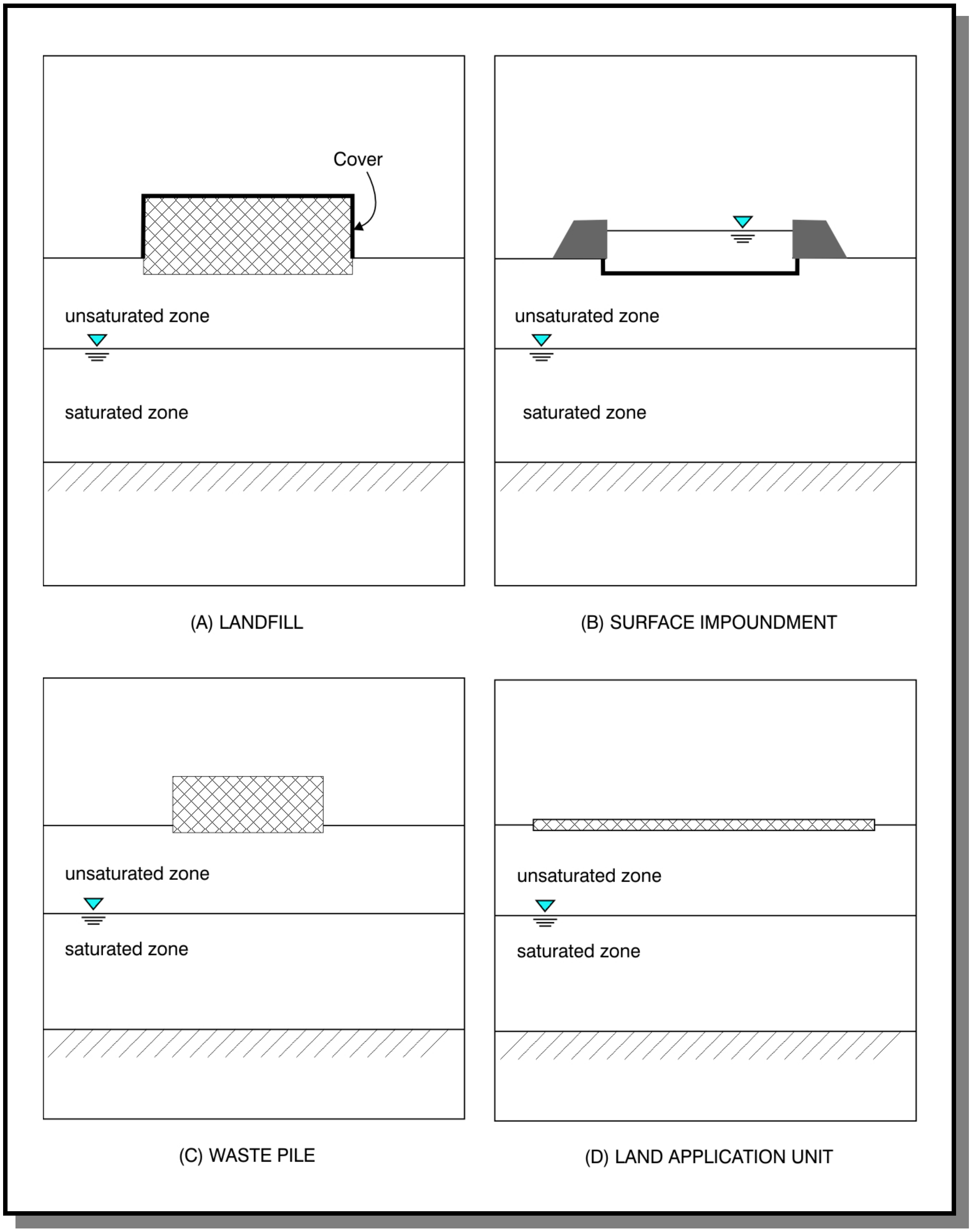


Figure 6.1 WMU Types Modeled in IWEM.

IWEM does not account for the losses due to volatilization during or after waste application. In Tier 1, land application units have a 40 year active life. In Tier 2, you can enter a site-specific value. The Tier 2 default value for operational life is 40 years. Land application units are evaluated for only the no-liner scenarios because liners are not typically used at this type of facility.

6.1.2 Waste Constituents

The IWEM software includes a built-in database with 206 organic constituents and 20 metals. Appendix A provides a list of these constituents. In IWEM you select the waste constituents for each WMU scenario that you wish to evaluate from a drop-down list, either by constituent name or by Chemical Abstract Service (CAS) identification number, or from a list of constituents sorted by constituent name or by CAS number. With each constituent, you also select a set of constituent-specific reference ground-water concentrations (see Section 6.1.4) and fate and transport characteristics. The fate and transport characteristics include sorption parameters and hydrolysis rate constants.

In Tier 1, you can only evaluate constituents found in the built-in database, and you are not able to change the fate and transport characteristic values associated with each constituent. In Tier 2, you can add constituents to IWEM's database as well as modify fate and transport characteristic values for constituents already in the database.

6.1.3 Leachate Concentration

Section 4.2.1.3
TBD

You must provide the leachate concentration in mg/L for each selected waste constituent that you expect in the leachate that will infiltrate into the soil underneath a WMU. EPA has developed a number of tests to measure the leaching potential of different wastes and waste constituents in the laboratory. These include the Toxicity Characteristic Leaching Procedure (TCLP) and the Synthetic Precipitation Leaching Procedure (SPLP). Consult Chapter 2 of the ***Guide*** (Characterizing Waste) for analytical procedures that can be used to determine expected leachate concentrations for waste constituents.

6.1.4 Reference Ground-water Concentrations

Section 5.0
TBD

Associated with each waste constituent is a set of RGCs that reflect not-to-exceed exposure levels for both drinking water ingestion and shower inhalation cancer risks and non-cancer hazards. These include regulatory MCLs and HBNs. Collectively, HBNs and MCLs are referred to in IWEM as RGCs. Each type of RGC is briefly described below.

6.1.4.1 Maximum Contaminant Level (MCL)

Section 5.0 TBD

For a number of constituents, the EPA has set MCLs as part of the National Primary Drinking Water Regulations (NPDWR). The MCL is the maximum permissible level of a contaminant in public water systems. For each contaminant to be regulated, EPA first sets a Maximum Contaminant Level Goal (MCLG) at a level that protects against health risks. EPA then sets each contaminant's MCL as close to its MCLG as feasible, taking costs and available analytical and treatment technologies into consideration.

6.1.4.2 Health-Based Number (HBN)

Section 5.0 TBD

All constituents included in the IWEM software have one or more HBNs. An HBN is the maximum exposure concentration of a contaminant in a domestic water supply that will not cause adverse health effects. Health effects and certain exposure assumptions are considered in the determination of the HBN, while other factors, such as the cost of treatment, are not considered. The HBNs in IWEM are based on the ingestion of drinking water and the inhalation of volatiles during showering. HBN values are based on a target risk of 1×10^{-6} for carcinogens and a hazard quotient of 1 for non-carcinogens. HBNs in IWEM were calculated using standard EPA risk assessment assumptions and equations. An overview of the approach used to develop HBNs is given below. Section 5 of the *IWEM Technical Background Document* provides a detailed description.

Ingestion of Drinking Water

Section 5.1 TBD

We calculated ingestion HBNs for a residential receptor who ingests contaminated drinking water for 350 days/year. Consistent with EPA policy, the ingestion HBNs were calculated to reflect consideration of children's exposure. The calculation of cancer HBNs assumed an exposure duration of 30 years and used a time-weighted average drinking water intake rate for individuals aged 0 to 29 years, equal to 0.0252 liters per day per kilogram body weight. In the case of cancer HBNs, the 30-year exposure period represents a high-end (95th percentile) value for population mobility. We chose the 30-year period to cover ages 0-29 to ensure childhood years were included. Non-cancer ingestion HBNs were developed to be protective of children aged 0 to 6 years; the calculations used a daily ingestion rate that is representative of children in this age-group, and is equal to 0.0426 liters per day per kilogram body weight.

Inhalation of Volatiles During Showering **Section 5.2 TBD**

Inhalation HBNs were calculated for adults because we assumed that children take baths. We assumed daily 15 minutes showers for 350 days per year over 30 years and used a shower model to calculate the average constituent concentration in air to which an individual is exposed during a day as a result of volatilization of a constituent in shower water. We assumed that the shower water is ground water from the well modeled by EPACMTP. We also made the important assumption that constituents are released into household air only a result of showering activity, and that exposure to air-phase constituents only occur in the shower stall and bathroom. EPA acknowledges that not considering exposures to children who bathe in bathtubs may be a significant limitation. However, we have not yet developed a "bath" model for evaluating children.

6.1.4.3 <u>Selection of the RGC within the IWEM Software</u>

Tier 1 LCTVs are provided for both MCLs and HBNs. In the case of HBNs, the LCTV reflects the most restrictive pathway and effect, i.e., the lowest of the available HBNs. At Tier 2, you can select the type of RGC (either MCL, ingestion HBN, inhalation HBN, or all) that you wish to use. You may also enter your own constituent-specific RGC values. For example, your state regulatory authority may request that you use HBNs that are calculated using a different target risk level or a different assumption regarding the weight of an adult. (Instructions regarding the selection of RGCs and entering user-specified RGCs are provided in Section 5.4.1.6 of this *User's Guide*.)

6.2 Additional Parameters for a Tier 2 Evaluation

This section describes the additional parameters for which you can provide site-specific values in a Tier 2 evaluation. There are two categories of Tier 2 input parameters: required parameters for which you must provide site-specific values; and optional parameters for which you can provide site-specific values if data are available. When site-specific data for some of the optional model inputs are not available, the suggested default values or distributions of values can be used.

6.2.1 Basis for Using Site-Specific Parameter Values

The Tier 1 evaluation provides a quick screening analysis of whether or not a WMU design is protective for wastes of concern. The IWEM Tier 1 analysis compensates for the lack of site-specific information by being conservative. Tier 1 LCTVs are based on simulating a wide range of conditions, and then selecting the 90^{th} percentile of the predicted ground-water concentration as the basis for assigning the

LCTV. In other words, the Tier 1 evaluation is expected to be protective in 90% of the cases.

The Tier 2 evaluation, which is designed to simulate a specific WMU, has less uncertainty in its liner recommendation than a Tier 1 evaluation of the same site. This reduction in uncertainty is achieved by using site-specific data which are both easily measured and important to the model output.

6.2.2 Tier 2 Parameters

Table 6.1 provides a list of the Tier 2 IWEM parameters. The table indicates: (1) the parameters the user may specify in Tier 2 grouped by the main input groups of the IWEM software, (2) the units of measurement; (3) whether the parameter is a required user input; (4) the IWEM default if the parameter is not a required user input; and (5) the ranges of allowable input values.

Parameters that require user inputs are indicated with **YES** in the corresponding column of the table. All other parameters are optional user inputs. The following sections discuss the Tier 2 parameters in more detail.

6.2.2.1 Tier 2 Parameters that Require User Inputs

Parameters in Table 6.1 that are marked with **YES** in the '*Required User Input?*' column are those for which you must provide a site-specific value in Tier 2; the software does not have a default value. In addition to selecting the WMU type and providing constituent leachate concentrations, there are only four other key parameters for which the user must provide data. They are:

- WMU Area;
- WMU Depth for landfills;
- Ponding Depth for surface impoundments; and
- Climate Center that is nearest to your site.

6.2.2.2 Optional Tier 2 Parameters

Except the required parameters listed above, all other Tier 2 parameters listed in Table 6.1 are optional user input parameters. Use of site-specific data is strongly recommended for these parameters, but if you do not have a value, the IWEM software will allow you to select a default value.

Table 6.1 Tier 2 Parameters

Parameter	Units	Required User Input?	Default	Range	
				Min	Max
WMU Parameters					
WMU Area	m^2	**YES**		1	1.0E+8
WMU Depth (LF only)	m	**YES**		>0	10
Ponding Depth (SI Only)	m	**YES**		0.01	100
Sediment Layer Thickness (SI Only)	m	-	0.2	0.2	100[a)]
WMU Base Depth below ground surface	m	-	0.0	-100[b)]	100[b)]
Operational Life (SI, WP, LAU)	yr	-	*(1)*	1.0	200
Surface Water Body within 2,000 (SI Only)	m	**-**	360	0	5,000
Distance to Ground-Water Well	m	-	150	0	1,609
Subsurface Parameters					
Subsurface Environment	-	-	*(2)*	NA	NA
Depth to Water Table	m	-	*(3)*	0.1	1,000
Saturated Zone Thickness	m	-	*(3)*	0.3	1,000
Hydraulic Gradient	m/m	-	*(3)*	>0	1
Hydraulic Conductivity	m/yr	-	*(3)*	3.15	$1x10^8$
Subsurface pH - Solution limestone environment - All other	-	-	 7.5 6.2	 7 1	 14 14
Infiltration and Recharge Parameters					
Infiltration Rate	m/yr	-	*(4)*	0	100
Nearest Climate Center	-	**YES**	*(5)*	NA	NA
Regional Soil Type	-	-	*(6)*	NA	NA
Waste Type Permeability	-	-	*(6)*	NA	NA
Constituent Parameters					
Constituent Name	-	-	*(7)*	NA	NA
CAS Number	-	-	*(7)*	50-00-0	999999-99-9
K_{oc} (organics only)	L/kg	-	*(7)*	0.0	1.0E+10
Overall Decay Coefficient (organics only)	1/yr	-	*(7)*	0.0	100
Acid Hydrolysis Rate	1/(M·yr)	-	*(7)*	0.0	1.0E+10
Neutral Hydrolysis Rate	1/yr	-	*(7)*	0.0	100

Table 6.1 Tier 2 Input Parameters (continued)

Parameter	Units	Required User Input?	Default	Range	
				Min	Max
Base Hydrolysis Rate	1/(M·yr)	-	*(7)*	0.0	1.0E+10
MCL	mg/L	-	*(7)*	>0	NA
Ingestion HBN - Cancer	mg/L	-	*(7)*	>0	NA
Ingestion HBN - Non Cancer	mg/L	-	*(7)*	>0	NA
Inhalation HBN - Cancer	mg/L	-	*(7)*	>0	NA
Inhalation HBN - Non Cancer	mg/L	-	*(7)*	>0	NA
User RGC	mg/L	-	*(8)*	>0	NA
Exposure Duration	yrs	-	*(9)*	>0	70

NA = Not Applicable
a) Value cannot be larger than impoundment ponding depth
b) Negative value indicates base is above ground surface; depth value cannot be larger than depth to water table.

NOTES:

(1) Default operational life is 50 years for Surface Impoundments, 20 years for Waste Piles, and 40 years for Land Application Units.

(2) Select from the IWEM list; if you select type "unknown," the subsurface parameters will be set to mean values from the IWEM nationwide database.

(3) Assigned from the IWEM database according to the selected subsurface environment.

(4) Assigned from the IWEM database according to the selected climate station, soil type or waste type.

(5) You must select a center from the IWEM list, usually the center nearest to your WMU location.

(6) Select from the IWEM list; if you select type "unknown," the soil type or waste type will be chosen randomly from the three known types during the Tier 2 modeling process.

(7) Applicable only when you wish to add constituents to the IWEM constituent list; you must provide at least one MCL or HBN value for each new constituent.

(8) Applicable when you want to add an HBN to a constituent already in the IWEM database.

(9) Applicable only when you supply a user-specific RGC.

6.2.2.3 Default Values for Missing Data

Default values for Tier 2 parameters are generally obtained from IWEM's internal ground-water modeling and constituent property databases. The IWEM software is designed to help you make reasonable choices for default parameter values. For instance, if you do not know the specific values for ground-water parameters, such as the thickness of the saturated aquifer zone and the hydraulic ground-water gradient, but you do know the general hydrogeology of your site (*e.g.*, you have an alluvial aquifer at your site), IWEM will use this information to select appropriate ground-water values for alluvial aquifers.

Depending on the parameter involved, IWEM may use either a single default value for a missing parameter, or it may use a probability distribution of values, to accommodate a range of possible values.

6.2.2.4 How IWEM Handles Infeasible User Input Parameters

The IWEM software checks all entered data values. It verifies that only numeric data are entered in data fields and that values are non-negative. In addition, IWEM checks that values are all within feasible ranges. When a value is outside the feasible range, IWEM will display a warning and will not allow you to proceed until you change the entered value. Table 6.1 lists the minimum and maximum allowed values for each Tier 2 parameter.

In addition to checking individual parameters, IWEM ensures that combinations of parameters will not lead to physically unrealistic results. This is particularly the case for parameter combinations which could cause an excessive degree of ground-water mounding underneath a WMU. The extent of ground-water mounding depends on WMU characteristics, the permeability of the unsaturated and saturated zones of the aquifer, the depth to ground water and the saturated thickness of the saturated zone. IWEM checks for infeasible parameter combinations after you have entered all Tier 2 parameters and alerts you if it has found a problem. If IWEM determines that the data you have provided will cause an excessive degree of ground-water mounding, IWEM will reduce the allowed infiltration rate.

6.2.3 Tier 2 Parameter Descriptions

This section provides a detailed description of the individual Tier 2 parameters, including how you may obtain site-specific values. The parameters are organized in groups, according to the grouping in the IWEM software data entry screens.

6.2.3.1 WMU Parameters

Sections 3.1, 4.2.1.3, 4.2.5
TBD

WMU Area (m^2). This parameter represents the footprint area of the WMU (area = length x width). This is a required user-input value for a Tier 2 evaluation. The area must be entered in square meters. To convert other units to square meters, use the following factors:

1 Acre = 4,046.9 m^2
1 Hectare = 10,000 m^2
1 ft^2 = 0.093 m^2

WMU Depth (m). If you select 'Landfill' as the WMU type, you must also enter the depth of the landfill. This parameter represents the average waste thickness in the landfill at closure. For landfills this is a required user input value. It does not apply to waste piles or land application units. For surface impoundments, you must enter an equivalent parameter, the ponding depth (see below). The landfill depth must be entered in meters. To convert other units to meters, use the following factors:

1 Foot = 0.305 m
1 Inch = 0.0254 m

Ponding Depth (m). This is a required user input parameter for surface impoundments only. This parameter represents the average depth of free liquid in the impoundment. Surface impoundments tend to build up a layer of consolidated 'sludge' at their bottom; the thickness of the layer, if present, should **not** be counted as part of the ponding depth. The ponding depth must be entered in meters. To convert other units to meters, use the same conversion factors listed above.

Sediment Layer Thickness (m). This is an optional user input value. It is applicable to surface impoundments only. This parameter represents the average thickness of accumulated sediment ('sludge') deposited on the bottom of the impoundment. The sediment layer thickness must be entered in meters. The default value is 0.2 m. To convert other units to meters, use the same conversion factors listed above.

Depth of the WMU Base Below Ground Surface (m). This is an optional user input value. It represents the depth of the base of the unit below the ground surface, as schematically depicted in Figure 6.2. The depth of the unit below the ground surface reduces the distance in the unsaturated zone through which leachate constituents have to travel before they reach ground water. This depth must be entered in meters. The default value is 0.0 meters, i.e., the base of the unit is level with the ground surface. To convert other units to meters, use the same conversion factors listed above. There may be circumstances in which the base of the WMU is elevated above the ground surface. IWEM can handle this situation in two ways:

a) If you know the depth to ground water of your site, you can enter the total vertical distance between the base of the WMU and the water table as the **Depth of the Water Table** in the subsurface parameters input screen. In this case, set the **Depth of the WMU Base Below Ground Surface** to zero (0.0).

b) If you do not know the depth to the water table, then you can enter the elevation of the WMU base as a **negative** value for the **Depth of the WMU Base Below Ground Surface.** For instance, if the unit is 1 meter above ground surface, enter a value of -1 as the depth.

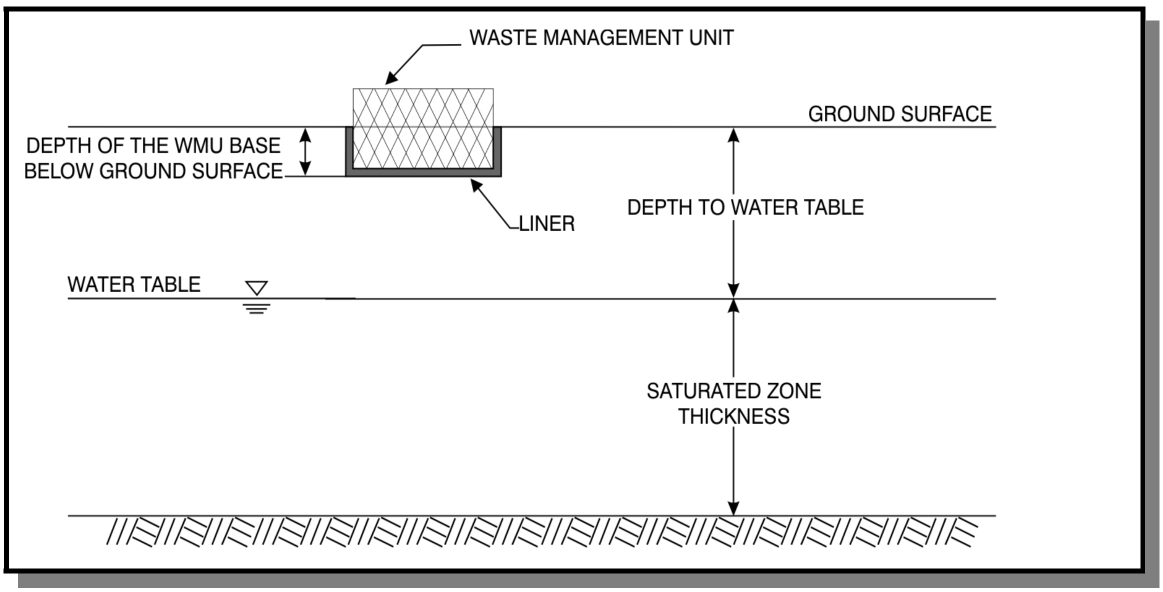


Figure 6.2 WMU with Base Below Ground Surface.

Operational Life (yr). For waste piles, surface impoundments, or land application units, the operational life is an optional Tier 2 user input parameter. This parameter does not apply to landfills because each landfill is assumed closed with waste in place and the time required to deplete the contaminants in a landfill waste is calculated for the user by IWEM. See Section 6.1.1 for more details on leaching durations. The operational life represents the number of years the WMU is in operation, or, more precisely for the purpose of IWEM, the number of years the unit releases leachate. Default values for this parameter are as follows:

- Waste Pile = 20 years
- Land Application Unit = 40 years
- Surface Impoundment = 50 years

Distance to Nearest Surface Water Body (m). For surface impoundments, IWEM needs to know whether or not there is a permanent surface water body within 2,000 meters of the WMU, (*i.e.*, a river, pond, or lake). This parameter is used in the calculation of ground-water mounding to cap the infiltration rate from surface impoundments. The surface water body does not have to be located in the direction of ground-water flow and can be in any direction from the WMU unit. If you know the distance to the nearest surface water body, IWEM will use that value. If the distance is unknown or known with some uncertainty, IWEM provides the following options:

- Distance to surface water body is unknown (IWEM uses 360 m),
- Exact distance is unknown but it is less than 2000 m (IWEM uses 360 m), or
- Exact distance is unknown but it is greater than 2000 m (IWEM uses 5000 m).

Distance to nearest well (m). This parameter represents the distance, in the **direction of downgradient ground-water flow**, to an actual or potential ground-water exposure location. This exposure location can be represented as a ground-water well. Figure 6.3 depicts how the well distance is measured. This figure shows a plan view (upper graph) and a cross-sectional view (lower graph) of a groundwater constituent plume emanating from a WMU. The WMU is represented as the dark rectangular area in the figure. The constituent plume is represented by the lighter shaded area. In this figure, the direction of ground-water flow underneath the WMU is from left to right. The constituent plume follows the direction of ground-water flow, but as it moves, the plume also spreads laterally (upper graph) as well as vertically (lower graph). In IWEM, these processes are modeled by EPACMTP. Figure 6.3 also shows the location of the well.

IWEM always assumes that the well is located along the center line of the plume, but the software randomly varies the depth of the well intake point (see lower graph) during the Monte Carlo simulation process. The distance between WMU and the location of the well is an optional user input parameter at Tier 2. This parameter must be entered in meters, and has a default value of 150 meters (492 feet). To enter a site-specific value, determine the direction of ground-water flow, and then the horizontal distance to the nearest well (or location at which you want to ensure that constituent concentrations in ground water do not exceed protective levels) along the direction of groundwater flow. If you are unsure of the ground water flow direction, it will be protective to enter the shortest distance between the edge of the WMU and the nearest location of concern.

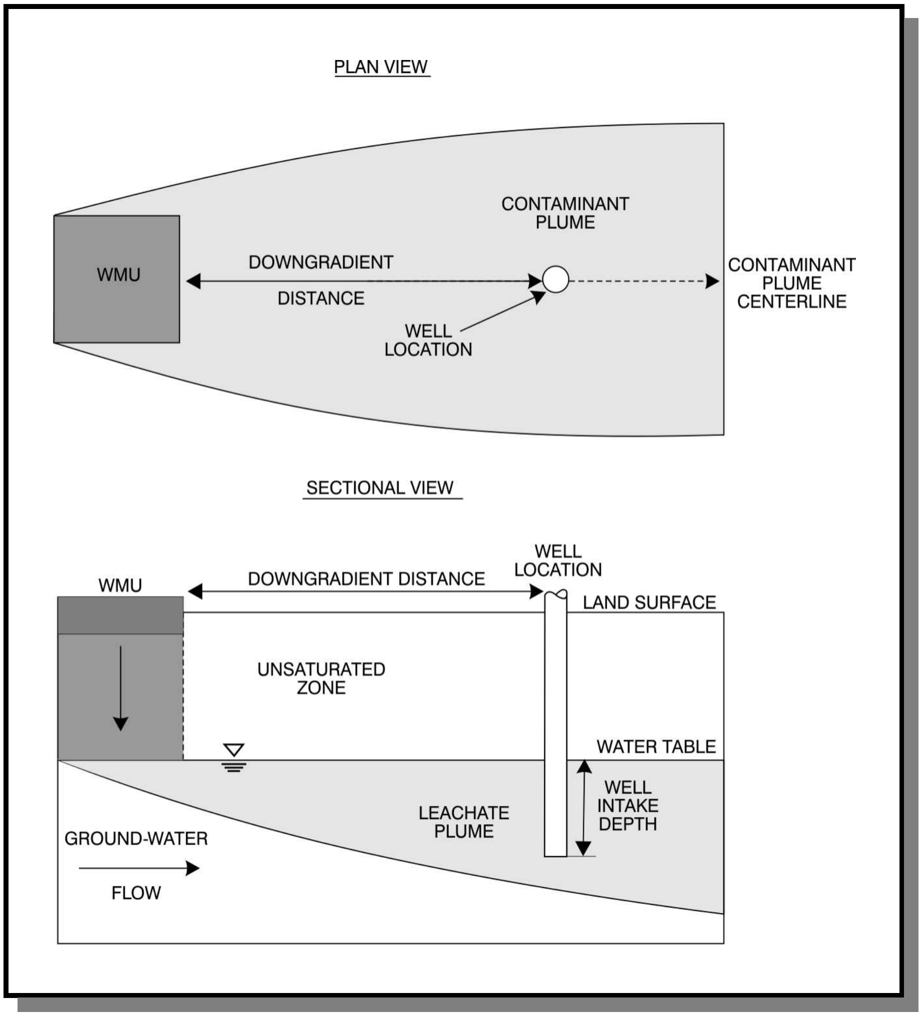


Figure 6.3 Position of the Modeled Well Relative to the Waste Management Unit.

For compatibility with the EPACMTP ground-water model and consistency with related EPA programs, we assume the well is located within 1 mile, or 1,609 meters, from the WMU. IWEM will not accept larger values.

While IWEM allows you to enter a site-specific value for the distance between the well and the WMU, the model does not allow you to modify the depth of the well intake point below the water table. In IWEM evaluations, the depth of the well intake point is always treated as a 'Monte Carlo' parameter, i.e., the tool will vary the well depth during the model simulations, from zero (right at the water table), up to a maximum depth of 10 meters (30 feet) below the water table. If the value for the saturated thickness of your aquifer (see section 6.2.3.2) is less than 10 meters, IWEM will use that actual depth as the maximum value for the well depth. Also, IWEM does not allow you to vary the distance from the center line of the plume.

6.2.3.2 Subsurface Parameters

Section 4.2.3.1 TBD

The subsurface parameters in IWEM comprise a group of the most important ground-water modeling parameters. Unfortunately, these parameters are not easily measured. Obtaining site-specific values for these parameters requires a hydrogeological site characterization. Such information may be available from WMU planning and siting studies, environmental impact assessments, and RCRA permit applications. The United States Geological Survey (www.usgs.gov) and your local state geological survey may also be good sources of site-specific information.

To assist you in performing a Tier 2 evaluation, the IWEM software provides multiple options for entering subsurface parameters to assist you in making the best possible use of information you have. The preferred option is to use accurate site-specific values for all of the parameters, entering them directly in the appropriate data input screens. The second option is where you have values for some, but not all of the parameters. In this case, you enter the parameter values that you know, and IWEM makes a best estimate of the missing values, utilizing knowledge the software has as to how the various parameters tend to be correlated from its national ground-water modeling database. The third, and least desirable, option is where you have no site-specific subsurface data whatsoever. In this case, IWEM simply assigns parameter values that are average values from its database.

The individual IWEM parameters in this group are discussed below.

Subsurface Environments. IWEM includes a built-in database of hydrogeological parameters, organized by 12 different subsurface environments, plus one 'unknown' category, as follows:

1) Metamorphic and Igneous
2) Bedded Sedimentary Rock
3) Till over Sedimentary Rock
4) Sand & Gravel
5) Alluvial Basins, Valleys & Fans
6) River Valleys and Floodplains with Overbank Deposits
7) River Valleys and Floodplains without Overbank Deposits
8) Outwash
9) Till and Till over Outwash
10) Unconsolidated and Consolidated Shallow Aquifers

Subsurface Environment Descriptions

1) Igneous and Metamorphic Rocks
This hydrogeologic environment is underlain by consolidated bedrock of volcanic origin. This hydrogeologic environment setting is typically associated with steep slopes on the sides of mountains, and a thin soil cover. Igneous and metamorphic rocks generally have very low porosities and permeabilities This hydrogeologic environment can occur throughout the United States, but is most prevalent in the western US.

2) Bedded Sedimentary Rock
Sedimentary rock is formed through erosion of bedrock. Deposited layers of eroded material may later be buried and compacted to form sedimentary rock. Generally, the deposition is not continuous but recurrent, and sheets of sediment representing separate events come to form distinct layers of sedimentary rock. Typically, these deposits are very permeable and yield large quantities of ground water. Examples of this hydrogeologic environment setting are found throughout the United States.

3) Till Over Sedimentary Rock
This hydrogeologic environment is found in glaciated regions in the northern United States which are frequently underlain by relatively flat-lying consolidated sedimentary bedrock consisting primarily of sandstone, shale, limestone, and dolomite. The bedrock is overlain by glacial deposits which, consists chiefly of till, a dense unsorted mixture of soil and rock particles deposited directly by ice sheets. Ground water occurs both in the glacial deposits and in the sedimentary bedrock. Till deposits often have low permeability.

4) Sand and Gravel
Sediments are classified into three categories based upon their relative sizes; gravel, consisting of particles that individually may be boulders, cobbles or pebbles; sand, which may be very coarse, coarse, medium, fine or very fine; and mud, which may consist of clay and various size classes of silt. Sand and gravel hydrogeologic environments are very common throughout the United States and frequently overlie consolidated and semi-consolidated sedimentary rocks. Sand and gravel aquifers have very high permeabilities and yield large quantities of ground water.

5) Alluvial Basins, Valleys and Fans
Thick alluvial deposits in basins and valleys bordered by mountains typify this hydrogeologic environment. Alluvium is a general term for clay, silt, sand and gravel that was deposited during comparatively recent geologic time by a stream or other body of running water. The sediments are deposited in the bed of the stream or on its flood plain or delta, or in fan shaped deposits at the base of a mountain slope. Alluvial basins, valleys and fans frequently occupy a region extending from the Puget Sound-Williamette Valley area of Washington and Oregon to west Texas. This region consists of alternating basins or valleys and mountain ranges. The surrounding mountains, and the bedrock beneath the basins, consist of granite and metamorphic rocks. Ground water is obtained mostly from sand and gravel deposits within the alluvium. These deposits are interbedded with finer grained layers of silt and clay.

Subsurface Environment Descriptions (continued)

6) River Alluvium with Overbank Deposits
This hydrogeologic environment is characterized by low to moderate topography and thin to moderately thick sediments of flood-deposited alluvium along portions of a river valley. The alluvium is underlain by either unconsolidated sediments or fractured bedrock of sedimentary or igneous/metamorphic origin. Water is obtained from sand and gravel layers which are interbedded with finer grained alluvial deposits. The alluvium typically serves as a significant source of water. The flood plain is covered by varying thicknesses of fine-grained silt and clay, called overbank deposits. The overbank thickness is usually greater along major streams and thinner along minor streams but typically averages 5 to 10 feet.

7) River Alluvium without Overbank Deposits
This hydrogeologic environment is identical to the River Alluvium with Overbank Deposits environment except that no significant fine-grained floodplain deposits occupy the stream valley. The lack of fine grained deposits may result in significantly higher recharge in areas with ample precipitation.

8) Outwash
Sand and gravel removed or "washed out" from a glacier by streams is termed outwash. This hydrogeologic environment is characterized by moderate to low topography and varying thicknesses of outwash that overlie sequences of fractured bedrock of sedimentary, metamorphic or igneous origin. These sand and gravel outwash deposits typically serve as the principal aquifers within the area. The outwash also serves as a source of regional recharge to the underlying bedrock.

9) Till and Till Over Outwash
This hydrogeologic environment is characterized by low topography and outwash materials that are covered by varying thicknesses of glacial till. The till is principally unsorted sediment which may be interbedded with localized deposits of sand and gravel. Although ground water occurs in both the glacial till and in the underlying outwash, the outwash typically serves as the principal aquifer because the fine grained deposits have been removed by streams. The outwash is in direct hydraulic connection with the glacial till and the glacial till serves as a source of recharge for the underlying outwash.

10) Unconsolidated and Semi-consolidated Shallow Surficial Aquifers
This hydrogeologic environment is characterized by moderately low topographic relief and gently dipping, interbedded unconsolidated and semi-consolidated deposits which consist primarily of sand, silt and clay. Large quantities of water are obtained from the surficial sand and gravel deposits which may be separated from the underlying regional aquifer by a low permeability or confining layer. This confining layer typically "leaks", providing recharge to the deeper zones.

11) Coastal Beaches
This hydrogeologic environment is characterized by low topographic relief, near sea-level elevation and unconsolidated deposits of water-washed sands. The term beach is appropriately applied only to a body of essentially loose sediment. This usually means sand-size particles, but could include gravel. Quartz particles usually predominate. These materials are well sorted, very permeable and have very high potential infiltration rates. These areas are commonly ground-water discharge areas although they can be very susceptible to the intrusion of saltwater.

12) Solution Limestone
Large portions of the central and southeastern United States are underlain by limestones and dolomites in which the fractures have been enlarged by solution. Although ground water occurs in both the surficial deposits and in the underlying bedrock, the limestones and dolomites, which typically contain solution cavities, generally serve as the principal aquifers. This type of hydrogeologic environment is often described as "karst."

13) Unknown Environment
If the subsurface hydrogeological environment is unknown, or it is different from any of the twelve main types used in IWEM, select the subsurface environment as Type 13. In this case, IWEM will assign values of the hydrogeological parameters (depth to groundwater, saturated zone thickness, saturated zone hydraulic conductivity, and saturated zone hydraulic gradient) that are simply national average values.

11) Coastal Beaches
12) Solution Limestone
13) Unknown

This *User's Guide* provides a summary of the geologic and hydrogeologic characteristic of each environment (see text box). You are cautioned that the assignment of a subsurface environment is best done by a professional trained in hydrogeology and is familiar with local site conditions.

<u>Depth to the Water Table (m)</u> This parameter is the vertical distance from the ground surface to the water table as depicted in Figure 6.2. The water table in this case is meant to represent the 'natural' water elevation, as it is or would be without the influence from the WMU. The presence of a WMU, particularly a surface impoundment, may cause a local rise in the water table called mounding. When you run a Tier 2 evaluation, IWEM assumes that the depth to water table value you have entered does not include mounding. The tool will calculate the predicted impact of each liner design on the ground water as part of the modeling evaluation.

If the water table elevation at your site shows seasonal fluctuation, it is best to enter an average annual depth to ground-water value. Note that entering a smaller depth to ground-water value will mean that constituents have less distance to travel before they reach the ground water, and this will tend to result in a more protective IWEM result (*i.e.*, IWEM will tend to predict higher ground-water exposure concentrations and hence return a lower LCTV). It is also important to remember that the depth to ground water should be measured from the ground surface, not from the base of the WMU. If the base of the unit is lower than the ground surface and, therefore, closer to the watertable, you should enter that value as the **<u>Depth of the WMU Base Below the Ground Surface</u>** (see section 6.2.3.1 above).

The depth to ground water should be entered in meters. To convert from other units to meters, use the factors listed in section 6.2.3.1. The default value for this parameter is a function of the selected subsurface environment. If you selected the "unknown" subsurface environment, IWEM will use the national average of 5.2 meters. If you selected one of the twelve subsurface environments and do not specify the depth to the water table, IWEM will treat the depth to the water table as a Monte-Carlo variable: IWEM will use a distribution of values that is appropriate for the selected subsurface environment.

<u>Saturated Zone Thickness (m)</u>. This parameter represents the vertical distance from the watertable down to the base of the aquifer, as shown in the diagram in Figure 6.2. Usually the base is an impermeable layer, e.g., bedrock. This parameter is used in

the Tier 2 model simulation to describe the thickness of the ground-water zone over which the leachate plume can mix with ground water. If your site has a highly stratified hydrogeology, it may be difficult to precisely define the "base of the aquifer," but in such cases, the stratification may effectively limit the vertical plume travel distance. In this case it may be appropriate to enter the maximum vertical extent of the plume as an "effective" saturated zone thickness in IWEM.

The parameter must be entered in meters. To convert from other units to meters, use the factors given in section 6.2.3.1. The default saturated zone thickness is a function of the selected subsurface environment. If you selected the "unknown" subsurface environment, IWEM will use the national average of 10.1 meters. If you selected one of the twelve subsurface environments and did not specify the saturated thickness, IWEM will treat the depth to the saturated thickness as a Monte-Carlo variable and use a distribution of values that is appropriate for the selected subsurface environment.

<u>Hydraulic Gradient (m/m)</u>. For unconfined aquifers, the hydraulic gradient is simply the slope of the water table in a particular direction. It is calculated as the difference in the elevation of the water table measured at two locations divided by the distance between the two locations. In IWEM, this parameter represents the average horizontal ground-water gradient in the vicinity of the WMU location. The gradient is meant to represent the 'natural' ground-water gradient as it is, or would be, without influence from the WMU. The presence of a WMU, particularly a surface impoundment, may cause local mounding of the water table and associated higher local ground-water gradients. When you run a Tier 2 evaluation, IWEM assumes that the gradient value you have entered does not include mounding; rather the software will calculate the predicted impact on the ground water of each liner design as part of the modeling evaluation.

The hydraulic gradient, together with the hydraulic conductivity (see below), controls the ground-water flow rate, in accordance with Darcy's Law. The effect of varying ground-water flow rate on contaminant fate and transport is complex. Intuitively, it would seem that factors that increase the ground-water flow rate would cause a higher ground-water exposure level at the receptor well, but this is not always the case. A higher ground-water velocity will cause leachate constituents to arrive at the well location more quickly. For constituents that are subject to degradation in ground water, the shorter travel time will cause the constituents to arrive at the well at higher concentrations as compared to a case of low ground-water velocity and long travel times. On the other hand, a high ground-water flow rate will tend to increase the degree of dilution of the leachate plume, due to mixing and dispersion. This will in turn tend to lower the magnitude of the concentrations reaching the well. The Tier 1 and Tier 2 evaluations are based on the maximum constituent concentrations at the well, rather than how long it might take for the exposure to occur, and therefore a higher ground-water flow rate may result in lower predicted exposure levels at the well.

The hydraulic gradient is a unitless parameter. Its default value depends on the subsurface environment you selected. If you selected the "unknown" environment, IWEM will use a nationwide average value of 0.0057. If you selected one of the twelve subsurface environments and did not specify the hydraulic gradient, IWEM will treat the hydraulic gradient as a Monte-Carlo variable, and it will use a distribution of values that is appropriate for the selected subsurface environment.

<u>Hydraulic Conductivity (m/yr)</u>. This parameter represents the permeability of the saturated aquifer in the horizontal direction. The hydraulic conductivity, together with the hydraulic gradient, controls the ground-water flow rate. For the same reasons as discussed above, assigning a low hydraulic conductivity value will not necessarily result in lower predicted ground-water exposures and higher LCTVs. In a broader sense, it means that siting a WMU in a low permeability aquifer setting is not always more protective than a high permeability setting. Low ground-water velocity means that it will take longer for the exposure to occur, and as a result, there is more opportunity for natural attenuation to degrade contaminants. For long-lived waste constituents, it also means that little dilution of the plume may occur.

The hydraulic conductivity of aquifers is sometimes reported as a transmissivity value, which is usually denoted with the symbol 'T'. Transmissivity is simply the product of hydraulic conductivity and saturated thickness. To back-calculate the hydraulic conductivity, you should divide the transmissivity by the value of the saturated zone thickness. The hydraulic conductivity parameter in IWEM must be entered in meters per year. To convert from other units, use the following factors:

1 meter/second	=	31,536,000 m/yr
1 foot/second	=	9,612,173 m/yr
1 gallon/day/foot^2	=	14.89 m/yr

The default value of hydraulic conductivity in IWEM varies with the subsurface environment you have selected. If you selected the "unknown" subsurface environment, IWEM will use a nationwide average value of 1,890 m/yr. If you selected one of the twelve hydrogeologic environments and the hydraulic conductivity as "unknown," IWEM will treat the hydraulic conductivity as a Monte-Carlo variable, and it will use a distribution of values that is appropriate for the selected subsurface environment.

<u>Subsurface pH</u>. This parameter represents the alkalinity or acidity of the soil and aquifer. The pH is one of the most important subsurface parameters controlling the

mobility of metals. Most metals are more mobile under acidic (low pH) conditions, as compared to neutral or alkaline (pH of 7 or higher) conditions. The pH may also affect the hydrolysis rate of organic constituents; some constituents degrade more rapidly or more slowly as pH varies. The pH of most aquifer systems is slightly acidic, the primary exception being aquifers in solution limestone settings. These may also be referred to as 'karst', 'carbonate' or 'dolomite' aquifers. The ground water in these systems is usually alkaline.

IWEM assumes the subsurface pH value is the same in the unsaturated zone and saturated zone. The default pH value depends on the hydrogeologic environment you selected; if you selected "Solution Limestone" (Subsurface Environment 12), the default pH is 7.5. In all other hydrogeologic environments, the default pH value is 6.2. These default values represent median values from EPA's Data Storage and Retrieval System, National Water Quality Database (STORET). If you do not know the hydrogeologic environment, IWEM will assume that the subsurface environment is of a non-solution-limestone type with the default pH of 6.2.

6.2.3.3 Infiltration and Recharge Parameters

Section 4.2.2
TBD

In IWEM, the infiltration rate is defined as the rate (annual volume divided by WMU area) at which leachate flows from the bottom of the WMU (including any liner) into the unsaturated zone beneath the WMU. Recharge is the regional rate of aquifer recharge outside of the WMU. For landfills, waste piles, and land application units, the infiltration rate is primarily determined by the local climatic conditions, especially annual precipitation, and WMU liner characteristics. For surface impoundments, the infiltration rate from the unit is a function of the surface impoundment ponding depth, liner characteristics, and the presence of a 'sludge' layer at the bottom of the impoundment. The regional recharge rate is a function of the annual precipitation rate, and varies with geographical location and soil type.

The WMU related parameters are entered in IWEM in the *WMU Parameters* group (see Section 6.2.3.1). The location and soil related parameters are entered in the *Infiltration and Recharge Parameters* group. Infiltration rate is among the most sensitive site-specific parameters in an IWEM evaluation, and, therefore, the software gives you the option to provide a site-specific value in Tier 2. The model is usually much less sensitive to recharge rate. IWEM determines the appropriate value for you, as a function of site location and soil type. The specific IWEM parameters in this group are as follows.

Site-specific Infiltration Rate (m/yr). This parameter represents the actual annual volume of leachate, per unit area of the WMU, which flows from the bottom of the WMU into the unsaturated zone underneath the WMU. The performance characteristics of a liner, if present, are among the most important factors controlling the infiltration rate, and therefore, the rate of leachate release. IWEM provides you the option to enter a site-specific infiltration rate to accommodate liner designs that are different from the standard liner designs (*i.e.*, (1) no liner, (2) single clay liner, or (3) composite liner), and to evaluate extreme climatic conditions.

IWEM provides default values for infiltration rate, which are a function of WMU type, liner design, and site location. These values are used in Tier 1 and as defaults in a Tier 2 evaluation. The default infiltration rates used in IWEM for landfills, waste piles, and land application units were developed using the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et. al., 1994). The infiltration rate from a WMU is difficult to measure directly; if you wish to determine site-specific WMU infiltration rates for use in IWEM, it is recommended to use a model such as HELP to estimate the rates.

The infiltration rate in IWEM must be entered in units of meter/year. To convert from other units, use the following factors:

1 foot/year	=	0.305 m/yr
1 inch/year	=	0.0254 m/yr

<u>Climate Center</u>. IWEM includes a database of infiltration rates and regional recharge rates for 102 climate centers located throughout the United States. To ensure that IWEM will use the most appropriate values (if you choose to let IWEM select a default value), you must select the climate center which is most appropriate for your site. Usually this is the nearest climate center. However, this is not always the case. Especially in coastal and mountain regions, the nearest climate center does not always represent conditions that most closely approximate conditions at your site. You should therefore use your judgment and also consider other adjacent climate centers. In the IWEM software tool, you select the climate center from a drop-down list which can be sorted by City or by State. Figure 6.4 shows the geographic locations of the 102 climate stations in the United States.

<u>Regional Soil Type.</u> In order to assign an appropriate recharge rate, IWEM needs to know the dominant, regional soil type in the vicinity of your site. IWEM provides a selection of three major soil types, which are representative of most soils in the United States:

- Sandy Loam
- Silty Loam
- Silty Clay Loam.

IWEM also allows you to select the soil type "unknown." In that case, IWEM will treat the soil type as a Monte-Carlo variable and randomly select from the three available soil types, in accordance with the relative frequency of occurrence of each type across the United States. By selecting the soil type, IWEM also assigns the soil parameters that are used in the modeling of fate and transport in the unsaturated zone of the aquifer.

<u>Waste Type Permeability</u> This parameter is used only for waste piles. Waste piles are not typically covered and the permeability of the waste itself is a factor in determining the rate of leachate released due to water percolating through the WMU. For waste piles, IWEM recognizes three categories of waste permeability and their associated infiltration rate: high permeability (0.041 cm/sec); moderate permeability (0.0041 cm/sec); and low permeability (0.00005 cm/sec). The waste permeability is correlated with the grain size of the waste material, ranging from coarse to five-grained materials.

If you do not specify the waste type for waste piles, IWEM will default to randomly selecting between the infiltration rates for each of the three waste types in the Tier 2 Monte Carlo process, with each type having equal probability. That is, IWEM will use a uniform probability distribution.

Figure 6.4 Locations of IWEM Climate Stations.

6.2.3.4 Constituent Parameters

Section 5.0

IWEM includes a database of 206 organic constituents and 20 metals. Appendix A provides a list of these constituents and their properties. The database provides the following information for each constituent.

- Descriptive Data: *Name,*
CAS Number
- Physical and Constituent Properties: *Organic Carbon Partition Coefficient (K_{oc})*
Metals sorption isotherm data (k_d)
Hydrolysis Rate Constants
- Reference Ground-water Concentrations: *Maximum Contaminant Level (MCL)*
Health Based Numbers (HBN)

To preserve the integrity of the database, IWEM gives you limited flexibility to modify these data. IWEM does give you the option of specifying an overall constituent decay rate which can include biodegradation, proving a constituent partitioning coefficient (k_d), and specifying one additional RGC to augment the built-in MCL and HBN values.

IWEM allows you to add new constituents to its database and this provides an indirect mechanism to assign different constituent parameter values, by entering a constituent of interest as a 'new' constituent in the database with its own parameter values.

The following sections discuss the IWEM constituent parameters.

Descriptive Data

Constituent Name and CAS Number. These parameters are used in IWEM to identify each constituent. Whereas constituents may have multiple names, the CAS number is an industry-standard, unique, identification code. If you want to use the "Add New Constituent" option to assign different fate and transport parameters to an existing IWEM constituent, it is recommended to use the actual CAS number and enter a new constituent name.

Physical and Constituent Properties **Section 4.2.4 TBD**

The physical and constituent properties that affect subsurface fate and transport include sorption parameters and degradation parameters.

Organic Carbon Partition Coefficient (K_{oc}). This parameter describes the sorption, or affinity of a constituent to attach itself to soil and aquifer grains. This parameter is applicable to organic constituents which tend to sorb onto the organic matter in soil or in an aquifer. Constituents with high K_{oc} values tend to move more slowly through the soil and ground water. Volatile organics tend to have low K_{oc} values, whereas semi-volatile organics often have high K_{oc} values. K_{oc} values can be obtained from many constituent property handbooks, as well as online databases, (e.g., *Handbook of Environmental Data on Organic Constituents,* Verschueren, 1983). Sometimes, these references provide an *octanol-water partition coefficient* (K_{ow}), rather than a K_{oc} value. K_{ow} and K_{oc} are roughly equivalent parameters. A number of conversion formulas exist to convert K_{ow} values into K_{oc}, and can be found in handbooks on environmental fate data (*e.g.*, Verschueren, 1983; Kollig et. al., 1983). Different conversion formulas exist for different constituents and environmental media, and there is no single formula that is valid for all organic constituents; therefore, they should be used with some caution.

In IWEM, K_{oc} has units of liters/kilogram (L/kg) or, equivalently, milliliters/gram (mL/g).

Metals Isotherm Data. In the case of metals, sorption is expressed in the partition coefficient k_d. IWEM provides a set of k_d values calculated using the MINTEQA2 geoconstituent speciation model for each metal. Rather than using a single k_d value for each metal constituent, IWEM includes multiple sets of k_d values to reflect the impact of variations in ground-water pH and other geochemical conditions. Each set of k_d values is referred to as a *sorption isotherm*. The sorption parameters for metals in IWEM are part of the software's built-in database and they cannot be modified by the user. Further information on how the MINTEQ sorption isotherms were developed can be found in the *IWEM Technical Background Document* and the *EPACMTP Parameters/Data Background Document*.

If you are adding a new constituent to the IWEM database, you can enter a single k_d value to model sorption for the constituent. The k_d must be entered in units of L/kg or, equivalently, mL/g.

Hydrolysis Rate Constants. Hydrolysis refers to the transformation of constituent constituents through reactions with water. For organic constituents, hydrolysis can be one of the main degradation processes that occur in soil and ground water. The hydrolysis rate values that are part of the IWEM database have been compiled by the U.S. EPA Office of Research and Development (Kollig, 1993). For each organic constituent, the database includes three hydrolysis rate constants: an acid-catalyzed rate constant, a neutral rate constant, and a base-catalyzed rate constant.

Biodegradation

Biodegradation can be a significant attenuation process for organic constituents in the subsurface. However, this process is also highly site- and constituent-specific. It is not possible to provide reliable default biodegradation rates to be used in IWEM. Evidence of the significance of biodegradation should be carefully considered in accordance with EPA guidance, such as the OSWER Directive 9200.4-17P on *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. A compendium of EPA bioremediation documents is available online at www.epa.gov/ORD/WebPubs/biorem.html.

By default, IWEM does not explicitly take into account biodegradation processes, and the IWEM constituent database does not include biodegradation rates. However, in Tier 2, the IWEM software allows you to add a constituent-specific biodegradation decay coefficient to its database, as part of the constituent properties input group[8]. This decay coefficient has units of 1/yr. The value of the decay coefficient is related to half-life as:

$$\text{Decay Coefficient (1/yr)} = 0.693 / \text{Half-life (yr)}$$

IWEM stores user-defined decay coefficients in its constituent property database. You should, however, be careful in using a decay coefficient value which is appropriate for one site and not appropriate for others.

Reference Ground-Water Concentrations

Section 5.0 TBD

The final set of parameters in the IWEM constituent database is a set of constituent-specific RGCs, comprising MCLs and risk-based HBNs.

The use of these RGCs in IWEM is discussed in Chapter 7 of this *User's Guide*. The derivation of the HBN values is discussed in Section 5 of the *IWEM Technical Background Document*. You cannot change existing RGCs in the IWEM database. You can, however, add a user-specified RGC value for each constituent in the database when selected for a Tier 2 analysis. IWEM imposes no restrictions on user-specified RGCs,

[8] Strictly speaking this decay coefficient can represent any first-order transformation process other than hydrolysis, which is already explicitly considered in IWEM.

other than that they should be expressed in units of mg/L and an exposure duration is provided (in years) that is consistent with the way the RGC was derived.

User-specified RGCs may represent either more or less stringent health-based values, or alternative regulatory standards. IWEM makes no assumptions about user-specified RGCs and, consequently, the software cannot check whether your value is correct or not.

If you wish to add constituents to the IWEM database, you will be required to provide at least one RGC for each new constituent, either a MCL, an ingestion HBN, or an inhalation HBN. Consult the *IWEM Technical Background Document* for details on the derivation of HBN values. This mechanism also provides an indirect way of using modified MCL and/or HBN values for constituents that are already in the database. In this case, you can add the constituent to the database as a 'new' constituent and provide your own HBN values.

7.0 Understanding Your IWEM Results

After completing an analysis, IWEM provides a recommendation for a liner design for a WMU or the appropriateness of land application. Section 7 provides guidance on how IWEM may assist you in answering the following questions:

- What kind of liner will be necessary to safely manage my waste in a landfill, surface impoundment or waste pile?
- Is land application appropriate for my waste?
- What are the maximum allowable leachate concentrations for all constituents in a waste for a particular type of WMU and liner design?
- Should you consider a Tier 3 assessment?

The IWEM liner recommendations and determination of maximum allowable leachate concentrations are based on protective ground-water concentrations at wells. In Tier 1, IWEM uses the tabulated LCTV values that represent protective national screening values. In Tier 2, IWEM calculates LCTVs to provide guidance on what leachate levels need to be achieved, for instance through treatment, to safely allow disposal in a particular WMU design. To help you understand the IWEM results, we will discuss LCTVs first.

7.1 Leachate Concentration Threshold Values (LCTVs)

An LCTV is the maximum concentration of a constituent in the waste leachate that is protective of ground water. That is, if the concentration in the leachate does not exceed the LCTV, then the concentration in ground water at the well will not exceed the RGC. IWEM uses the EPACMTP fate and transport model to calculate LCTVs. EPACMTP is a fate and transport model that simulates the concentration of a constituent in ground-water, as a function of the constituent's concentration in the waste leachate. The LCTV is determined by comparing the predicted well concentration against a selected RGC, i.e., an MCL or HBN. By definition, the LCTV is the value of the leachate concentration for which the well concentration is equal to the RGC. LCTVs depend on: 1) the combined effects of WMU design characteristics and hydrogeological fate and transport processes; and 2) the effect of constituent-specific regulatory standards such as an MCL and constituent toxicity represented by the HBN.

Tier 1 LCTVs are different from Tier 2 LCTVs. LCTVs from the Tier 1 analysis are generally applicable to sites across the country. Tier 2 LCTVs on the other hand, are based on site-specific data for several sensitive parameters and are not applicable to other sites.

7.2 Limits on the LCTV

While the LCTVs are based on fate and transport modeling, and regulatory and risk-based ground-water standards, EPA also considered other factors in developing final LCTV values for some waste constituents. These are described in this section.

7.2.1 Toxicity Characteristic Rule (TC Rule) Regulatory Levels

Section 6.2 TBD

In 1990, EPA adopted the Toxicity Characteristic (TC) Rule making wastes containing certain constituents at or above listed leachate concentrations a hazardous waste.

For any waste constituent included in the TC rule, we capped the LCTV at the TC Rule Regulatory Level. This level is the leachate concentration above which the waste is considered to be a hazardous waste (U.S. EPA, 1990). TC levels have been determined for the constituents listed in Table 7.1.

7.2.2 1,000 mg/L Cap

Section 6.2 TBD

EPA does not expect leachate concentrations from WMUs covered by this guidance to exceed 1,000 mg/L for a single constituent, and therefore, has limited the expected waste constituent leachate concentrations to be less than or equal to 1,000 mg/L. One of the reasons to cap the leachate concentration in IWEM is that the fate and transport assumptions in IWEM may not be valid at high concentrations. For instance, high leachate concentrations may indicate the presence of a free organic phase. Consequently, all Tier 1 and Tier 2 LCTVs are capped at a maximum value of 1,000 mg/L.

Table 7.1 Toxicity Characteristic Leachate Levels

Waste Constituent	TC Rule Leachate Regulatory Level (mg/L)	Waste Constituent	TC Rule Leachate Regulatory Level (mg/L)
Arsenic	5	Hexachloro-1,3-butadiene	0.5
Barium	100	Hexachloroethane	3
Benzene	0.5	Lead	5
Cadmium	1	Lindane	0.4
Carbon Tetrachloride	0.5	Mercury	0.2
Chlordane	0.03	Methoxychlor	10
Chlorobenzene	100	Methyl ethyl ketone	200
Chloroform	6	Nitrobenzene	2
Chromium	5	Pentachlorophenol	100
o-cresol	200	Pyridine	5
m-cresol	200	Selenium	1
p-cresol	200	Silver	5
2,4-D	10	Tetrachloroethylene	0.7
1,4-dichlorobenzene	7.5	Toxaphene	0.5
1,2-dichloroethane	0.5	Trichloroethylene	0.5
1,1-dichloroethylene	0.7	2,4,5-trichlorophenol	400
2,4-dinitrotoluene	0.13	2,4,6-trichlorophenol	2
Endrin	0.02	2,4,5-TP acid (silvex)	1
Heptachlor	0.008	Vinyl chloride	0.2
Hexachlorobenzene	0.13		

7.2.3 Constituents with Toxic Daughter Products

Section 6.2 TBD

A number of the constituents included in the IWEM constituent database can be transformed in soil and ground water into one or more toxic daughter products as a result of hydrolysis reactions. For these constituents, the LCTVs are calculated such that they accommodate both the parent constituent as well as any toxic daughter products. For instance, if a parent waste constituent rapidly hydrolyses into a persistent daughter product, the ground-water exposure caused by the parent itself may be minimal (it has already degraded before it reaches the well), but the final LCTV for this constituent would be based on the exposure caused by the daughter product, under the protective assumption that the parent compound fully transforms into the daughter product. If an IWEM constituent has more than one toxic daughter product, the final LCTV is based on the LCTV for the most protective compound in the parent-daughter sequence. If the

LCTV of the parent constituent is lower than that of the daughter, the LCTV of the parent remains unchanged. Additionally, if the daughter constituent has a particular RGC but the parent constituent does not, the RGC of the daughter product is used to determine the parent constituent LCTV. This methodology is designed to be protective of downgradient ground water in terms of both the parent waste constituent and its daughter constituent(s).

The IWEM constituent database includes information on the toxic daughter products associated which each hydrolyzing constituent, and the user does not need to know which constituents transform into toxic daughter products. In Tier 1, the capping the LCTV of parent constituents at the LCTV of their respective daughters is transparent to the user. The capping of LCTVs is done automatically by the software and are flagged in the Tier 1 tables and reports.

In a Tier 2 evaluation, if you select a waste constituent that hydrolyses, the IWEM software will automatically add any toxic daughters products associated with that constituent to the evaluation. In the Tier 2 input screens, daughter products are listed immediately after their parent(s) in the Toxicity Standards Screen (Screen 22, see Figure 5.23). Constituents that are included because they are daughter products of constituents in the waste, are identified as such in the input screens. In the Tier 2 reports, the results of all waste constituents and any toxic daughter constituents produced by hydrolysis are shown in the Tier 2 report. Daughter products are listed separately from parent constituents, but for each daughter product, the parent waste constituent from which it originated is identified.

Due to the chemical transformation of waste constituents, it is possible the same constituent is included more than once in the evaluation. A constituent can be selected because it is present in the waste, but it can also be added by the IWEM software because it is produced as the result of hydrolysis transformations on one or more other waste constituents. IWEM evaluates each occurrence of the constituent separately, and the same constituent may lead to different liner recommendations in the same Tier 2 evaluation. For instance, assume that a constituent is present at low concentration in the waste itself, but this compound is also produced as the result of hydrolysis of a second waste constituent which is in the waste at a much higher concentration. IWEM will first evaluate the constituent as an original waste constituent. In this example, we assumed that the concentration in the waste is low, and the IWEM software in that case may recommend a no-liner design as being protective. Next, IWEM will evaluate the ground-water impact of the same constituent as a daughter product resulting from the transformation of the second waste constituent. Because this second waste constituent (the parent) is present in the waste at high concentrations, its transformation may cause the ground-water concentration of our constituent of concern (which is now evaluated as a daughter product) to be so high that IWEM determines that a no-liner design is not protective. This example would lead to a result in which the same constituent has two different liner recommendations.

Even though the chemical compound is the same, IWEM treats these two instances as if they were different constituents. One of the reasons EPA chose to do this, is that it allows the user to make waste management decisions in terms of the constituents that are actually present in the waste. In the example described here, an option may be to treat the waste to reduce constituent concentrations to acceptable levels. In our example, the goal should be not to reduce the level of the constituent of concern in the waste (it is only present at low levels), but rather to reduce the concentration of its parent constituent. Doing this will automatically reduce the ground-water impact of its daughter product(s).

7.3 IWEM Liner Recommendations

Section 6.3 TBD

IWEM makes liner recommendations by identifying the minimum design that is protective of ground water for all waste constituents. In Tier 1, a liner design is protective if the expected leachate concentrations for all waste constituents are less than the LCTV determined by IWEM for the same constituents. In the case of LAUs, land application of waste is considered appropriate if the leachate concentrations of all constituents do not exceed LAU LCTVs.

The IWEM Tier 1 software automatically performs the comparisons of leachate concentration to all of the LCTVs for each waste constituent and liner scenario. The results of the evaluation are presented in terms of a MCL summary and a HBN summary. The HBN summary reflects the liner recommendation based on the most protective, that is the lowest, HBN available for each constituent. The recommendation also takes into account the possible formation of toxic daughter products, as discussed in Section 7.2.3.

If the leachate concentrations for all constituents are lower than the corresponding no-liner LCTVs, then no liner is recommended as being sufficiently protective of groundwater. If any leachate concentration is higher than the corresponding no-liner LCTV, then a minimum of a single clay liner is recommended. If any leachate concentration is higher than the corresponding single clay liner LCTV, then a minimum of a composite liner is recommended. If any concentration is higher than the composite liner, consider pollution prevention, treatment, or additional controls. For waste streams with multiple constituents, the recommended liner design is the most protective minimum recommended liner.

After conducting a Tier 1 analysis, you can choose to implement the Tier 1 recommendation by designing the unit based on the liner recommendations given by the IWEM software. If you choose to implement the Tier 1 recommendation, consultation with state authorities is recommended to ensure compliance with state regulations, which may require more protective measures than the Tier 1 lookup tables recommend. Alternatively, if the waste has one or very few "problem" constituents that call for a more stringent and costly liner system (or which make land application inappropriate), evaluate pollution prevention, recycling, and treatment efforts for those constituents.

If, after conducting the Tier 1 analysis, you are not satisfied with the resulting recommendations, or if site-specific conditions seem likely to support the use of a liner design different from the one recommended (or suggest a different conclusion regarding the appropriateness of land application of a waste), then you may conduct a Tier 2 analysis or a site-specific groundwater fate and transport analysis (Tier 3).

In a Tier 2 evaluation, IWEM uses the EPACMTP fate and transport model to determine the ground-water exposure concentration that is expected for each waste constituent given its leachate concentration. IWEM uses the technique of *Monte Carlo analysis* to develop a probability distribution of ground-water well exposure concentrations for each constituent and liner scenario. Analogous to Tier 1 (which uses a 90^{th} percentile LCTV value), IWEM uses the 90^{th} percentile of the ground-water well exposure concentration in Tier 2 to make liner recommendations. The software compares the 90^{th} percentile ground-water exposure concentration to the RGC(s) for that constituent. IWEM first makes this evaluation for the no-liner scenario. If the ground-water exposure concentration is less than the applicable RGC(s), then the no-liner scenario is protective for that constituent. IWEM evaluates all waste constituents in this manner. If the 90^{th} percentile ground-water exposure concentrations of all waste constituents are below their respective RGCs, then IWEM recommends the no-liner scenario as being protective and the evaluation is complete. However, if the ground-water exposure concentrations of one or more waste constituents exceed their RGCs, then the no-liner scenario is not protective, and IWEM will evaluate the single clay liner scenario (unless the WMU is a LAU). If the single clay liner scenario is protective for all constituents, IWEM will recommend this design. If any waste constituents fail the single clay liner design, then IWEM will recommend at least a composite liner.

In a Tier 2 evaluation, IWEM also calculates LCTVs. The Tier 2 LCTVs are different from the Tier 1 values; they represent location-adjusted thresholds. While the Tier 2 LCTVs are not directly used in IWEM to make liner recommendations, they are displayed on the detailed results screen, and printed in the IWEM reports. These LCTVs can be used in the same manner as in Tier 1 to identify pollution prevention, recycling, or treatment alternatives to reduce the leachate concentrations of "problem" constituents to levels that allow disposal of a waste in a less stringent WMU design.

The Monte Carlo simulations required for a Tier 2 evaluation can be computationally demanding, and an evaluation of multiple liner designs for a single waste constituent can take several hours. In order to optimize the computational process, IWEM will first perform the liner evaluations from least protective (no-liner) to most protective (composite liner). If during this process, IWEM identifies a liner design that is protective for all constituents (for instance, a single clay liner), it will stop the evaluation process, and not evaluate more protective designs (in the example case, it would skip the composite liner evaluation).

After conducting the Tier 2 Evaluation, you can choose to implement the Tier 2 recommendation by designing the unit based on the liner recommendations given by the IWEM software or continue to a Tier 3 analysis. If you choose to implement the Tier 2 recommendation, consultation with state authorities is recommended to ensure compliance with state regulations, which may require more protective measures than the Tier 2 results recommend.

If after conducting the Tier 2 Evaluation, you are not satisfied with the resulting recommendations or if site-specific conditions seem likely to support the use of a liner design different from the one recommended (or suggest a different conclusion regarding the appropriateness of land application of a waste), then you may conduct a fully site-specific groundwater fate and transport analysis (Tier 3).

8.0 Trouble Shooting

The IWEM Version 1.0 has been extensively tested on the following combinations of Windows operating system and Internet Explorer:

Latest versions of MS Windows operating systems	Corresponding version of MS Internet Explorer
95 (Version 4.00.950B)	Version 5.5 Service Pack 2
98 Second Edition (Version 4.10.2222A)	Version 6.0
NT 4.0 (Service Pack 6a)	Version 6.0
2000 (Service Pack 2)	Version 6.0
XP (Version 2002)	Version 6.0

If you encounter any problems during installation, it is likely that your operating system and/or version of Internet Explorer are not up-to-date. Check the version of your operating system and Internet Explorer and compare them to the list above. If either of these two are not up-to-date, visit the Microsoft Support web site at http://support.microsoft.com, click on the |DOWNLOAD SOFTWARE| link, and then click on either the |MICROSOFT WINDOWS UPDATES| link or the |INTERNET EXPLORER| link and follow the prompts to download and install the updates. Check with your system administrator if you do not have the correct privileges to install software on your computer.

How do I determine what version of Windows I am using?

Right click on the |MY COMPUTER| icon on your desktop and select |PROPERTIES| from the pop-up menu. A dialog box will appear and near the top will be the version information of Windows installed on your computer.

How do I determine what version of Internet Explorer I am using?

Start Internet Explorer, click on |HELP|ABOUT INTERNET EXPLORER|. A dialog box will appear and list first is the version of Internet Explorer installed on your computer.

What do I do if I am still having problems?

If your operating system and Internet Explorer versions are up-to-date and you still encounter problems installing or running the IWEM software, please contact the RCRA Information Center in any of the following ways:

- E-mail: rcra-docket@epa.gov
- Phone: 703-603-9230
- Fax: 703-603-9234
- In person: Hours: 9:00 am to 4:00 pm, weekdays, closed on Federal Holidays
  Location: USEPA
  West Building Basement
  1300 Constitution Ave., NW
  Washington, D.C.
- Mail: RCRA Information Center (5305W)
  U.S. Environmental Protection Agency
  Ariel Rios Building
  1200 Pennsylvania Avenue, NW
  Washington, DC 20460-0002

When contacting the RCRA Information Center, please cite RCRA Docket number: F1999-IDWA-FFFFF.

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Appendix A

List of Waste Constituents

Appendix A
List of Waste Constituents

CAS Number	Constituent Name	CAS Number	Constituent Name
Organics			
83-32-9	Acenaphthene	510-15-6	Chlorobenzilate
75-07-0	Acetaldehyde [Ethanal]	124-48-1	Chlorodibromomethane
67-64-1	Acetone (2-propanone)	75-00-3	Chloroethane [Ethyl chloride]
75-05-8	Acetonitrile (methyl cyanide)	67-66-3	Chloroform
98-86-2	Acetophenone	74-87-3	Chloromethane
107-02-8	Acrolein	95-57-8	Chlorophenol 2-
79-06-1	Acrylamide	107-05-1	Chloropropene, 3- (Allyl Chloride)
79-10-7	Acrylic acid [propenoic acid]	218-01-9	Chrysene
107-13-1	Acrylonitrile	108-39-4	Cresol m-
309-00-2	Aldrin	95-48-7	Cresol o-
107-18-6	Allyl alcohol	106-44-5	Cresol p-
62-53-3	Aniline (benzeneamine)	1319-77-3	Cresols
120-12-7	Anthracene	98-82-8	Cumene
56-55-3	Benz{a}anthracene	108-93-0	Cyclohexanol
71-43-2	Benzene	108-94-1	Cyclohexanone
92-87-5	Benzidine	72-54-8	DDD
50-32-8	Benzo{a}pyrene	72-55-9	DDE
205-99-2	Benzo{b}fluoranthene	50-29-3	DDT, p,p'-
100-51-6	Benzyl alcohol	2303-16-4	Diallate
100-44-7	Benzyl chloride	53-70-3	Dibenz{a,h}anthracene
111-44-4	Bis(2-chloroethyl)ether	96-12-8	Dibromo-3-chloropropane1,2-
39638-32-9	Bis(2-chloroisopropyl)ether	95-50-1	Dichlorobenzene1,2-
117-81-7	Bis(2-ethylhexyl)phthalate	106-46-7	Dichlorobenzene1,4-
75-27-4	Bromodichloromethane	91-94-1	Dichlorobenzidine3,3'-
74-83-9	Bromomethane	75-71-8	Dichlorodifluoromethane (Freon 12)
106-99-0	Butadiene, 1, 3-	75-34-3	Dichloroethane 1,1-
71-36-3	Butanol	107-06-2	Dichloroethane1,2-
85-68-7	Butyl benzyl phthalate	156-59-2	Dichloroethylene cis-1,2-
88-85-7	Butyl-4,6-dinitrophenol,2-sec-(Dinoseb)	156-60-5	Dichloroethylene trans-1,2-
75-15-0	Carbon disulfide	75-35-4	Dichloroethylene1,1-
56-23-5	Carbon tetrachloride	120-83-2	Dichlorophenol 2,4-
57-74-9	Chlordane	94-75-7	Dichlorophenoxyacetic acid 2,4-(2,4-D)
126-99-8	Chloro-1,3-butadiene 2-(Chloroprene)	78-87-5	Dichloropropane 1,2-
106-47-8	Chloroaniline p-	542-75-6	Dichloropropene 1,3-(mixture of isomers)
108-90-7	Chlorobenzene	10061-01-5	Dichloropropene cis-1,3-

Appendix A (continued)
List of Waste Constituents

CAS Number	Constituent Name	CAS Number	Constituent Name
10061-02-6	Dichloropropene trans-1,3-	206-44-0	Fluoranthene
60-57-1	Dieldrin	50-00-0	Formaldehyde
84-66-2	Diethyl phthalate	64-18-6	Formic acid
56-53-1	Diethylstilbestrol	98-01-1	Furfural
60-51-5	Dimethoate	319-85-7	HCH beta-
119-90-4	Dimethoxybenzidine 3,3'-	58-89-9	HCH (Lindane) gamma-
68-12-2	Dimethyl formamide N,N- [DMF]	319-84-6	HCH alpha-
57-97-6	Dimethylbenz{a}anthracene 7,12-	76-44-8	Heptachlor
119-93-7	Dimethylbenzidine 3,3'-	1024-57-3	Heptachlor epoxide
105-67-9	Dimethylphenol 2,4-	87-68-3	Hexachloro-1,3-butadiene
84-74-2	Di-n-butyl phthalate	118-74-1	Hexachlorobenzene
99-65-0	Dinitrobenzene 1,3-	77-47-4	Hexachlorocyclopentadiene
51-28-5	Dinitrophenol 2,4-	55684-94-1	Hexachlorodibenzofurans [HxCDFs]
121-14-2	Dinitrotoluene 2,4-	34465-46-8	Hexachlorodibenzo-p-dioxins [HxCDDs]
606-20-2	Dinitrotoluene 2,6-	67-72-1	Hexachloroethane
117-84-0	Di-n-octyl phthalate	70-30-4	Hexachlorophene
123-91-1	Dioxane 1,4-	110-54-3	Hexane n-
122-39-4	Diphenylamine	7783-06-4	Hydrogen Sulfide
122-66-7	Diphenylhydrazine, 1, 2-	193-39-5	Indeno{1,2,3-cd}pyrene
298-04-4	Disulfoton	78-83-1	Isobutyl alcohol
115-29-7	Endosulfan (Endosulfan I and II, mixture)	78-59-1	Isophorone
72-20-8	Endrin	143-50-0	Kepone
106-89-8	Epichlorohydrin	126-98-7	Methacrylonitrile
106-88-7	Epoxybutane, 1, 2-	67-56-1	Methanol
110-80-5	Ethoxyethanol 2-	72-43-5	Methoxychlor
111-15-9	Ethoxyethanol acetate, 2-	109-86-4	Methoxyethanol 2-
141-78-6	Ethyl acetate	110-49-6	Methoxyethanol acetate 2-
60-29-7	Ethyl ether	78-93-3	Methyl ethyl ketone
97-63-2	Ethyl methacrylate	108-10-1	Methyl isobutyl ketone
62-50-0	Ethyl methanesulfonate	80-62-6	Methyl methacrylate
100-41-4	Ethylbenzene	298-00-0	Methyl parathion
106-93-4	Ethylene dibromide (1,2-Dibromoethane)	1634-04-4	Methyl tert-butyl ether [MTBE]
107-21-1	Ethylene glycol	56-49-5	Methylcholanthrene 3-
75-21-8	Ethylene oxide	74-95-3	Methylene bromide (Dibromomethane)
96-45-7	Ethylene thiourea	75-09-2	Methylene Chloride (Dichloromethane)
91-20-3	Naphthalene	1746-01-6	Tetrachlorodibenzo-p-dioxin, 2,3,7,8-

Appendix A (continued)
List of Waste Constituents

CAS Number	Constituent Name	CAS Number	Constituent Name
98-95-3	Nitrobenzene	630-20-6	Tetrachloroethane 1,1,1,2-
79-46-9	Nitropropane 2-	79-34-5	Tetrachloroethane 1,1,2,2-
55-18-5	Nitrosodiethylamine N-	127-18-4	Tetrachloroethylene
62-75-9	Nitrosodimethylamine N-	58-90-2	Tetrachlorophenol 2,3,4,6-
924-16-3	Nitroso-di-n-butylamine N-	3689-24-5	Tetraethyl dithiopyrophosphate (Sulfotep)
621-64-7	Nitroso-di-n-propylamine N-	137-26-8	Thiram [Thiuram]
86-30-6	Nitrosodiphenylamine N-	108-88-3	Toluene
10595-95-6	Nitrosomethylethylamine N-	95-80-7	Toluenediamine 2,4-
100-75-4	Nitrosopiperidine N-	95-53-4	Toluidine o-
930-55-2	Nitrosopyrrolidine N-	106-49-0	Toluidine p-
152-16-9	Octamethyl pyrophosphoramide	8001-35-2	Toxaphene (chlorinated camphenes)
56-38-2	Parathion (ethyl)	75-25-2	Tribromomethane (Bromoform)
608-93-5	Pentachlorobenzene	76-13-1	Trichloro-1,2,2-trifluoro- ethane 1,1,2-
30402-15-4	Pentachlorodibenzofurans [PeCDFs]	120-82-1	Trichlorobenzene 1,2,4-
36088-22-9	Pentachlorodibenzo-p-dioxins [PeCDDs]	71-55-6	Trichloroethane 1,1,1-
82-68-8	Pentachloronitrobenzene (PCNB)	79-00-5	Trichloroethane 1,1,2-
87-86-5	Pentachlorophenol	79-01-6	Trichloroethylene
108-95-2	Phenol	75-69-4	Trichlorofluoromethane (Freon 11)
62-38-4	Phenyl mercuric acetate	95-95-4	Trichlorophenol 2,4,5-
108-45-2	Phenylenediamine 1,3-	88-06-2	Trichlorophenol 2,4,6-
298-02-2	Phorate	93-72-1	Trichlorophenoxy)propionic acid 2-
85-44-9	Phthalic anhydride	93-76-5	Trichlorophenoxyacetic acid 2,4,5-
1336-36-3	Polychlorinated biphenyls (Aroclors)	96-18-4	Trichloropropane 1,2,3-
23950-58-5	Pronamide	121-44-8	Triethylamine
75-56-9	Propylene oxide [1,2-Epoxypropane]	99-35-4	Trinitrobenzene
129-00-0	Pyrene	126-72-7	Tris(2,3-dibromopropyl)phosphate
110-86-1	Pyridine	108-05-4	Vinyl acetate
94-59-7	Safrole	75-01-4	Vinyl chloride
57-24-9	Strychnine and salts	108-38-3	Xylene m-
100-42-5	Styrene	95-47-6	Xylene o-
95-94-3	Tetrachlorobenzene 1,2,4,5-	106-42-3	Xylene p-
51207-31-9	Tetrachlorodibenzofuran, 2,3,7,8-	1330-20-7	Xylenes (total)

Appendix A (continued)
List of Waste Constituents

CAS Number	Constituent Name	CAS Number	Constituent Name
Metals			
7440-36-0	Antimony	7439-92-1	Lead
7440-38-2	Arsenic	7439-96-5	Manganese
7440-39-3	Barium	7439-97-6	Mercury
7440-41-7	Beryllium	7439-98-7	Molybdenum
7440-43-9	Cadmium	7440-02-0	Nickel
16065-83-1	Chromium (III)	7782-49-2	Selenium
18540-29-9	Chromium (VI)	7440-22-4	Silver
7440-48-4	Cobalt	7440-28-0	Thallium
7440-50-8	Copper	7440-62-2	Vanadium
16984-48-8	Fluoride	7440-66-6	Zinc

Appendix B

Sample Reports From Tier 1 and Tier 2

Tier 1 Evaluation Results

Recommendation : **Composite Liner**

Facility Type	Landfill
Facility name	Southern Industries Landfill
Street address	122 Industrial Ave
City	Raleigh
State	NC
Zip	27611
Date of sample analysis	October 31, 1998
Name of user	
Additional information	

List of Constituents Selected by the User

CAS Number	Constituent Name	Leachate Conc. (mg/L)
71-43-2	Benzene	0.01
7440-36-0	Antimony	0.03
75-09-2	Methylene Chloride (Dichloromethane)	0.02

Minimum Liner Recommendation Based on MCL

CAS Number	Constituent Name	Minimum Liner Recommendation
71-43-2	Benzene	No Liner
7440-36-0	Antimony	Single Liner
75-09-2	Methylene Chloride (Dichloromethane)	Single Liner

Minimum Liner Recommendation Based on HBN

CAS Number	Constituent Name	Minimum Liner Recommendation
71-43-2	Benzene	Composite Liner
7440-36-0	Antimony	Single Liner
75-09-2	Methylene Chloride (Dichloromethane)	No Liner

In the following tables, the LCTV is generally calculated as LCTV = DAF * RGC. However, in some instances, the DAF is denoted here with an asterisk (*). This occurs when the ground-water concentration is either exceedingly low, thus capping the LCTV, or the LCTV is capped by some other constraint. In instances where the toxic daughter cap is applied, the RGC is either absent or denoted by an asterisk. Please refer to Section 7.2 of the IWEM User's Guide (Limits on the Leachate Concentration Threshold Value) for more details. A brief explanation of LCTV caps is given in this report after the detailed HBN results.

Detailed Results Based on MCL - No Liner

CAS Number	Constituent Name	MCL (mg/L)	DAF	LCTV (mg/L)	Leachate Conc. (mg/L)	Protective ?
71-43-2	Benzene	0.005	2.2	0.011	0.01	Yes
7440-36-0	Antimony	0.006		0.014	0.03	No
75-09-2	Methylene Chloride (Dichloromethane)	0.005	2.2	0.011	0.02	No

Detailed Results Based on MCL - Single Liner

CAS Number	Constituent Name	MCL (mg/L)	DAF	LCTV (mg/L)	Leachate Conc. (mg/L)	Protective ?
71-43-2	Benzene	0.005	6.1	0.031	0.01	Yes
7440-36-0	Antimony	0.006		0.04	0.03	Yes
75-09-2	Methylene Chloride (Dichloromethane)	0.005	6.2	0.031	0.02	Yes

Detailed Results Based on MCL - Composite Liner

CAS Number	Constituent Name	MCL (mg/L)	DAF	LCTV (mg/L)	Leachate Conc. (mg/L)	Protective?
71-43-2	Benzene	0.005	1.90E+04	0.5 (A)	0.01	Yes
7440-36-0	Antimony	0.006		1000 (B)	0.03	Yes
75-09-2	Methylene Chloride (Dichloromethane)	0.005	6.20E+05	1000 (B)	0.02	Yes

Detailed Results Based on HBN - No Liner

CAS Number	Constituent Name	HBN (mg/L)	Exposure Pathway & Effect	DAF	LCTV (mg/L)	Leachate Conc . (mg/L)	Protective?
71-43-2	Benzene	0.0016	Inhalation Cancer	2.2	0.0036	0.01	No
7440-36-0	Antimony	0.0098	Ingestion Non-cancer		0.023	0.03	No
75-09-2	Methylene Chloride (Dichloromethane)	0.013	Ingestion Cancer	2.2	0.029	0.02	Yes

Detailed Results Based on HBN - Single Liner

CAS Number	Constituent Name	HBN (mg/L)	Exposure Pathway & Effect	DAF	LCTV (mg/L)	Leachate Conc. (mg/L)	Protective ?
71-43-2	Benzene	0.0016	Inhalation Cancer	6.1	0.0097	0.01	No
7440-36-0	Antimony	0.0098	Ingestion Non-cancer		0.068	0.03	Yes
75-09-2	Methylene Chloride (Dichloromethane)	0.013	Ingestion Cancer	6.2	0.081	0.02	Yes

Detailed Results Based on HBN - Composite Liner

CAS Number	Constituent Name	HBN (mg/L)	Exposure Pathway & Effect	DAF	LCTV (mg/L)	Leachate Conc. (mg/L)	Protective?
71-43-2	Benzene	0.0016	Inhalation Cancer	1.90E+04	0.5 (A)	0.01	Yes
7440-36-0	Antimony	0.0098	Ingestion Non-cancer		1000 (B)	0.03	Yes
75-09-2	Methylene Chloride (Dichloromethane)	0.013	Ingestion Cancer	6.30E+05	1000 (B)	0.02	Yes

CAPS & WARNINGS

A - The LCTV is capped by the Toxicity Characteristic Rule Exit Level (TC LEVEL) of the constituent.
B - The LCTV is capped by 1000 mg/L (EPA Policy).
C - The LCTV exceeds the cited solubility for this constituent.
D - The parent constituent LCTV is derived from the LCTV of a more conservative toxic daughter product(s).
E - The parent constituent does not have a RGC for this exposure pathway and effect, but the toxic daughter product(s) does. The LCTV of the parent is derived from the LCTV of the toxic daughter product.

Constituent Name	CAS ID
Benzene	71-43-2

Physical Properties

Property	Value	Data Source
Constituent Type	Organic	
Molecule Weight (g/mol)	78.1134	
Log Koc (distribution coefficient for organic carbon) (mL/g)	1.8	USEPA, 1993a
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Kn: neutral hydrolysis rate constant (1/yr)	0	USEPA, 1993a
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Solubility (mg/L)	1750	USEPA, 1997c
Diffusivity in air (cm^2/sec)	282	Calc., based on USEPA, 2001a
Diffusivity in water (m^2/yr)	0.0325	Calc., based on USEPA, 2001a
Henry's law constant (atm-m^3/mol)	0.0056	USEPA, 1997c

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)	0.005	USEPA, 2000h
HBN-Ingestion, Non-Cancer (mg/L)		
HBN-Ingestion, Cancer (mg/L)	0.0018	USEPA, 2001b
HBN-Inhalation, Non-Cancer (mg/L)	0.19	CALEPA, 1999b
HBN-Inhalation, Cancer (mg/L)	0.0016	USEPA, 2001b
Reference Dose (mg/kg-day)		
Reference Concentration (mg/m^3)	0.06	CALEPA, 2000
Carcinogenic Slope Factor-Oral (1/mg/kg-day)	0.055	USEPA, 2001b
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)	0.027	Calc, based on USEPA, 2001b

Constituent Name	CAS ID
Antimony	7440-36-0

Physical Properties

Property	Value	Data Source
Constituent Type	Metal	
Molecule Weight (g/mol)	121.76	
Log Koc (distribution coefficient for organic carbon) (mL/g)		
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)		
Kn: neutral hydrolysis rate constant (1/yr)		
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)		
Solubility (mg/L)	1.00E+06	CambridgeSoft Corporation, 2001
Diffusivity in air (cm^2/sec)		
Diffusivity in water (m^2/yr)		
Henry's law constant (atm-m^3/mol)		

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)	0.006	USEPA, 2000h
HBN-Ingestion, Non-Cancer (mg/L)	0.0098	USEPA, 2001b
HBN-Ingestion, Cancer (mg/L)		
HBN-Inhalation, Non-Cancer (mg/L)		
HBN-Inhalation, Cancer (mg/L)		
Reference Dose (mg/kg-day)	0.0004	USEPA, 2001b
Reference Concentration (mg/m^3)		
Carcinogenic Slope Factor-Oral (1/mg/kg-day)		
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)		

Constituent Name	CAS ID
Methylene Chloride (Dichloromethane)	75-09-2

Physical Properties

Property	Value	Data Source
Constituent Type	Organic	
Molecule Weight (g/mol)	84.9328	
Log Koc (distribution coefficient for organic carbon) (mL/g)	0.93	USEPA, 1993a
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Kn: neutral hydrolysis rate constant (1/yr)	0.001	USEPA, 1993a
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)	0.6	USEPA, 1993a
Solubility (mg/L)	1.30E+04	USEPA, 1997c
Diffusivity in air (cm^2/sec)	315	Calc., based on USEPA, 2001a
Diffusivity in water (m^2/yr)	0.0394	Calc., based on USEPA, 2001a
Henry's law constant (atm-m^3/mol)	0.0022	USEPA, 1997c

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)	0.005	USEPA, 2000h
HBN-Ingestion, Non-Cancer (mg/L)	1.5	USEPA, 2001b
HBN-Ingestion, Cancer (mg/L)	0.013	USEPA, 2001b
HBN-Inhalation, Non-Cancer (mg/L)	10	USEPA, 1997a
HBN-Inhalation, Cancer (mg/L)	0.028	USEPA, 2001b
Reference Dose (mg/kg-day)	0.06	USEPA, 2001b
Reference Concentration (mg/m^3)	3	USEPA, 1997a
Carcinogenic Slope Factor-Oral (1/mg/kg-day)	0.0075	USEPA, 2001b
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)	0.0016	Calc, based on USEPA, 2001b

References

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USEPA. 2001b. Integrated Risk Information System (IRIS). National Center for Environmental Assessment, Office of Research and Development, Washington, DC. http://www.epa.gov/iris/

Calculated from inhalation unit risk factors from USEPA, 2001b.

Tier 2 Evaluation Results

Recommendation: **Composite Liner**

Facility Type	Landfill
Facility name	
Street address	
City	
State	
Zip	
Date of sample analysis	
Name of user	
Additional information	

Landfill Parameters

Parameter	Value	Data Source
Depth of base of the LF below ground surface (m)	0	Default
Distance to well (m)	150	Default
Landfill area (m^2) [requires site specific value]	1.23E+04	132
WMU depth (m) [requires site specific value]	6.5	zxc

Subsurface Parameters

Subsurface Environment **Sand and Gravel**

Parameter	Value	Data Source
Ground-water pH value (metals only)	Distribution	Monte Carlo [See IWEM TBD 4.2.3.1]
Depth to water table (m)	Distribution	Monte Carlo [See IWEM TBD 4.2.3.1]
Aquifer hydraulic conductivity (m/yr)	Distribution	Monte Carlo [See IWEM TBD 4.2.3.1]
Regional hydraulic gradient	Distribution	Monte Carlo [See IWEM TBD 4.2.3.1]
Aquifer thickness (m)	Distribution	Monte Carlo [See IWEM TBD 4.2.3.1]

Regional Soil and Climate Parameters

Parameter	Value
Soil Type	Medium-grained soil (silt loam)
Climate Center	Greensboro NC
No Liner Infiltration Rate (m/yr)	.3256
Clay Liner Infiltration Rate (m/yr)	.0362
Composite Liner Infiltration Rate (m/yr)	Monte Carlo
Recharge Rate (m/yr)	0.3256

Constituent Reference Ground-water Concentrations and Constituent Properties

Constituent Name	RGC (mg/L)	RGC Based On	Kd* (L/kg)	Decay Coeff* (1/yr)	Leachate Conc. (mg/L)
Acrylonitrile	0.0002	HBN - Ingestion, Cancer			0.1

*If a site-specific value was entered by the user, it will be displayed here; otherwise, the model used the constituent properties listed at the end of the report.

Daughter Constituent Reference Ground-water Concentrations and Constituent Properties

Parent Constituent	Daughter Constituent	RGC (mg/L)	RGC Based On	Kd* (L/kg)	Decay Coeff.* (1/yr)
Acrylonitrile	Acrylamide	2.20E-05	HBN - Ingestion, Cancer		
Acrylonitrile	Acrylic acid [propenoic acid]	12	HBN - Ingestion, NonCancer		

*If a site-specific value was entered by the user, it will be displayed here; otherwise, the model used the constituent properties listed at the end of the report.

Detailed Results for Parent Constituents -- No Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylonitrile	0.1	2.4	4.11E-05 (D)	HBN - Ingestion, Cancer	2.20E-05	0.0413	No

Detailed Results for Parent Constituents -- Clay Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylonitrile	0.1	13	0.0003 (D)	HBN - Ingestion, Cancer	2.20E-05	0.0075	No

Detailed Results for Parent Constituents -- Composite Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylonitrile	0.1	2.40E+04	4.32	HBN - Ingestion, Cancer	2.20E-05	4.10E-06	Yes

Detailed Results for Daughter Constituents -- No Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylamide	0.134	2.5	5.50E-05	HBN - Ingestion, Cancer	2.20E-05	0.0539	No
Acrylic acid [propenoic acid]	0.1358	2.4	28.8	HBN - Ingestion, NonCancer	12	0.0562	Yes

Detailed Results for Daughter Constituents -- Clay Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylamide	0.134	17	0.0004	HBN - Ingestion, Cancer	2.20E-05	0.008	No
Acrylic acid [propenoic acid]	0.1358	NA	NA	All Available		NA	See No Liner

Detailed Results for Daughter Constituents -- Composite Liner

Constituent Name	Leachate Conc. (mg/L)	DAF (mg/L)	LCTV (mg/L)	Selected RGC	RGC (mg/L)	90th %tile Exp. Conc. (mg/L)	Protective?
Acrylamide	0.134	1.00E+30	1000	HBN - Ingestion, Cancer	2.20E-05	0	Yes
Acrylic acid [propenoic acid]	0.1358	NA	NA	All Available		NA	See No Liner

<u>CAPS & WARNINGS</u>

A - The LCTV is capped by the Toxicity Characteristic Rule Exit Level (TC LEVEL) of the constituent.

B - The LCTV is capped by 1000 mg/L (EPA Policy).

C - The LCTV exceeds the cited solubility for this constituent.

D - The parent constituent LCTV is derived from the LCTV of a more conservative toxic daughter product(s).

Constituent Name	CAS ID
Acrylonitrile	107-13-1

Physical Properties

Property	Value	Data Source
ChemicalType	Organic	
Molecule Weight (g/mol)	53.0634	
Log Koc (distribution coefficient for organic carbon) (mL/g)	-0.089	USEPA, 1993a
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)	500	USEPA, 1993a
Kn: neutral hydrolysis rate constant (1/yr)	0	USEPA, 1993a
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)	5200	USEPA, 1993a
Solubility (mg/L)	7.40E+04	USEPA, 1997c
Diffusivity in air (cm^2/sec)	360	Calc., based on USEPA, 2001a
Diffusivity in water (m^2/yr)	0.0388	Calc., based on USEPA, 2001a
Henry's law constant (atm-m^3/mol)	0.0001	USEPA, 1997c

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)		
HBN-Ingestion, Non-Cancer (mg/L)	0.025	USEPA, 1997a
Reference Dose (mg/kg-day)	0.001	USEPA, 1997a
HBN-Ingestion, Cancer (mg/L)	0.0002	USEPA, 2001b
Carcinogenic Slope Factor-Oral (1/mg/kg-day)	0.54	USEPA, 2001b
HBN-Inhalation, Non-Cancer (mg/L)	0.038	USEPA, 2001b
Reference Concentration (mg/m^3)	0.002	USEPA, 2001b
HBN-Inhalation, Cancer (mg/L)	0.001	USEPA, 2001b
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)	0.24	Calc, based on USEPA, 2001b

Constituent Name	CAS ID
Acrylamide	79-06-1

Physical Properties

Property	Value	Data Source
ChemicalType	Organic	
Molecule Weight (g/mol)	71.0786	
Log Koc (distribution coefficient for organic carbon) (mL/g)	-0.989	USEPA, 1993a
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)	31.5	USEPA, 1993a
Kn: neutral hydrolysis rate constant (1/yr)	0.018	USEPA, 1993a
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Solubility (mg/L)	6.40E+05	USEPA, 1997c
Diffusivity in air (cm^2/sec)	337	Calc., based on USEPA, 2001a
Diffusivity in water (m^2/yr)	0.0397	Calc., based on USEPA, 2001a
Henry's law constant (atm-m^3/mol)	1.00E-09	USEPA, 1997c

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)		
HBN-Ingestion, Non-Cancer (mg/L)	0.0049	USEPA, 2001b
Reference Dose (mg/kg-day)	0.0002	USEPA, 2001b
HBN-Ingestion, Cancer (mg/L)	2.20E-05	USEPA, 2001b
Carcinogenic Slope Factor-Oral (1/mg/kg-day)	4.5	USEPA, 2001b
HBN-Inhalation, Non-Cancer (mg/L)		
Reference Concentration (mg/m^3)		
HBN-Inhalation, Cancer (mg/L)	5.1	USEPA, 2001b
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)	4.6	Calc, based on USEPA, 2001b

Constituent Name	CAS ID
Acrylic acid [propenoic acid]	79-10-7

Physical Properties

Property	Value	Data Source
ChemicalType	Organic	
Molecule Weight (g/mol)	72.1	
Log Koc (distribution coefficient for organic carbon) (mL/g)	-1.84	USEPA, 1993a
Ka: acid-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Kn: neutral hydrolysis rate constant (1/yr)	0	USEPA, 1993a
Kb: base-catalyzed hydrolysis rate constant (1/mol yr)	0	USEPA, 1993a
Solubility (mg/L)	1.00E+06	USEPA, 1997c
Diffusivity in air (cm^2/sec)	325	Calc., based on USEPA, 2001a
Diffusivity in water (m^2/yr)	0.0378	Calc., based on USEPA, 2001a
Henry's law constant (atm-m^3/mol)	1.17E-07	USEPA, 1997c

Reference Ground-water Concentration Values

Property	Value	Data Source
Maximum Contamination Level (mg/L)		
HBN-Ingestion, Non-Cancer (mg/L)	12	USEPA, 2001b
Reference Dose (mg/kg-day)	0.5	USEPA, 2001b
HBN-Ingestion, Cancer (mg/L)		
Carcinogenic Slope Factor-Oral (1/mg/kg-day)		
HBN-Inhalation, Non-Cancer (mg/L)	15	USEPA, 2001b
Reference Concentration (mg/m^3)	0.001	USEPA, 2001b
HBN-Inhalation, Cancer (mg/L)		
Carcinogenic Slope Factor-Inhalation (1/mg/kg-day)		

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