A SUBTITLE D LANDFILL APPLICATION MANUAL FOR THE MULTIMEDIA EXPOSURE ASSESSMENT MODEL (MULTIMED 2.0)

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FINAL REPORT

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FOREWORD

As environmental controls become more costly to implement and the penalties of judgment errors become more severe, environmental quality management requires more efficient management tools based on greater knowledge of the environmental phenomena to be managed. As part of this Laboratory's research on the occurrence, movement, transformation, impact and control of environmental contaminants, the Assessment Branch develops management or engineering tools to help pollution control officials assess the risk to human health and the environment posed by land disposal of hazardous wastes.

EPA's Multimedia Exposure Assessment (MULTIMED) simulates the transport and transformation of contaminants released from a hazardous waste disposal facility into the multimedia environment. MULTIMED includes contaminant release to either air or soil and possible interception of the subsurface plume by a surface stream. An important application of MULTIMED would be the prediction of pollutant movement in leachate from a Subtitle D landfill, a use that requires only a subset of the model's full capabilities. This manual, then, provides instruction for inexperienced as well as experienced model users who seek to study or design waste disposal facilities.

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ABSTRACT

The Environmental Protection Agency's Multimedia Exposure Assessment Model (MULTIMED) for exposure assessment simulates the movement of contaminants leaching from a landfill. The model consists of a number of modules which predict concentrations at a receptor due to transport in the subsurface, surface water, or air. This report is an application manual for the use of MULTIMED in modeling Subtitle D land disposal facilities.

When applying MULTIMED to Subtitle D facilities, the landfill, surface water, and air modules in the model are not accessible by the user; only flow and transport through the unsaturated zone and transport in saturated zone can be considered. A one-dimensional, semi-analytical module simulates flow in the unsaturated zone. The output from this module, water saturation as a function of depth, is used as input to the unsaturated zone transport module. The latter simulates transient, one-dimensional (vertical) transport in the unsaturated zone using either an analytical model that includes the effects of longitudinal dispersion, linear adsorption, and first-order decay or a numerical model that includes the effects of longitudinal dispersion, non-linear adsorption, first-order decay, time variable infiltration rates, and arbitrary initial conditions of chemical concentration in the unsaturated zone. The unsaturated zone transport module calculates steady-state or transient contaminant concentrations. Output from both unsaturated zone modules is used to couple the unsaturated zone transport module with the steady-state or transient, semi-analytical saturated zone transport module. The latter includes one-dimensional uniform flow, three-dimensional dispersion, linear adsorption, first-order decay, and dilution due to direct infiltration into the groundwater plume.

The fate of contaminants in the various media depends on the chemical properties of the contaminants as well as a number of media- and environment-specific parameters. The uncertainty in these parameters can be quantified in MULTIMED using the Monte Carlo simulation technique.

To enhance the user-friendly nature of MULTIMED, a preprocessor, PREMED, and a postprocessor, POSTMED, have been developed. The preprocessor guides the user in the creation of a correct Subtitle D input file by restricting certain options and parameters and by setting appropriate defaults.

This report was submitted in partial fulfillment of Work Assignment Number 32, Contract Number 68-03-3513 by Work Assignment Number 1-16, Contract Number 68-CO-0019 by Aqua Terra Consultants, under the sponsorship of the U.S. Environmental Protection Agency. The 1993 version of this report, which covers the period June 1993 to September 1993, updates the August 1990 version of this document. The 1993 document revisions coincide with the release of MULTIMED version 2.0, which includes a numerical unsaturated transport model to allow the user to stimulate (1) non-linear adsorption, (2) initial contamination conditions, (3) time-varying infiltration rates, and (4) volatilization of chemicals in the unsaturated zone.

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At AQUA TERRA Consultants, the report was co-authored by Constance Travers and Susan Sharp-Hansen, the Project Manager. Anthony Donigian supplied technical and administrative guidance and he and John Kittle reviewed the document. Word processing was performed by Dorothy Inahara. The material in Appendix A, which summarizes the code structure and input format, and in Appendix B, which lists the model subroutines, is based on a report by Salhotra and Mineart (1988).

A number of individuals were involved in the development and implementation of the MULTIMED computational codes. Key individuals include Jan Kool and Peter Huyakorn of HydroGeoLogic Inc., Terry Allison of Computer Sciences Corporation, Barry Lester of Geotrans Inc., Michael Ungs of TetraTech, Inc., Bob Ambrose of U.S. EPA, John Kittle of AQUA TERRA Consultants, and Rob Schanz, Yvonne Meeks, and Peter Mangarella of Woodward-Clyde Consultants. Robert Johns and William Mills of Tetra Tech, Inc. revised the original MULTIMED code to enhance the unsaturated zone transport model capabilities and prepared this revised model documentation.

The pre- and postprocessor for MULTIMED were developed by John Kittle and Paul Hummel at AQUA TERRA Consultants. Paul Hummel and Constance Travers created the tutorials for the preprocessor.

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SECTION 1

INTRODUCTION

This document provides information needed to apply the U.S. Environmental Protection Agency's Multimedia Model (MULTIMED) to scenarios related to the study and design of Subtitle D land disposal facilities. Application of MULTIMED to Subtitle D facilities requires the use of only a subset of the model's capabilities. MULTIMED's model theory documentation (Salhotra et al., 1995) provides detailed information about the model's full capabilities. In this section, the model's full capabilities are first briefly addressed (Section 1.1). A summary of the methods used for application to the design of Subtitle D facilities follows (Section 1.2).

1.1 OVERVIEW OF MULTIMED

MULTIMED simulates the transport and transformation of contaminants released from a waste disposal facility into the multimedia environment. Release to either air or soil, including the unsaturated and the saturated zones, and possible interception of the subsurface contaminant plume by a surface stream are included in the model. Thus, the model can be used as a technical and quantitative management tool to address the problem of the land disposal of chemicals in the multimedia environment. At this time, the air modules of the model are not linked to the other model modules. As a result, the estimated release of contaminants to the air is independent of the estimated contaminant release to the subsurface and surface water.

MULTIMED utilizes analytical, semi-analytical, and numerical solution techniques to solve the mathematical equations describing flow and transport. The simplifying assumptions required to obtain the solutions limit the complexity of the systems, which can be represented by MULTIMED. The recently incorporated numerical solution allows for time variable infiltration rates, arbitrary initial conditions, and non-linear adsorption. However, the model does not account for other compli-cating features such as site-specific spatial variability, the shape of the land disposal facility, site-specific boundary conditions, or multiple aquifers and pumping wells. Nor can MULTIMED simu-late processes, such as flow in fractures, multi-phase flow, and chemical reactions between contami-nants, which can have a significant effect on the concentration of contaminants at a site. In more complex systems, it may be beneficial to use MULTIMED as a "screening level" model which would allow a user to obtain an understanding of the system. A three-dimensional numerical model could then be used if there are sufficient data and necessity to justify the use of a more complex model.

1.1.1 Model Capabilities

During the development of this model, emphasis was placed on the creation of a unified, user-friendly, software framework, with the capability to perform uncertainty analysis, that can be easily enhanced by adding modules and/or modifying existing modules.

To enhance the user-friendly nature of the model, separate interactive preprocessing and postprocessing software has been developed for use in creating and editing input and in plotting model output. The pre- and postprocessors, PREMED and POSTMED, have not been integrated with MULTIMED because of the size limitations of PC computers. Therefore, after using the preprocessor to create or modify input, the model is run in batch mode. Afterwards, the postprocessor can be used to produce plots of the Monte Carlo output or plots of concentration versus time for transient output.

The fate of contaminants critically depends on a number of media-specific parameters. Typically many of these parameters exhibit spatial and temporal variability as well as variability due to measurement errors. MULTIMED has the capability to analyze the impact of uncertainty and variability in the model inputs on the model outputs (concentrations at specified points in the multimedia environment), using the Monte Carlo simulation technique.

The major functions currently performed by this model include:

- Allocation of default values to some input parameters/variables.
- Reading of the input data files.
- Echo of input data to output files.
- Derivation of some parameters, if specified by the user.
- Depending on user-selected options:
  - simulation of leachate flux emanating from the source
  - simulation of unsaturated zone flow and transport
  - simulation of saturated zone transport only
  - computation of in-stream concentrations due to contaminant loading assuming complete interception of a plume in the saturated zone
  - computation of the rate of contaminant emission from the waste disposal unit into the atmosphere
  - simulation of dispersion of the contaminants in the atmosphere
- Generation of random input values for Monte Carlo simulations.
- Performance of statistical analyses of Monte Carlo simulations.

- Writing the concentrations at specified receptors to output files for deterministic runs. In the Monte Carlo mode, writing the cumulative frequency distribution and selected percentiles of concentrations at receptors to output files.
- Printing the values of randomly generated input parameters and the computed concentration values for each Monte Carlo run.

1.1.2 Interaction Framework (AIDE)

The pre- and postprocessor for MULTIMED have been developed using the ANNIE Interaction Development Environment (AIDE) (Kittle et al., 1989). Consequently, the construction of input and the analysis of output is standardized in terms of screen formats, movement within and between screens, and methods of entering data, seeking on-line assistance and invoking commands. A full explanation of the conventions used is provided in Section 3.

1.1.3 Revisions in MULTIMED Version 2.0

Version 2.0 of MULTIMED includes a numerical unsaturated zone transport model to allow the user to simulate (1) non linear adsorption, (2) initial contamination conditions, (3) time-varying infiltration rates, and (4) volatilization of chemicals in the unsaturated zone. The numerical unsaturated zone transport model in MULTIMED version 2.0 originated from the VADOFT code in the EPA RUSTIC model (Dean, et al., 1989), which was later modified for non-linear adsorption and incorporated into the EPA CML model (Geotrans, 1990). The original analytical unsaturated zone transport model is also in version 2.0, such that the user has an option of either the analytical or numerical unsaturated zone transport modules. The analytical model may be preferred for less complex problems, especially in the Monte Carlo mode, because it is computationally more efficient. However, if the user wishes to simulate either non-linear adsorption, arbitrary initial conditions, time-varying infiltration rates, or volatilization in the unsaturated zone, then the numerical model must be used.

The theory relating to the four MULTIMED model revisions associated with the addition of the numerical unsaturated zone transport model is discussed in the accompanying theory document. Revisions to the model input parameters associated with the use of the numerical unsaturated zone transport model, or any of these four enhanced capabilities are discussed in this document. These four model enhancements are briefly summarized as follows:

(1) Non-linear Adsorption. MULTIMED now has the capability to simulate transport through the unsaturated zone, of chemicals which do not adsorb to the solid phase in a linear manner. The analytical model in earlier versions of MULTIMED (and as still retained in version 2.0) considered only the transport of chemicals which had a simple linear relationship between the dissolved and adsorbed phase concentration of a chemical, such that the partition coefficient was independent of concentration. The numerical model

allows the user to simulate chemicals, such as metals, which have a non-linear relationship between the dissolved and adsorbed phase concentration such that the partition coefficient is a function of the total chemical concentration in the soil. There are two non-linear adsorption models considered, the Freundlich adsorption isotherm and an empirical adsorption model defined by the user. The impact of these non-linear adsorption models varies depending on the adsorption formulation, however, non-linear adsorption typically results in deviations from the gaussian plume behavior associated with simple linear adsorption. Note that the new adsorption model in version 2.0 considers deviations from linear adsorption, but it does not consider deviations from equilibrium. The dissolved and adsorbed phases are con-sidered to be in equilibrium in both the linear or non-linear adsorption models.

(2) Initial Contamination Conditions. MULTIMED now has the capability to simulate the transport of chemicals which have already migrated out of the waste source, and are present as soil contamination in the unsaturated zone. For example, if soil data available for a particular site indicates contaminants are present in the soils above the water table, the user can directly enter the profile of soil chemical concentrations versus depth, bypassing the necessity to simulate this pre-existing contamination as a waste source.

(3) Time-varying Infiltration Rates. MULTIMED now has the capability to simulate leaching of chemicals from a waste source whose water infiltration rates vary with time. The earlier MULTIMED model considered only a single infiltration rate through the waste source for the duration of the model simulation. The capability to simulate time-varying infiltration rates allows the user to simulate the effects of changes in waste management alternatives, such as caps, on chemical migration. The user may enter an arbitrary time series of infiltration rates that allows infiltration to increase or decrease with time as may be associated with failure of waste containment systems, the addition of new waste containment systems, etc.

(4) Volatilization of Chemicals from the Unsaturated Zone. MULTIMED now has the capability to simulate the vertical transport of chemicals in the unsaturated zone by both infiltration within the water phase and diffusion within the vapor phase. The earlier version of MULTIMED considered only the presence of dissolved and adsorped phases, and the leaching of chemicals to the water table; whereas the new model considers the presence of dissolved, adsorbed, and vapor phases, the leaching of chemicals to the water table, and the volatilization of chemicals to the atmosphere. The leaching and volatilization processes are simulated simultaneously such that the air and groundwater pathways can compete for the chemical, and a mass balance is maintained between the initial chemical mass and the chemical mass ultimately released to the air or groundwater.

Note that the use of any of these four MULTIMED model enhancements requires the use of the numerical unsaturated zone transport model.

1.2 APPLICATION OF MULTIMED TO SUBTITLE D LAND DISPOSAL FACILITIES

The U.S. EPA has developed several restrictions for Subtitle D applications of MULTIMED. These restrictions were made in an effort to develop a conservative approach for simulating leachate migration from Subtitle D facilities.

- Only the Saturated and/or Unsaturated Modules may be active in Subtitle D applications, because the Surface Water, Landfill and Air Modules have not been sufficiently tested at this time.

- Although MULTIMED can simulate either steady-state or transient transport conditions, only steady-state transport simulations are recommended for Subtitle D applications. No decay of the source term is allowed; the concentration of contaminants entering the aquifer system must be constant in time. The contami-nant pulse is assumed continuous and constant for the duration of the simulation.

- The receptor must be located directly downgradient of the facility, so that it intercepts the center of the contaminant plume. In addition, the contaminant concentration must be calculated at the top of aquifer. Therefore, the angle from the plume centerline to the receptor and the vertical distance to the receptor must be specified as zero in Subtitle D applications.

Thus, MULTIMED can be applied at many Subtitle D land disposal facility sites to simulate the transport of contaminants from the source, through the saturated and/or unsaturated zones by groundwater, to a receptor (i.e. a well). When MULTIMED is used in conjunction with a separate source model, such as HELP (Schroeder et al., 1984), it can be used in a variety of applications. These applications include 1) development and comparison of the effects of different facility designs on groundwater quality, 2) prediction of the results of different types of "failure" of the landfill, and 3) if leachate migration into the groundwater below an existing waste disposal facility occurs, prediction of the fate and transport of the contaminants in the subsurface. The user should bear in mind, however, that MULTIMED may not be an appropriate model for application to some sites. This issue, which is discussed in Section 5.1, should be considered before modeling efforts proceed.

As stated above, MULTIMED can be used in the design process to demonstrate that a particular design will adequately prevent contaminant concentrations in groundwater from exceeding health-based thresholds. In other words, MULTIMED combined with a source model can be used to demonstrate that either a landfill design, or the specific hydrogeologic conditions present at a site will prevent the migration of significant quantities of contaminants from the landfill. Procedures have been developed for the application of MULTIMED to the design of Subtitle D facilities. These procedures are outlined in Section 5.2.4 and are briefly summarized here.

- Collect site-specific hydrogeologic data
- Determine the contaminant to be simulated and the active modules in MULTIMED and the point of compliance
- Propose a landfill design and determine the corresponding infiltration rate
- Run MULTIMED and calculate the dilution attenuation factor (i.e., the factor by which the concentration is expected to decrease between the landfill and the point of compliance)
- Based on the resulting dilution attenuation factor, determine if the design is acceptable

1.3 REPORT ORGANIZATION

This report contains the information needed to apply MULTIMED, in conjunction with another model, such as HELP (Schroeder et al., 1984 a and b), to Subtitle D land disposal facilities. Section 2 contains information about installation and execution of the code. In Section 3, general information about the format and operation of the pre- and post-processors is provided and Section 4 describes how to use the pre- and postprocessors for Subtitle D applications of the model. Section 5 discusses the development of a conceptual model for Subtitle D applications, the limitations and capabilities of MULTIMED, and details about the input required to run each model module. Help in estimating some of the model parameters is contained in Section 6. In Section 7, appropriate example problems are in-cluded. Finally, contained in Appendices are 1) detailed information on the structure of the code and the format of data in the input files, and 2) a listing of the subroutines in the code.

1.4 HOW TO USE THIS MANUAL

This application manual for the MULTIMED model and its pre- and postprocessors, PREMED and POSTMED, is designed to be used by inexperienced as well as experienced users. Instructions are suggested for two types of inexperienced users: the "hands-on, learn-as-you-go" user and the "read the document first" user, as well as for the experienced user. An experienced user is defined as one who is already familiar with the basic capabilities and operational aspects of PREMED, MULTIMED and POSTMED, and wants to use the programs to perform simulations. These instructions are based on a similar set of instructions found in Imhoff et al. (1990).

"Hands-on, Learn-as-you-go" Users

1. Read Section 2 for instructions on model installation and execution.

2. Install PREMED, MULTIMED, and POSTMED. Execute the tests provided with the code and/or described in Section 2 to verify that PREMED and POSTMED are properly installed.

3. From the DOS operating system, execute PREMED by typing <PREMED> (do not type the brackets). The opening screen will appear. Utilize one of the two tutorials by typing either <@DETER.LOG> for a deterministic Subtitle D application or <@MONTE.LOG> for a Monte Carlo Subtitle D application.

4. Use the completed input sequence generated by the selected tutorial to run MULTIMED. The input sequence created by the <@DETER.LOG> tutorial is the same as that used in Example 2 in Section 7. The input generated by the <@MONTE.LOG> tutorial corresponds to Example 3 in Section 7.

5. Examine the output generated by the MULTIMED model. Because new versions of MULTIMED may be released after publication of this document, the output may not be identical to the output shown in Section 7. Therefore, compare the output generated by MULTIMED with the appropriate output file provided with the code. This will allow you to verify that the MULTIMED model is properly installed.

6. Try the other example problems described in Section 7 to become more familiar with MULTIMED.

7. Practice producing plots using POSTMED and the SAT1.OUT file generated when the Example 3 input is run.

8. Proceed with suggestions 2 through 5 provided below for "experienced users."

"Read the Documentation First" Users

1. Read Section 1 to familiarize yourself with the basic capabilities and framework of the MULTIMED model. If you need more detailed information on the capabilities and limitations of MULTIMED to determine if the model will be suitable for your needs, read Section 5.1.

2. Read Section 3 which discusses the format and basic operation of the preprocessor, PREMED.

3. Read Section 2 for instructions on model installation and execution.

4. Install PREMED, MULTIMED, and POSTMED. Execute the tests provided with the code and/or described in Section 2 to verify that PREMED and POSTMED are properly installed.

5. From the DOS operating system, execute PREMED by typing <PREMED> (do not type the brackets). The opening screen will appear. Utilize one of the two tutorials by typing either <@DETER.LOG> for a deterministic Subtitle D application or <@MONTE.LOG> for a Monte Carlo Subtitle D application.

6. Section 4 discusses the use of the pre- and post-processor. Read Section 4.1 in conjunction with the tutorial to provide a complete description of PREMED.

7. Use the completed input sequence generated by the selected tutorial to run MULTIMED. The input sequence created by the <@DETER.LOG> tutorial is the same as that used in Example 2 in Section 7. The input generated by the <@MONTE.LOG> tutorial corresponds to Example 3 in Section 7.

8. Examine the output generated by the MULTIMED model. Because new versions of MULTIMED may be released after publication of this document, the output may not be identical to the output shown in Section 7. Therefore, compare the output generated by MULTIMED with the appropriate output file provided with the code. This will allow you to verify that the MULTIMED model is properly installed.

9. Try the other example problems described in Section 7 to become more familiar with MULTIMED.

10. Practice producing plots using POSTMED and the SAT1.OUT file generated when the Example 3 input is run.

11. Proceed with suggestions 2 through 5 provided below for "experienced users."

<u>Experienced Users</u>

1. Read Section 2 and install PREMED, MULTIMED, and POSTMED. Execute the tests provided with the code and/or described in Section 2 to verify that PREMED and POSTMED are properly installed, and execute the test run for PREMED.

2. Read Section 5.2 which discusses applying MULTIMED to Subtitle D facility problems. Refer to Section 5.1, which includes a discussion of issues related to conceptualization of the system, and the capabilities and limitations of MULTIMED, as needed.

3. Read Section 6 as needed to estimate parameters required by MULTIMED.

4. Try using MULTIMED to simulate actual scenarios.

5. If you wish to make changes to input files without using the preprocessor, refer to Appendix A which discusses the format for input files.

SECTION 2

PROGRAM INSTALLATION AND EXECUTION

This section describes how to install and test MULTIMED and the related pre- and postprocessor software on the user's computer. Hardware and software requirements are discussed. Exact details of installation are included with the software when it is distributed by the EPA Center for Exposure Assessment Modeling (CEAM) at the Environmental Research Laboratory in Athens, Georgia. If problems are experienced, the user should contact CEAM for support.

2.1 SYSTEM REQUIREMENTS

2.1.1 Hardware

MULTIMED and the related pre- and postprocessors, PREMED and POSTMED, were designed to be used on an IBM-PC compatible computer. The PC must use either the Intel 386 or 486 technology, have 4 MB of extended memory, a math coprocessor, and approximately 5 MB of free disk space.

Additional machines which should run the software include Digital Equipment Corporation VAX computers running the VMS operation system, Prime 50 Series computer running PRIMOS and Sun Microsystems or Data General workstations running UNIX. Contact CEAM for details.

2.1.2 Software

MULTIMED and its related software are written in FORTRAN 77. If compilation of the code is required, a FORTRAN compiler and linker are needed. In addition, compilation of the preprocessor, PREMED, and postprocessor, POSTMED, requires the use of ANNIE-IDE software (Kittle et al., 1989), which is available from CEAM. Consult CEAM for additional information about obtaining these device drivers.

2.2 LOADING THE EXECUTABLE CODE

Included with the distribution media for MULTIMED and its related pre- and postprocessing software is a README.1ST document and file that provides detailed instructions for installing the programs. It is recommended that data files be maintained in directories separate from the code.

2.3 EXECUTING AND VERIFYING TEST SESSIONS

Sample input data files and the related output files are distributed with the model. In order to test the installation of MULTIMED, the user should run these example problems and compare the output generated by the code with the output files supplied with the code. The code is executed on a PC by typing **MULTIMED<CR>** (<CR> is the enter key). The model will query the user for the name of the input file and the name of the file to which output should be written. Be careful not to overwrite existing output files.

In order to test the installation of the preprocessor, perform the following check. First, execute the program (on a PC type **PREMED<CR>**). Next type the following sequence of keys:

BCS<CR><CR><F2>M<F2>FU<F2>RRYRY

Note that **<F2>** is the F2 function key. The screen in Figure 2.1 should appear on the display screen. To return to the operating system, type the key **R**.

The best test of the installation of the postprocessor is to plot the results of the Monte Carlo simulation distributed with the model. The output file is called EX3SAT1.OUT. First, execute the program (on a PC type POSTMED<CR>). Next, for plotting results to the screen type the following sequence of keys:

D<F2>EX3SAT1.OUT<F2>P

```
ÚÄOpening ScreenÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿

³          WELCOME TO PREMED, THE PREPROCESSOR FOR MULTIMED                 ³
³                                                                           ³
³          Type '@DETER.LOG' or '@MONTE.LOG' for an application tutorial    ³
³                                                                           ³
³      Select an option?                                                    ³
³                                                                           ³
³      Build   / Modify input sequence for model                            ³
³      Analyze model results                                                ³
³      Execute MULTIMED model                                               ³
³      Return  to operating system                                          ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
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³Editing a new file                                                         ³
³Application type: Subtitle D landfill                                      ³
³Scenario: Unsaturated and Saturated Zone modules                           ³
³                                                                           ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
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³                   Select an option using arrow keys                       ³
³               then confirm selection with the F2 key,   or                ³
³                   Type the first letter of an option.                     ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
Help:F1  Accept:F2  Status:F7  Quiet:F8  Xpad:F9  Cmhlp
Build
```

Figure 2.1 Preprocessor screen after installation.

A cumulative frequency plot will appear on the computer screen. This plot should be the same as the cumulative frequency plot found in the main output file for the same problem. After examining the plot, press the Enter key, <CR>, to clear the plot from the screen. To return to the operating system, type the key **R**.

For computers without graphics capabilities, the following check can be performed. After executing the program (on a PC type **POSTMED<CR>**), type the following sequence of keys:

D<F2>EX3SAT1.OUT<F2>S

At this point, hit the down arrow key once, then type **PR<F2>P**. The cumulative frequency plot will be sent to the printer. After the plot has been sent, return to the operating system by typing the key **R**.

If there is a problem with any of the three software components of MULTIMED, review the installation instructions carefully before calling CEAM for support.

SECTION 3

FORMAT AND OPERATION OF THE PRE- AND POSTPROCESSOR

A pre- and a postprocessor, PREMED and POSTMED, have been developed for MULTIMED in order to improve the ease with which input can be created and/or edited and output can be analyzed. The pre- and postprocessors have been developed using the ANNIE Interaction Development Environment (Annie-IDE) (Kittle et al., 1989). Consequently, user interaction within the program is standardized in terms of screen formats, movement within and between screens, and methods of entering data, seeking on-line assistance and invoking commands.

Two tutorials are distributed with the preprocessor (see Section 4.1.3 for information about running the tutorials). These tutorials familiarize the user with the operation and features of the preprocessor and are recommended for new users. Although no tutorial exists for the postprocessor, its format and operation are identical to that of the preprocessor. To complement the tutorials, the format and operation of the screens are described in detail below. The summary is taken, with minimal adaptation, from the manual for another Annie-IDE application, called DBAPE (Imhoff et al., 1989).

3.1 SCREEN FORMAT

Figure 3.1 defines the basic layout of a preprocessor screen. The layout is consistent for all screens used by PREMED, with specific kinds of information always located at the same region of the screen. Screen information is divided into four compon-ents: three windows (data window, assistance window, instruction window) and the com-mand line. For convenience, the dimensions, content, and important features of the four screen components are summarized along the periphery of the screen area in the figure.

3.1.1 Data Window

The top portion of the screen is the **data window**. The data window contents consist of one or more of the following.

(1) Prompts for user-supplied decisions by means of menu selection
(2) Prompts for user-supplied data by means of form fill-in
(3) Echoes for current state of data

Two user-controlled sizes for the data window are used. In the default layout, the assistance window is not displayed, resulting in a two window, one command line screen (see Figure 3.2 for example). If the user desires any of the forms of assistance described in Section 3.1.2, then the data window is reduced in size to accommodate the assistance window (see Figure 3.3).

```
ÚÄDATA WINDOW TITLE AND SCREEN PATHÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿  DATA WINDOWUP TO 24 CHARACTER SCREEN DESCRIPTOR
                                                         SCREEN PATH     : STRING OF 1-LETTER CODES SPECIFYING PATH
                                                                           OF OPERATIONS (UP TO 48 CHARACTERS)
                                                         DIMENSIONS      : 78 X 16 (WITHOUT ASSISTANCE INFO WINDOW)
                                                                           78 X 10 (WITH ASSISTANCE INFO WINDOW)
                                                         CONTENT         : PROMPTS FOR DECISIONS OR DATA, ECHOES OF
                                                                           STATE OF DATA, OR RESULTS OF OPERATIONS
                                                         FEATURES        : ACCOMMODATES DATA FILE OF MAXIMUM
                                                                           DIMENSIONS 78 X 50 WITH SCROLLING
                                                         DATA RANGE      : LINES OF DATA CURRENTLY DISPLAYED
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄASSISTANCE WINDOW TITLEÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿  ASSISTANCE WINDOW
                                                         TITLE           : HELP, COMMANDS, LIMITS, STATUS OR XPAD
                                                         DIMENSIONS      : 78 X 4
                                                         CONTENT         : INFORMATION PROVIDED BY PROGRAM (COMMANDS,
                                                                           HELP, LIMITS, STATUS) OR BY USER (XPAD)
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ      HELP  - DETAILED USER ASSISTANCE FOR SCREEN CONTENTS
ÚÄINSTRUCTION WINDOW TITLEÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿   COMMANDS- DEFINITIONS OF AVAILABLE COMMANDS
                                                           LIMITS        - RANGE OF ACCEPTABLE VALUES
                                                           STATUS        - SYSTEM STATUS INFORMATION
                                                           XPAD          - USER NOTES AND REMINDERS
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ     FEATURES: ALLOWS SCROLLING IF INFORMATION EXCEEDS
Help:F1  Accept:F2  Status:F7  Quiet:F8  Xpad:F9  Cmhlp                            VERTICAL DIMENSION
Build

COMMAND LINE                                                INSTRUCTION WINDOW
DIMENSIONS  : 80 X 1                                          TITLE          : INSTRUCT OR ERROR
CONTENT     : MENU OF ABBREVIATIONS FOR AVAILABLE COMMANDS    DIMENSIONS     : 78 X 3
FEATURES    : COMMANDS ARE ORDERED BY EXPECTED FREQUENCY OF USE  CONTENT     : SYSTEM GENERATED INSTRUCTIONS AND
                   STANDARDIZED SET OF COMMANDS AVAILABLE (SEE TABLE 3-1)        ERROR MESSAGES
                                                          FEATURES       : DIRECTS USERS TO ACCEPTABLE KEY STROKES
```

Figure 3.1   Screen format utilized by the pre- and postprocessor.

```
ÚÄOpening ScreenÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿
³                                                                              ³
³         Type '@DETER.LOG' or '@MONTE.LOG' for an application tutorial        ³
³                                                                              ³
³     Select an option?                                                        ³
³                                                                              ³
³     Build   / Modify input sequence for model                                ³
³     Analyze model results                                                    ³
³     Execute MULTIMED model                                                   ³
³     Return  to operating system                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
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³                   Select an option using arrow keys                          ³
³               then confirm selection with the F2 key,  or                    ³
³                  Type the first letter of an option.                         ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
 Help:F1  Accept:F2  Status:F7  Xpad:F9  Cmhlp
 Build
```

Figure 3.2 Example of a two-window, one command line screen.

```
ÚÄOpening ScreenÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿
```

```
³         WELCOME TO PREMED, THE PREPROCESSOR FOR MULTIMED                     ³
³                                                                              ³
³         Type '@DETER.LOG' or '@MONTE.LOG' for an application tutorial        ³
³                                                                              ³
³     Select an option?                                                        ³
³                                                                              ³
³     Build   / Modify input sequence for model                                ³
³     Analyze model results                                                    ³
³     Execute MULTIMED model                                                   ³
³     Return  to operating system                                              ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄSTATUSÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
³Editing a new file                                                            ³
³Application type: Subtitle D landfill                                         ³
³Scenario: Unsaturated and Saturated Zone modules                              ³
³                                                                              ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
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³                   Select an option using arrow keys                          ³
³               then confirm selection with the F2 key,  or                    ³
³                  Type the first letter of an option.                         ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
 Help:F1  Accept:F2  Status:F7  Quiet:F8  Xpad:F9  Cmhlp
 Build
```

Figure 3.3. Example of a three-window, one command line screen.

3.1.2 Assistance Window

Several types of user assistance are available within the pre- and postprocessors. A layered approach to assistance is used as follows.

(1) Use of descriptive and unique words or abbreviations for field or menu option names in the data window always provides "first-cut" definitions.

(2) When space allows, additional information in the data window near the data field or menu option clarifies the desired information.

(3) If additional parameter- or screen-specific assistance is available, it is supplied, upon request by the user, in the assistance window. Two types of screen-dependent assistance can be displayed in the assistance window: HELP and LIMITS.

(4) If assistance of a global nature (i.e., independent of individual screens) is available, it, also, is displayed in the assistance window upon request by the user. The three types of global assistance which can be displayed in the assistance window are CMHLP, STATUS and XPAD.

The layered "help" in PREMED and POSTMED is designed so that the user must specifically request the higher levels of assistance; consequently, experienced users are not subjected to unnecessary information.

As specified above, the **assistance window**, which is located directly below the data window (Figure 3.1), is used to display the more detailed levels of assistance (HELP, LIMITS, CMHLP, STATUS and XPAD). All types of detailed assistance are further described later in this section. The user selects one assistance type at a time and the available assistance of that type is displayed in the assistance window. The title of the window (i.e., HELP, LIMITS, CMHLP, STATUS or XPAD) is displayed on the left portion of the upper border for the window and corresponds to the type of assistance which has been re-quested by the user. The types of assistance which are available for a particular screen are indicated by the options listed in the command line (Section 3.1.4). If the amount of available assistance exceeds the window size, scrolling in the window by using cursor keys is allowed.

An example of screen layout for a three-window screen is shown in Figure 3.3. Details on each of the assistance types which may be displayed within the assistance window follow.

HELP

HELP assistance provides further information on model and system parameters and menu options (see Figure 3.4). As noted above, HELP text is specific to a particular screen and can be scrolled in the assistance window.

LIMITS

LIMITS displays the allowable values for a specific field in the data window. LIMITS information may be (1) maximum and minimum acceptable numeric values or (2) a list of acceptable alphanumeric values. LIMITS text is specific to the field currently highlighted in the data window, and it, also, can be scrolled. Figure 3.5 shows the type of information displayed in the assistance window when LIMITS has been selected.

```
ÚÄControl (BEFC)ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿

  3                                                                          3
  3   Modify desired Control Parameters                                      3
  3                                                                          3
  3   NMAT   - number of different porous materials     >       1            3
  3   KPROP  - Van Genuchten or Brooks/Corey parameters > VANGEN             3
  3   NVFLAY - number of physical flow layers           >       1            3
  3                                                                          3
  3                                                                          3
  3                                                                          3
  3                                                                          3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄHELPÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
  3Indicates the type of relationships of relative permeability              3
  3versus saturation, and pressure head versus saturation.                   3
  3 VANGEN - van Genuchten's functional parameters to be used.               3
  3 BROOKS - Brooks/Corey functional parameters to be used.                  3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
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  3                 Page Down or Down Arrow for more text                    3
  3                        F3 to return to Data                              3
  3                                                                          3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ

     Control_BEFC_KPROP
```

Figure 3.4. Example of a HELP assistance window.

```
ÚÄSaturated (BEFMS)ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿

  3                                                                          3
  3                                                                          3
  3   Sat hydraulic conduct (cm/hr)                                          3
  3                                                                          3
  3   What is the new value?        none                                     3
  3                                                                          3
  3                                                                          3
  3                                                                          3
  3                                                                          3
  3                                                                          3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄLIMITSÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
  3                                                                          3
  3 Default: none          Minimum: 0.00000000001   Maximum: 10000.0         3
  3                                                                          3
  3                                                                          3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄINSTRUCTÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
  3                   Enter data in highlighted field(s).                    3
  3   Use carriage return or arrow keys to enter data and move between fields.  3
  3      Use 'Accept' command to go to next screen when done entering data.    3
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
   Accept:F2  Prev:F4  Limits:F5  Status:F7  Quiet:F8  Xpad:F9  Cmhlp  Oops
   Saturated_BEFMS_PRM1
```

Figure 3.5. Example of a LIMITS assistance window.

CMHLP

CMHLP displays the names and definitions of all active commands at the current location. The command definitions never change. It should be noted, however, that the list of available commands varies according to location within the program. For example, the STATUS command is available only at certain program "levels." CMHLP text can be scrolled in the assistance window.

STATUS

STATUS assistance displays system status messages that summarize previous actions and indicate the relative location of the user within the program structure. A maxi-mum of 10 lines of STATUS assistance may be viewed by the user at any point within an application; STATUS assistance cannot be scrolled. Figure 3.6 illustrates the type of infor-mation displayed in the STATUS message. The screen contains the following information.

(1) Whether a file is being created or edited. If editing an existing file, the file name is given.

(2) The type of application (i.e., a generic model application or a Subtitle D application).

(3) The scenario being modeled (i.e., the MULTIMED modules which have been selected by the user).

```
ÚÄGeneral-1 (BEG)ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿
```

```
³Run Title (2 lines)                                                      ³
³DEFAULT                                                                  ³
³CASE                                                                     ³
³                                                                         ³
³  Active Modules         Run Specifications                              ³
³      Surface Water        X Deterministic                               ³
³    X Unsat. Zone            Monte Carlo                                 ³
³    X Saturated Zone                                                     ³
³      Air                    Transient                                   ³
³      Landfill             X Steady State                                ³
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄSTATUSÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
³Editing a new file                                                       ³
³Application type: Subtitle D landfill                                    ³
³Scenario: Unsaturated and Saturated Zone modules                         ³
³                                                                         ³
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄINSTRUCTÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
³                  Enter data in highlighted field(s).                    ³
³ Use carriage return or arrow keys to enter data and move between fields.³
³    Use 'Accept' command to go to next screen when done entering data.   ³
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
Help:F1  Accept:F2  Prev:F4  Limits:F5  Status:F7  Quiet:F8  Xpad:F9  Cmhlp
General-1_BEG_PRM1
```

Figure 3.6. Example of information contained in a STATUS assistance window.

XPAD

Scratch pad (XPAD) assistance allows the user to write notes and reminders during an interactive session. The user may record information in a single XPAD with a maximum width of 78 characters and length of 10 lines. Regardless of where the user is located within the interactive session, a request for XPAD assistance will call up the same XPAD with the same information. XPAD information in the assistance window can be scrolled. New notes can be added to existing notes, and existing notes can be overwritten.

3.1.3 Instruction Window

The **instruction window** is always present on every screen. In the screen layout, it is located below the data and assistance windows and directly above the command line (see Figure 3.1). Two types of information are provided in the window: instructions for the user's next keystroke or error messages reporting incorrect keystrokes with instructions for corrective actions. Depending on which type of information is displayed by the system, the window title on the screen will be either "INSTRUCT" or "ERROR." Figure 3.5 gives an example of the type of information commonly provided in an INSTRUCT-type instruction window, and Figure 3.7 illustrates an ERROR-type instruction window.

```
ÚÄDepth (BEAqDD)ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄPREMED 2.00Ä¿
```

```
³                                                                              ³
³                                                                              ³
³   Aquifer thickness (m)                                                      ³
³                                                                              ³
³   What is the new value?       -920.4                                        ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
³                                                                              ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄSTATUSÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
³Editing a new file                                                            ³
³Application type: Subtitle D landfill                                         ³
³Scenario: Unsaturated and Saturated Zone modules                              ³
³                                                                              ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
ÚÄERRORÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¿
³                  Invalid data input in highlighted field.                    ³
³              Use 'Limits' command to see acceptable range,  or               ³
³                  'Help' command to see field definition.                     ³
ÀÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÙ
 Accept:F2  Prev:F4  Limits:F5  Status:F7  Quiet:F8  Xpad:F9  Cmhlp  Oops
 Depth_BEAqDD_PRM1
```

Figure 3.7. Example of an ERROR message in the instruction window.

3.1.4 Command Line

The final component of the standard pre- and postprocessor screen is the command line (Figure 3.1). The command line is restricted to one line. It contains a menu of abbreviations for the available commands at the user's current location within the program structure. Definitions of the abbreviated commands are available by invoking the CMHLP assistance in the assistance window.

Table 3.1 lists the commands available in PREMED, the function keys used to invoke commands, and command definitions. Inspection of the **command line** in Figure 3.1 shows that some of the commands are associated with the PC function keys and some are not. Instructions on the alternate methods for invoking the various commands are provided in Section 3.3.

TABLE 3-1. COMMANDS FOR APPLICATION OF PREMED

Command Name	Function Key	Command Name
CMHLP		Display definitions of commands in assistance information window
DNPG		Display next page in data window.
HELP	<F1>	Display HELP information in assistance information window
LIMITS	<F5>	Display limits of current field in assistance information window
ACCEPT	<F2>	Go to next screen (sets screen exit status code to 1)
OOPS		Reset data values in data window to values when screen was first displayed
PREV	<F4>	Go to previous screen
QUIET	<F8>	Turn off assistance information window to allow more room for data
STATUS	<F7>	Display system status in assistance information window
XPAD	<F9>	Display users scratch pad, allow changes

A final feature of the command line is mentioned here to avoid confusion. As will be explained in the following section, three interaction modes can be utilized: data mode, command mode, and assist mode. The command line appears on the screen when the user is utilizing either the data mode or the command mode. When the user has invoked the assist mode, the command line is removed from the screen to avoid confusion, and command instructions are displayed in the instruction window. When the user leaves the assist mode to return to either of the other two modes, the command line reappears.

3.2 INTERACTION MODES

User interaction is organized into three "modes," each with a specific function:

(1) Use **data mode** to enter data or select from menu options in data window.

(2) Use **command mode** to invoke commands or functions listed in the command line; commands perform three functions:

- (a) Allow exit from screens (ACCEPT, PREV).
- (b) Manage assistance window (HELP, LIMITS, XPAD, STATUS, CMHLP, QUIET).
- (c) Manipulate data window (OOPS).

(3) Use **assist mode** to provide supplemental information in the scratch pad (XPAD) on which to base subsequent actions or to scroll up or down in the assistance window.

Movement from each of the interaction modes to the other modes can be accomplished as follows.

data mode to **command mode**	-	press <**esc**> key
data mode to **assist mode**	-	press function key associated with appropriate type of assistance **or** enter command mode and select appropriate assistance from options in command line
command mode to **data mode**	-	press <**esc**> key
command mode to **assist mode**	-	select appropriate type of assistance from options in command line
assist mode to **data mode**	-	press <**esc**> key
assist mode to **command mode**	-	press <**esc**> key twice (goes through data mode)

3.3 SCREEN MOVEMENT

Commands may be invoked either by pressing designated function keys or by typing the first letter of a command name. Likewise, menu options may be selected either by moving the cursor to the selection field and confirming, or by typing the first letter (or letters, if needed) of the menu item.

Several general features of user communication should be noted:

(1) There are no restrictions to upper- or lower-case mode.
(2) A key or command is always used to invoke the same function.
(3) Function keys are only used to invoke commands.

3.3.1 Movement Within Screens

Movement within screens may consist of (1) movement between interaction modes, (2) movement between the three windows and the command line, or (3) movement within a window or command line. The first type of movement, between interaction modes, has already been described in Section 3.2 and will not be further considered here. Procedures which cause movement within and between the three windows and the command line of a screen are outlined below. For organization, the procedures which cause movement are categorized in terms of the three interaction modes.

Data Mode--

In data mode, screen movement and operations may be accomplished by pressing either printable character keystrokes, the **<enter>** or **<return>** key, the cursor keys or selected function keys. However, the result of pressing some of these keys depends on the type of screen which is presently displayed.

If one is prompted for decisions by means of a menu (i.e., a **menu screen**), keystrokes cause the following results.

(1) **Type** the first letter (or more, if needed) of any option in the menu in order to select the option.

(2) **Use** cursor keys to move between highlighted menu options.

(3) **Press** function keys designated on the command line to invoke the following commands.

<F1> - HELP **<F2>** - ACCEPT **<F4>** - PREV **<F9>** - XPAD

If one is prompted for data by means of form fill-in (i.e., a **data screen**), keystrokes cause the following results.

(1) **Type** alphanumeric characters needed to correctly fill in the data screen; the

characters will be inserted in the screen at the cursor position.

(2) **Press** **<enter>** or **<return>** to end entry in one data field and move to another.
(3) **Use** cursor keys to move within and among data screen fields as needed.

(4) **Use** function keys to invoke the following command functions.

<F1> - HELP **<F2>** - ACCEPT **<F4>** - PREV **<F5>** - LIMITS
<F9> - XPAD

Command Mode--

In the command mode, three categories of keystrokes cause movement within screens.

(1) All commands, with the exception of NEXT and PREV (see Section 3.3.2), cause movement within screens. **Type** the first character of any of these commands to invoke the command and cause activity in either the data or the assistance window. The activity caused by invoking each command is summarized in Table 3-1. As described in Section 3.1.2, the commands CMHLP, HELP, LIMITS, STATUS, QUIET and XPAD cause activity in the assistance window. The command OOPS, which resets values in data screen to the values present when the screen was first displayed, causes activity exclusively in the data window.

(2) **Press** the **<enter>** or **<return>** key to execute the command currently highlighted in the command line.

(3) **Use** the right or left cursor keys to move the highlighting to another command along the command line.

Assist Mode--

While the user is in the assist mode, keystrokes cause no actions whatsoever unless (1) the scratch pad (XPAD) is active or (2) information which can be scrolled is contained in the assistance window. If the scratch pad is active, typed characters are inserted into the scratch pad at the current location of the cursor. The cursor can move in all directions, and pressing the **<enter>** or **<return>** key causes the start of a new line. Cursor keys can be used to scroll up or down in any assistance window when the available assistance exceeds the window height.

3.3.2 Movement Between Screens

A user can leave one screen and move on to another either by (1) selecting a menu option in the data window or (2) invoking commands displayed on the command line.

Menu Options--

Selection of a menu option always leads to a new screen. From the data mode, menu selections can be made by one of two methods.

(1) **Type** the first letter (or letters, if needed) of the menu item.

(2) **Move** the cursor by use of cursor keys to the selection field and confirm by typing **<esc> N**.

Command Options--

Invoking either the ACCEPT or the PREV command results in movement to another screen. From the command mode, command selections can be made by one of three methods.

(1) **Type** the first letter of the command.

(2) **Move** the cursor by use of cursor keys to the selection field in the command line and confirm by pressing **<enter>**.

(3) For commands which are associated with a function key (as indicated in the command line), **press** the appropriate function key.

3.3.3 Screen Path

During an interactive session, an aid is provided for remembering the sequence of screens which have led up to the screen which is currently being displayed. The **screen path** is connoted along the upper left hand border of the data window following the window title (see Figure 3.7). The screen path is a series of one or two letter codes which identify both (1) the type of operations and (2) the sequence of operations which have occurred from the time the user leaves the opening screen until arriving at the current screen. For example, a screen path "BCS" in the preprocessor signifies that the current screen is a result of (1) selecting the **B**uild option on the opening screen, (2) opting to **C**reate a new input file, and (3) selecting a Subtitle D application.

As the user branches downward, a letter is added to the screen path each time an operation is performed which results in the display of a new screen. The letter corresponds to the first letter of the option selected in the previous screen. In the case of some menus two letters are needed to differentiate between options. In such cases, both letters are added to the screen path. Conversely, upward movement, which is accomplished by using the **Return** option in any menu, results in the elimination of a letter from the screen path.

It should be noted that familiarity with screen sequencing can also speed up the time it takes to perform frequent tasks. After memorizing the screen path needed to perform a sequence of operations and, hence, arrive at a particular location in the program, one may type ahead and pass quickly over intermediate screens.

SECTION 7

EXAMPLE PROBLEMS

Three example problems are presented in this section. These problems are designed to demonstrate the application of MULTIMED to a variety of scenarios which might be encountered while studying Subtitle D facilities. Example 1 is a deterministic, steady-state simulation of transport in the saturated zone. The second example is identical to Example 1, but includes flow and transport in the unsaturated zone. This example is included in the deterministic tutorial for the preprocessor, PREMED, and can be accessed from the opening screen of the preprocessor by typing <@DETER.LOG> (do not type the brackets). Example 3 is similar to Example 2, but it is run in Monte Carlo mode. This example is the same as the input generated by the Monte Carlo tutorial, which is accessed from the preprocessor opening screen by typing <@MONTE.LOG>.

Because new versions of the MULTIMED code may be released after the publication of this document, the results presented in this section may differ from the result obtained from using the input generated by the tutorials. Therefore, these examples should not be viewed as validation data sets. Input and output for model validation are distributed with the code.

Note that the scenarios represented by these simulations are hypothetical, and are not intended to resemble any actual sites. The values used in these example problems are <u>not</u> EPA-recommended values for use in MULTIMED.

7.1 EXAMPLE 1

7.1.1 The Hypothetical Scenario

A well which supplies drinking water to a small community is located 152 meters directly downgradient from a waste disposal facility. The members of the community want to predict the effect of the waste disposal facility on the water quality in the well.
The bottom of the waste disposal facility is located just above the water table. Therefore, simulation of flow and transport in the unsaturated zone is unnecessary, and only saturated transport is simulated.

One contaminant has been selected by the community for simulation, based on its unusual persistence in the subsurface environment. This contaminant is not biodegradable, and has an overall chemical decay coefficient which is so small it can be assumed to be zero (this is a conservative approach). The normalized distribution coefficient for the contaminant is also assumed to be zero, so the chemical will not be removed from the groundwater by the process of adsorption. For convenience in calculating the dilution attenuation factor (DAF), discussed in Section 5.2.4, the concentration of the contaminant at the bottom of the facility is assumed to be 1.00 mg/l. This source concentration is constant in time. The area of the waste disposal site is approximately 400 m^2 and it is square in shape. The infiltration rate into the aquifer beneath the facility is .007 m/yr, and the recharge rate into the aquifer downgradient of the facility is slightly higher at .0076 m/yr. No temporal variability in these rates has been observed.

The aquifer is 78.6 meters thick and the hydraulic gradient within the aquifer is constant at 0.0306. The estimated longitudinal dispersivity in the aquifer is 160 m, the transverse dispersivity is 15.2 m and the vertical dispersivity is 8 m. The fraction of organic carbon in the aquifer is .00315. The pH of the groundwater in the aquifer is typical of many groundwaters in the United States and has been measured to be 6.20. The average annual temperature in the aquifer is 14.4 ^{o}C.

The lack of temporal variability in this system indicates that a steady-state simulation is appropriate. Furthermore, the values of the parameters are known with a high degree of certainty, so a deterministic simulation was selected.

7.1.2 Input

MULTIMED input for Example 1 is shown in Table 7-1. It consists of the title for the Example 1 simulation, followed by several data groups. The values assigned to specific parameters are clearly labeled for all of the data groups except the General data group. The parameters in the General Data Group and the format of the entire input sequence are discussed in Appendix A. Since only the saturated transport module is used in this example, the General Data Group is followed by three data groups: the Chemical, Source and Aquifer Specific Variable Data. In these data groups, the name of the input parameter and the units for the parameter are in the left hand column. The values listed under "Distribution" indicate whether the parameter is to be derived from other parameters (-1 or -2) or read from the input sequence (0). Since this is a deterministic simulation, only the values listed in the "Mean" column will be used by the model (the standard deviation, and the minimum and maximum limits are applicable only in a Monte Carlo simulation).

All of the Chemical Specific Parameters used by MULTIMED are listed in the input file. However, not all of these parameters are used in the Example 1 simulation. A discussion of which parameters are required by the saturated zone transport module can be found in Section 5.3. To avoid obtaining values for unnecessary parameters when developing an input sequence for MULTIMED, refer to Section 5.3, which discusses the parameters required for specific modules, and Section 6, which discusses the estimation and/or derivation of these parameters.

TABLE 7-1. INPUT SEQUENCE FOR EXAMPLE 1

Test input sequence for MULTIMED
Example 1.

GENERAL DATA

```
*** CHEMICAL NAME FORMAT(80A1)
DEFAULT CHEMICAL

***  ISOURC                ROUTE    NT    IYCHK  PALPH    APPTYP  IVTRAN  IINFLVAR
***OPTION  OPTAIR  RUN         MONTE  ISTEAD   IOPEN    IZCHK   LANDF  COMPLETE  IINITCON  IVOLOPT
  1   0   0   DETERMINISTIC   1  1  1  1  0  0  0 90.0  0  2  1  0  0  0  0

***  XST
```

END GENERAL

CHEMICAL SPECIFIC VARIABLE DATA
ARRAY VALUES
*** CHEMICAL SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Solid phase decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
2 Dissolved phase decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
3 Overall chemical decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
4 Acid catalyzed hydrolysis rate (1/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
5 Neutral hydrolysis rate constant (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
6 Base catalyzed hydrolysis rate (1/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
7 Reference temperature (C)		0	25.0	0.000E+00	0.000E+00	100.
8 Normalized distribution coefficient (ml/g)		0	0.000E+00	0.000E+00	0.000E+00	-999.
9 Distribution coefficient		-2	0.219	0.000E+00	0.000E+00	0.100E+11
10 Biodegradation coefficient (sat. zone) (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
11 Air diffusion coefficient (cm2/s)		0	0.000E+00	0.645E-02	0.000E+00	10.0
12 Reference temperature for air diffusion (C)		0	0.000E+00	0.000E+00	0.000E+00	100.
13 Molecular weight (g/M)		0	-999.	0.000E+00	0.000E+00	-999.
14 Mole fraction of solute		0	-999.	0.100E-01	0.100E-08	1.00
15 Solute vapor pressure (mm Hg)		0	-999.	0.230E-01	0.000E+00	100.
16 Henry`s law constant (atm-m^3/M)		0	-999.	0.000E+00	0.100E-09	1.00
17 Not in use		0	1.00	0.000E+00	0.000E+00	1.00
18 Not in use		0	1.00	0.000E+00	0.000E+00	1.00
19 Not in use		0	1.00	0.000E+00	0.000E+00	1.00

END ARRAY

END CHEMICAL SPECIFIC VARIABLE DATA

(Continued)

TABLE 7-1. (Concluded)

SOURCE SPECIFIC VARIABLE DATA
ARRAY VALUES
*** SOURCE SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Infiltration rate (m/yr)		0	0.700E-02	-999.	0.100E-09	0.100E+11
2 Area of waste disp unit (m^2)		0	400.	-999.	0.100E-01	-999.
3 Duration of pulse (yr)		0	-999.	-999.	0.100E-08	-999.
4 Spread of contaminant srce (m)		-1	-999.	-999.	0.100E-08	0.100E+11
5 Recharge rate (m/yr)		0	0.760E-02	-999.	0.100E-09	0.100E+11
6 Source decay constant (1/yr)		0	0.000E+00	-999.	0.000E+00	-999.
7 Init conc at landfill (mg/l)		0	1.00	-999.	0.000E+00	-999.
8 Length scale of facility (m)		-1	-999.	-999.	0.100E-08	0.100E+11
9 Width scale of facility (m)		-1	-999.	-999.	0.100E-08	0.100E+11

END ARRAY

END SOURCE SPECIFIC VARIABLE DATA

AQUIFER SPECIFIC VARIABLE DATA
ARRAY VALUES
*** AQUIFER SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Particle diameter (cm)		0	0.630E-03	-999.	0.100E-08	100.
2 Aquifer porosity		-2	-999.	-999.	0.100E-08	0.990
3 Bulk density (g/cc)		-2	-999.	-999.	0.100E-01	5.00
4 Aquifer thickness (m)		0	78.6	-999.	0.100E-08	0.100E+06
5 Mixing zone depth (m)		-1	-999.	-999.	0.100E-08	0.100E+06
6 Hydraulic conductivity (m/yr)		-2	-999.	-999.	0.100E-06	0.100E+09
7 Hydraulic Gradient		0	0.306E-01	-999.	0.100E-07	-999.
8 Grndwater seep velocity (m/yr)		-2	-999.	-999.	0.100E-09	0.100E+09
9 Retardation coefficient		-1	-999.	-999.	1.00	0.100E+09
10 Longitudinal dispersivity (m)		0	160.	-999.	0.100E-02	0.100E+05
11 Transverse dispersivity (m)		0	15.2	-999.	0.100E-02	0.100E+05
12 Vertical dispersivity (m)		0	8.00	-999.	0.100E-02	0.100E+05
13 Temperature of aquifer (C)		0	14.4	-999.	0.000E+02	100.
14 pH		0	6.20	-999.	0.300	14.0
15 Organic carbon content (fract)		0	0.315E-02	-999.	0.100E-05	1.00
16 Receptor distance from site (m)		0	152.	-999.	1.00	-999.
17 Angle off center (degree)		0	0.000E+00	-999.	0.000E+00	360.
18 Well vert dist from water table		0	0.000E+00	-999.	0.000E+00	1.00

END ARRAY

END AQUIFER SPECIFIC VARIABLE DATA
END ALL DATA

Values for some parameters may be listed as -999. These parameters are undefined. Files generated by the preprocessor list some of the parameters which are not used by the code as -999. PREMED will check that all of the necessary values for a particular simulation have been defined before saving an input file. If a value of -999 appears in the input sequence for a parameter which is required by the code, this parameter will be listed as "Undefined", and must be specified to complete the input sequence for use in MULTIMED. The specification of "Undefined" parameters is clearly demonstrated in the PREMED tutorials.

7.1.3 Output

The output for example 1 consists of the main output file, the SAT.OUT file, and files with a *.VAR extension, which are not shown. For deterministic simulations, the *.VAR files echo the values of the constant parameters and list the values calculated by the code for the derived parameters. Table 7-2 presents the main output file, which consists of an echo of the input and the predicted contaminant concentration at the well. The SAT.OUT file, shown in Table 7-3, lists the predicted contaminant concentration at the well.

7.2 EXAMPLE 2

7.2.1 The Hypothetical Scenario

The second example is identical to the first with one exception: the water table is located at a depth of 6.1 meters below the bottom of the waste disposal facility. Therefore, unsaturated flow and transport must also be simulated.

In this example, the unsaturated zone consists of one homogeneous layer with the following known values for material and transport properties. The saturated hydraulic conductivity is .017 cm/hr, the porosity is 0.43 and the bulk density is 1.67 g/cm^3. The percent organic matter is 0.026 and the Brooks and Corey exponent is 0.5. The van Genuchten parameters, α and β, which describe the relationship between the pressure head and water saturation, are .009 and 1.23, respectively. The residual water content is .088 and the longitudinal dispersivity is .4 m.

7.2.2 Input

The chemical, source, and aquifer specific parameters are the same as those described in Example 1. However, simulation of the unsaturated zone requires additional data groups in the input file including soil moisture parameters and unsaturated zone transport parameters. The input for Example 2 is shown in Table 7-4.

7.2.3 Output

The output for Example 2 is similar to that described for Example 1. In addition to the main output file, shown in Table 7-5, the SAT.OUT file, presented in Table 7-6, and the *.VAR files, two

TABLE 7-2. OUTPUT FILE FOR EXAMPLE 1

U.S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

VERSION 3.3, DECEMBER 1988

Developed by Phillip Mineart and Atul Salhotra of
Woodward-Clyde Consultants, Oakland, California
In cooperation with:
Hydrogeologic, Inc., Herndon, Virginia,

Geotrans, Inc., Herndon, Virginia,
and
Aqua Terra Consultants, Mountain View, California

1
Run options
--- -------

Subtitle D landfill application.
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated zone model
Run was	DETERMIN

Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1

(continued)

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX	
Solid phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11	
Dissolved phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11	
Overall chemical decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11	
Acid catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.	
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.	
Base catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.	
Reference temperature	C	CONSTANT	25.0	0.000E+00	0.000E+00	100.	
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.	
Distribution coefficient	--	DERIVED	0.219	0.000E+00	0.000E+00	0.100E+11	Biodegradation
coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.	
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	0.645E-02	0.000E+00	10.0	
Reference temperature for air diffusion	C	CONSTANT	0.000E+00	0.000E+00	0.000E+00	100.	
Molecular weight	g/M	CONSTANT	-999.	0.000E+00	0.000E+00	-999.	
Mole fraction of solute	--	CONSTANT	-999.	0.100E-01	0.100E-08	1.00	
Vapor pressure of solute	mm Hg	CONSTANT	-999.	0.230E-01	0.000E+00	100.	
Henry's law constant	atm-m^3/M	CONSTANT	-999.	0.000E+00	0.100E-09	1.00	
RFD value for drinking water	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00	
ADIF value for fish consumption	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00	
CCC for aquatic organisms	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00	

1

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Infiltration rate	m/yr	CONSTANT	0.700E-02	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	400.	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	-999.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.760E-02	-999.	0.100E-09	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		CONSTANT	0.000E+00	0.000E+00	0.000E+00	0.000E+00

1

TABLE 7-2. (Continued)

(continued)

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.630E-03	-999.	0.100E-08	100.
Aquifer porosity	--	DERIVED	-999.	-999.	0.100E-08	0.990
Bulk density	g/cc	DERIVED	-999.	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	78.6	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	DERIVED	-999.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.306E-0	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	-999.	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	160.	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	15.2	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	8.00	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	14.4	-999.	0.000E+00	100.
pH	--	CONSTANT	6.20	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.315E-02	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	152.	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.5736E-03

TABLE 7-2. (Concluded)

TABLE 7-3. SAT.OUT FILE FOR EXAMPLE 1

1

STEADY STATE SATURATED ZONE TRANSPORT RESULTS
AT 0.1000E+04 YEARS, CONCENTRATION IS 0.5736E-03

126

TABLE 7-4. INPUT SEQUENCE FOR EXAMPLE 2.

Test input sequence for MULTIMED.
Example 2.

GENERAL DATA

*** CHEMICAL NAME FORMAT(80A1)
DEFAULT CHEMICAL

```
***  ISOURCE                              ROUTE     NT      IYCHK   PALPH    APPTYP    IVTRAN      IINFLVAR
***OPTION     OPTAIR    RUN               MONTE   INSTEAD   IOPEN   IZCHK     LANDF    COMPLETE    IINITCON    IVOLOPT
   2     0      0     DETERMINISTIC     1   1   1   1   0   0   0  90.0   0    2     1    0    0   0     0
```

*** XST

END GENERAL

CHEMICAL SPECIFIC VARIABLE DATA
ARRAY VALUES
*** CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Solid phase decay coefficient (1/yr)	-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11	
2 Dissolved phase decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
3 Overall chemical decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
4 Acid catalyzed hydrolysis rate (1/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
5 Neutral hydrolysis rate constant (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
6 Base catalyzed hydrolysis rate (1/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
7 Reference temperature (C)		0	25.0	0.000E+00	0.000E+00	100.
8 Normalized distribution coefficient (ml/g)	0	0.000E+00	0.000E+00	0.000E+00	-999.	
9 Distribution coefficient		-2	0.219	0.000E+00	0.000E+00	0.100E+11
10 Biodegradation coefficient (sat. zone) (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
11 Air diffusion coefficient (cm2/s)		0	0.000E+00	0.645E-02	0.000E+00	10.0
12 Reference temperature for air diffusion (C)		0	0.000E+00	0.000E+00	0.000E+00	100.
13 Molecular weight (g/M)		0	-999.	0.000E+00	0.000E+00	-999.
14 Mole fraction of solute		0	-999.	0.100E-01	0.100E-08	1.00
15 Solute vapor pressure (mm Hg)		0	-999.	0.230E-01	0.000E+00	100.
16 Henry's law constant (atm-m^3/M)		0	-999.	0.000E+00	0.100E-09	1.00
17 Not in use		0	1.00	0.000E+00	0.000E+00	1.00
18 Not in use		0	1.00	0.000E+00	0.000E+00	1.00
19 Not in use		0	1.00	0.000E+00	0.000E+00	1.00

END ARRAY

END CHEMICAL SPECIFIC VARIABLE DATA

(continued)

TABLE 7-4. (Continued)

SOURCE SPECIFIC VARIABLE DATA
ARRAY VALUES
*** SOURCE SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
1 Infiltration rate	(m/yr)	0	0.700E-02	-999.	0.100E-09	0.100E+11
2 Area of waste disp unit	(m^2)	0	400.	-999.	0.100E-01	-999.
3 Duration of pulse	(yr)	0	-999.	-999.	0.100E-08	-999.
4 Spread of contaminant srce	(m)	-1	-999.	-999.	0.100E-08	0.100E+11
5 Recharge rate	(m/yr)	0	0.760E-02	-999.	0.100E-09	0.100E+11
6 Source decay constant	(1/yr)	0	0.000E+00	-999.	0.000E+00	-999.
7 Init conc at landfill	(mg/l)	0	1.00	-999.	0.000E+00	-999.
8 Length scale of facility	(m)	-1	-999.	-999.	0.100E-08	0.100E+11
9 Width scale of facility	(m)	-1	-999.	-999.	0.100E-08	0.100E+11

END ARRAY

END SOURCE SPECIFIC VARIABLE DATA

VFL UNSATURATED FLOW MODEL PARAMETERS

CONTROL PARAMETERS

*** DUMMY	NMAT	KPROP	DUMMY	NVFLAY
7	1	2	1	1

END CONTROL PARAMETERS
MATERIAL NUMBER FOR EACH LAYER
6.10 1
END MATERIAL PARAMETERS
SATURATED MATERIAL PROPERTY PARAMETERS
ARRAY VALUES
*** SATURATED MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
1 Sat hydraulic conduct	(cm/hr)	0 0.170E-01	-999.	0.100E-10	0.100E+05	
2 Unsaturated zone porosity		0	0.430	-999.	0.100E-08	0.990
3 Air entry pressure head	(m)	0	0.000E+00	-999.	0.000E+00	-999.
4 Depth of the unsat zone	(m)	0	6.10	-999.	0.100E-08	-999.

END ARRAY

END MATERIAL 1
END

(Continued)

TABLE 7-4. (Continued)

```
SOIL MOISTURE PARAMETERS
***     FUNCTIONAL COEFFICIENTS
ARRAY VALUES
***     FUNCTIONAL COEFFICIE VARIABLES

***         VARIABLE NAME                  UNITS              DISTRIBUTION          PARAMETERS              LIMITS
***                                                                            MEAN          STD DEV     MIN           MAX
**************************************************************************************************************************
 1 Residual water content                                    0               0.880E-01      -999.      0.100E-08      1.00
 2 Brooks and Corey exponent, EN                                 0              0.500         -999.      0.000E+00     10.0
 3 ALFA van Genuchten coefficient                                0              0.900E-02     -999.      0.000E+00     1.00
 4 BETA Van Genuchten coefficient                                0              1.23          -999.      1.00          5.00
END ARRAY

END MATERIAL  1
END
END UNSATURATED FLOW


VTP   UNSATURATED TRANSPORT MODEL
CONTROL PARAMETERS
*** NLAY   DUMMY   IADU   ISOL    N   NTEL  NGPTS   NIT  DUMMY  DUMMY
     1      20       1      1    18    3    104     2     1      1
*** WTFUN
   1.200

END CONTROL PARAMETERS
TRANSPORT PARAMETER
ARRAY VALUES
***     UNSATURATED TRANSPOR VARIABLES

***         VARIABLE NAME                  UNITS              DISTRIBUTION          PARAMETERS              LIMITS
***                                                                            MEAN          STD DEV     MIN           MAX
**************************************************************************************************************************
 1 Thickness of layer (m)                                    0               6.10           -999.      0.100E-08     -999.
 2 Longit disper of layer  (m)                                   0              0.400         -999.      0.100E+00     0.100+05
 3 Percent organic matter  (m)                                   0              0.260E-01     -999.      0.000E+00     100.
 4 Bulk dens of soil layer  (g/cc)                           0               1.67           -999.      0.100E-01     5.00
 5 Biological decay coeff  (1/yr)                            0               0.000E+00      -999.      0.000E+00     -999.
END ARRAY

END LAYER  1
END UNSATURATED TRANSPORT PARAMETERS
END TRANSPORT MODEL
```

(continued)

128

TABLE 7-4. (Concluded)

AQUIFER SPECIFIC VARIABLE DATA
ARRAY VALUES
*** AQUIFER SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
1 Particle diameter (cm)		0	0.630E-03	-999.	0.100E-08	100.
2 Aquifer porosity		-2	-999.	-999.	0.100E-08	0.990
3 Bulk density (g/cc)		-2	-999.	-999.	0.100E-01	5.00
4 Aquifer thickness (m)		0	78.6	-999.	0.100E-08	0.100E+06
5 Source thickness (mixing zone depth) (m)		-1	-999.	-999.	0.100E-08	0.100E+06
6 Conductivity (hydraulic) m/yr		-2	-999.	-999.	0.100E-06	0.100E+09
7 Gradient (hydraulic)		0	0.306E-01	-999.	0.100E-07	-999.
8 Groundwater seepage velocity (m/yr)		-2	-999.	-999.	0.100E-09	0.100E+09
9 Retardation coefficient		-1	-999.	-999.	1.00	0.100E+09
10 Longitudinal dispersivity (m)		0	160.	-999.	0.100E-02	0.100E+05
11 Transverse dispersivity (m)		0	15.2	-999.	0.100E-02	0.100E+05
12 Vertical dispersivity (m)		0	8.00	-999.	0.100E-02	0.100E+05
13 Temperature of aquifer (C)		0	14.4	-999.	0.000E+00	100.
14 pH		0	6.20	-999.	0.300	14.0
15 Organic carbon content (fraction)		0	0.315E-02	-999.	0.100E-05	1.00
16 Receptor distance from site (m)		0	152.	-999.	1.00	-999.
17 Angle off center (degree)		0	0.000E+00	-999.	0.000E+00	360.
18 Well vertical distance from water (m)		0	0.000E+00	-999.	0.000E+00	1.00

END ARRAY

END AQUIFER SPECIFIC VARIABLE DATA

END ALL DATA

TABLE 7-5. MAIN OUTPUT FILE FOR EXAMPLE 2.

U.S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

VERSION 3.3, DECEMBER 1988

Developed by Phillip Mineart and Atul Salhotra of
Woodward-Clyde Consultants, Oakland, California
In cooperation with:
Hydrogeologic, Inc., Herndon, Virginia,
Geotrans, Inc., Herndon, Virginia,
and
Aqua Terra Consultants, Mountain View, California

1
Run options
----- ---------

Subtitle D landfill application.
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated and unsaturated zone models
Run was	DETERMIN

Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1
UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	-	Total number of nodal points	240
NMAT	-	Number of different porous materials	1
KPROP	-	Van Genuchten or Brooks and Corey	2
IMSHGN	-	Spatial discretization option	1

1

OPTIONS CHOSEN
------- -------

Brooks and Corey functional coefficients
User defined coordinate system
1

(continued)

TABLE 7-5. (Continued)

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	6.10	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Saturated hydraulic conductivity	cm/hr	CONSTANT	0.170E-01	-999.	0.100E-10	0.100E+05
Unsaturated zone porosity	--	CONSTANT	0.430	-999.	0.100E-08	0.990
Air entry pressure head	m	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Depth of the unsaturated zone	m	CONSTANT	6.10	-999.	0.100E-08	-999.

1

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

NLAY -	Number of different layers used	1
NTSTPS -	Number of time values concentration calc	20
DUMMY	- Not presently used	1
ISOL -	Type of scheme used in unsaturated zone	1
N -	Stehfest terms or number of increments	18
NTEL -	Points in Lagrangian interpolation	3
NGPTS -	Number of Gauss points	104
NIT -	Convolution integral segments	2
IBOUND -	Type of boundary condition	1
ITSGEN -	Time values generated or input	1
TMAX -	Max simulation time --	0.0
WTFUN -	Weighting factor --	1.2

OPTIONS CHOSEN

Stehfest numerical inversion algorithm
Nondecaying continuous source
Computer generated times for computing concentrations

(continued)

TABLE 7-5. (Continued)

DATA FOR LAYER 1

VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Thickness of layer	m	CONSTANT	6.10	-999.	0.100E-08	-999.
Longitudinal dispersivity of layer	m	CONSTANT	0.400	-999.	0.000E+00	0.100E+05
Percent organic matter	--	CONSTANT	0.260E-01	-999.	0.000E+00	100.
Bulk density of soil for layer	g/cc	CONSTANT	1.67	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.

1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Base catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Reference temperature	C	CONSTANT	25.0	0.000E+00	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Distribution coefficient	--	DERIVED	0.219	0.000E+00	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	0.645E-02	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	0.000E+00	0.000E+00	0.000E+00	100.
Molecular weight	g/M	CONSTANT	-999.	0.000E+00	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	-999.	0.100E-01	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	-999.	0.230E-01	0.000E+00	100.
Henry's law constant	atm-m^3/M	CONSTANT	-999.	0.000E+00	0.100E-09	1.00
RFD value for drinking water	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00
ADIF value for fish consumption	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00
CCC for aquatic organisms	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00

1

(continued)

TABLE 7-5. (Concluded)

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Infiltration rate	m/yr	CONSTANT	0.700E-02	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	400.	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	-999.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.760E-02	-999.	0.100E-09	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		CONSTANT	0.000E+00	0.000E+00	0.000E+00	0.000E+00

1

AQUIFER SPECIFIC VARIABLES

13
3

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Particle diameter	cm	CONSTANT	0.630E-03	-999.	0.100E-08	100.
Aquifer porosity	--	DERIVED	-999.	-999.	0.100E-08	0.990
Bulk density	g/cc	DERIVED	-999.	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	78.6	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	DERIVED	-999.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.306E-01	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	-999.	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	CONSTANT	160.	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	CONSTANT	15.2	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	8.00	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	14.4	-999.	0.000E+00	100.
pH	--	CONSTANT	6.20	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.315E-02	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	152.	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.5736E-03

TABLE 7-6. SAT.OUT FILE FOR EXAMPLE 2.

```
1
                    STEADY STATE SATURATED ZONE TRANSPORT RESULTS
  AT 0.1000E+04 YEARS, CONCENTRATION IS 0.5736E-03
  ------------------------------------------------
```

additional files, VFLOW.OUT and VTRNSPT.OUT, are created. VFLOW.OUT contains output for the Unsaturated Zone Flow Module, including the depth of each node and the Darcy velocity, water saturation, and head at each node. (Note that the number and location of nodes is determined by the MULTIMED code.) VTRNSPT.OUT lists the steady-state concentration at the water table.

7.3 EXAMPLE 3

7.3.1 The Hypothetical Scenario

The third example is similar to Example 2. The difference is that Example 3 is run in Monte-Carlo mode instead of in a deterministic framework. In this example, spatial variability is observed in the measured values for two parameters, which introduces uncertainty into the model. Therefore, it is necessary to utilize the Monte Carlo option in MULTIMED.

In Example 3, all but three of the parameter values are constant or derived and are identical to those in Example 2. The three parameters have some uncertainty associated with their values. Thus, they are described in terms of probability density functions which represent the uncertainty in the parameter value. The theory behind the Monte Carlo analysis technique, and the probability density distributions included in MULTIMED, are discussed in Section 9 of Salhotra et al. (1995).

The three uncertain parameters in Example 3 are the unsaturated zone hydraulic conductivity (cm/hr), the unsaturated zone porosity, and the aquifer pH. In this example, the probability density distribution is lognormal for the hydraulic conductivity, normal for the unsaturated zone porosity, and uniform for the aquifer pH. The normal and lognormal distributions both require specification of a mean, standard deviation, and minimum and maximum limits. The uniform distribution requires only the minimum and maximum limits of values. Values for these parameters are shown in Table 7-7.

7.3.2 Input

The input sequence for Example 3 is shown in Table 7-8. It is identical to the input file for Example 2 except for changes in the General Data Group related to running the model in a Monte Carlo framework, and differences in the input for the three parameters which have been assigned Monte Carlo distributions.

The type of distribution associated with each parameter is indicated in the "Distribution" column. The number assigned to each of the distribution types is shown in Table A-4. A value of 0 in the "Distribution" column indicates a constant value for the parameter. A value of -1 or -2 indicates that the parameter is derived from other parameters in the code. As Table A-4 indicates, other values are used for Monte Carlo distributions. For example, the saturated hydraulic conductivity for Material 1 in the unsaturated zone has a

TABLE 7-7. MONTE CARLO DISTRIBUTION VALUES IN EXAMPLE 3

Parameter	Distribution	Mean	Standard Deviation	Limits Min.	Max.
Saturated hydraulic conductivity (cm/hr) for the unsaturated zone	Lognormal	.017	.020	.001	.250
Unsaturated zone porosity	Normal	.330	.100	.200	.450
Aquifer pH	Uniform	NA	NA	5.80	6.90

TABLE 7-8. INPUT SEQUENCE FOR EXAMPLE 3.

```
Example 3 input
Subtitle D application

GENERAL DATA

*** CHEMICAL NAME FORMAT(80A1)
DEFAULT CHEMICAL

***     ISOURC                        ROUTE     NT       IYCHK     PALPH     APPTYP   IVTRAN   IINFLVAR
***OPTION  OPTAIR        RUN        MONTE   ISTEAD   IOPEN     IZCHK               LANDF       COMPLETE         IINITCON         IVOLOPT
    2     0         0     MONTE       500   1    1    1    1   0    0   90.0       0     2         1       0       0       0      0

*** XST

END GENERAL

CHEMICAL SPECIFIC VARIABLE DATA
ARRAY VALUES
***     CHEMICAL SPECIFIC VARIABLES
```

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Solid phase decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
2 Dissolved phase decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
3 Overall chemical decay coefficient (1/yr)		-1	0.000E+00	0.000E+00	0.000E+00	0.100E+11
4 Acid catalyzed hydrolysis rate (l/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
5 Neutral hydrolysis rate constant (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
6 Base catalyzed hydrolysis rate (l/M-yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
7 Reference temperature (C)		0	25.0	0.000E+00	0.000E+00	100.
8 Normalized distribution coefficient (ml/g)		-2	140	0.000E+00	0.000E+00	-999.
9 Distribution coefficient		0	0.219	0.000E+00	0.000E+00	0.100E+11
10 Biodegradation coefficient (sat. zone) (1/yr)		0	0.000E+00	0.000E+00	0.000E+00	-999.
11 Air diffusion coefficient (cm2/s)		0	0.000E+00	0.645E-02	0.000E+00	10.0
12 Reference temperature for air diffusion (C)		0	0.000E+00	0.000E+00	0.000E+00	100.
13 Molecular weight (g/M)		0	-999.	0.000E+00	0.000E+00	-999.
14 Mole fraction of solute		0	-999.	0.100E-01	0.100E-08	1.00
15 Vapor pressure of solute (mm Hg)		0	-999.	0.230E-01	0.000E+00	100.
16 Henry's law constant (atm-m^3/M)		0	-999.	0.000E+00	0.100E-09	1.00
17 RFD value for drinking water (mg-kg/day)		0	1.00	0.000E+00	0.000E+00	1.00
18 ADIF value for fish consumption (mg-kg/day)		0	1.00	0.000E+00	0.000E+00	1.00
19 CCC for aquatic organisms (mg-kg/day)		0	1.00	0.000E+00	0.000E+00	1.00

```
END ARRAY

END CHEMICAL SPECIFIC VARIABLE DATA
```

(continued)

TABLE 7-8. (Continued)

SOURCE SPECIFIC VARIABLE DATA
ARRAY VALUES
*** SOURCE SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Infiltration rate (m/yr)		0	0.700E-02	-999.	0.100E-09	0.100E+11
2 Area of waste disposal unit (m^2)		0	400.	-999.	0.100E-01	-999.
3 Duration of pulse (yr)		0	-999.	-999.	0.100E-08	-999.
4 Spread of contaminant source (m)		-1	-999.	-999.	0.100E-08	0.100E+11
5 Recharge rate (m/yr)		0	0.760E-02	-999.	0.100E-09	0.100E+11
6 Source decay constant (1/yr)		0	0.000E+00	-999.	0.000E+00	-999.
7 Initial concentration at landfill (mg/l)		0	1.00	-999.	0.000E+00	-999.
8 Length scale of facility (m)		-1	-999.	-999.	0.100E-08	0.100E+11
9 Width scale of facility (m)		-1	-999.	-999.	0.100E-08	0.100E+11

END ARRAY

END SOURCE SPECIFIC VARIABLE DATA

VFL UNSATURATED FLOW MODEL PARAMETERS

CONTROL PARAMETERS

*** DUMMY	NMAT	KPROP	DUMMY	NVFLAY
7	1	1	1	1

END CONTROL PARAMETERS
SATURATED MATERIAL PROPERTY PARAMETERS
ARRAY VALUES
*** SATURATED MATERIAL VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Saturated hydraulic conductivity	cm/hr	2	0.170E-01	.020	0.100E-03	0.250
Unsaturated zone porosity	--	1	0.330	.108	0.200	0.450
Air entry pressure head	m	0	0.000E+00	-999.	0.000E+00	-999.
Depth of the unsaturated zone	m	0	6.10	-999.	0.100E-08	-999.

END ARRAY

END MATERIAL 1
END

(continued)

TABLE 7-8. (Continued)

```
SOIL MOISTURE PARAMETERS
***    FUNCTIONAL COEFFICIENTS
ARRAY VALUES
***    FUNCTIONAL COEFFICIE VARIABLES

***        VARIABLE NAME                UNITS        DISTRIBUTION          PARAMETERS              LIMITS
***                                                                   MEAN       STD DEV      MIN          MAX
**********************************************************************************************************************
1 Residual water content                              0             0.880E-01    -999.     0.100E-08    1.00
2 Brooks and Corey exponent, EN                          0            0.500        -999.      0.000E+00    10.0
3 ALFA van Genuchten coefficient                         0            0.900E-02    -999.      0.000E+00    1.00
4 BETA Van Genuchten coefficient                         0            1.23         -999.      1.00         5.00
END ARRAY

END MATERIAL 1
END
END UNSATURATED FLOW


VTP   UNSATURATED TRANSPORT MODEL
CONTROL PARAMETERS
*** NLAY   DUMMY   IADU   ISOL   N   NTEL   NGPTS   NIT   DUMMY   DUMMY
     1      20      1      1     18   3      104     2      1       1
*** WTFUN
   1.200


END CONTROL PARAMETERS
TRANSPORT PARAMETER
ARRAY VALUES
***    UNSATURATED TRANSPOR VARIABLES

***        VARIABLE NAME                UNITS        DISTRIBUTION          PARAMETERS              LIMITS
***                                                                   MEAN       STD DEV      MIN          MAX
**********************************************************************************************************************
1 Thickness of layer  (m)                             0             6.10         -999.     0.100E-08    -999.
2 Longit disper of layer (m)                             0            0.400        -999.      0.100E+00    0.100+05
3 Percent organic matter (m)                             0            0.260E-01    -999.   0.000E+00    100.
4 Bulk dens of soil layer  (g/cc)                     0             1.67         -999.     0.100E-01    5.00
5 Biological decay coeff  (1/yr)                      0             0.000E+00    -999.     0.000E+00    -999.
END ARRAY

END LAYER 1
END UNSATURATED TRANSPORT PARAMETERS
END TRANSPORT MODEL
```

(continued)

TABLE 7-8. (Concluded)

AQUIFER SPECIFIC VARIABLE DATA
ARRAY VALUES
*** AQUIFER SPECIFIC VARIABLES

*** VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
1 Particle diameter (cm)		0	0.630E-03	-999.	0.100E-08	100.
2 Aquifer porosity		-2	-999.	-999.	0.100E-08	0.990
3 Bulk density (g/cc)		-2	-999.	-999.	0.100E-01	5.00
4 Aquifer thickness (m)		0	78.6	-999.	0.100E-08	0.100E+06
6 Conductivity (hydraulic) (m/yr)		-2	-999.	-999.	0.100E-06	0.100E+09
7 Gradient (hydraulic)		0	0.306E-01	-999.	0.100E-07	-999.
8 Groundwater seepage velocity (m/yr)		-2	-999.	-999.	0.100E-09	0.100E+09
9 Retardation coefficient		-1	-999.	-999.	1.00	0.100E+09
10 Longitudinal dispersivity (m)		1	160.	-999.	50.0	200
11 Transverse dispersivity (m)		0	15.2	-999.	0.100E-02	0.100E+05
12 Vertical dispersivity (m)		0	8.00	-999.	0.100E-02	0.100E+05
13 Temperature of aquifer (C)		0	14.4	-999.	0.000E+00	100.
14 pH		4	-999.	-999.	5.80	6.90
15 Organic carbon content (fraction)	0	0.315E-02	-999.	0.100E-05	1.00	
16 Receptor distance from site (m)		0	152.	-999.	1.00	-999.
17 Angle off center (degree)		0	0.000E+00	-999.	0.000E+00	360.
18 Well vert dist from water table (m)		0	0.000E+00	-999.	0.000E+00	1.00

END ARRAY

END AQUIFER SPECIFIC VARIABLE DATA

END ALL DATA

value of 2 in the "Distribution" column, which indicates that a lognormal probability density distribution has been assigned to the parameter.

7.3.3 Output

The output from MULTIMED is presented in Tables 7-9 through 7-11. Because the General Data Group flag for the level of output from Monte Carlo runs was set to SOME for this example problem (see Section 5.3.2.2), the output consists of the main output file, the STATS.OUT file, and the SAT1.OUT file. The main output file consists of an echo of the input parameters, selected statistical results, and printer plots of frequency and cumulative frequency. The STATS.OUT file contains a summary of the statistical analyses resulting from the Monte Carlo simulations. The cumulative distribution function of well concentrations (i.e., well concentrations in ascending order) is listed in the SAT1.OUT file. This file can be used by the postprocessor, POSTMED, to produce frequency and cumulative frequency plots of higher quality than those found in the main output file. Examples of these plots are shown in Section 4.2.

TABLE 7-9. MAIN OUTPUT FILE FOR EXAMPLE 3.

U.S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

VERSION 3.3, DECEMBER 1988

Developed by Phillip Mineart and Atul Salhotra of
Woodward-Clyde Consultants, Oakland, California
In cooperation with:
Hydrogeologic, Inc., Herndon, Virginia,
Geotrans, Inc., Herndon, Virginia,
and

Run options
----- -------------

Example 3 input

Subtitle D application
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated and unsaturated zone models
Run was	MONTE
Infiltration input by user	
Number of monte carlo simulations	500
Run was steady-state	
Reject runs if Y coordinate outside plume	
Reject runs if Z coordinate outside plume	
Gaussian source used in saturated zone model	

1
1

UNSATURATED ZONE FLOW MODEL PARAMETERS
(input parameter description and value)

NP	-	Total number of nodal points	240
NMAT	-	Number of different porous materials	1
KPROP	-	Van Genuchten or Brooks and Corey	1
IMSHGN	-	Spatial discretization option	1

1

(continued)

TABLE 7-9. (Continued)

OPTIONS CHOSEN

Van Genuchten functional coefficients
User defined coordinate system
1

Layer information

LAYER NO.	LAYER THICKNESS	MATERIAL PROPERTY
1	0.00	1

DATA FOR MATERIAL 1

VADOSE ZONE MATERIAL VARIABLES

NAME	UNITS		DISTRIBUTION		PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Saturated hydraulic conductivity cm/hr		LOG NORMAL	0.170E-01	0.200E-01	0.100E-03	0.250		
Unsaturated zone porosity	--		NORMAL		0.330	0.100	0.200	0.450
Air entry pressure head	m		CONSTANT	0.000E+00	-999.	0.000E+00	-999.	
Depth of the unsaturated zone	m		CONSTANT	6.10	-999.	0.100E-08	-999.	

DATA FOR MATERIAL 1

VADOSE ZONE FUNCTION VARIABLES

NAME	UNITS		DISTRIBUTION		PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Residual water content	--	CONSTANT	0.880E-01	-999.	0.100E-08	1.00		
Brook and Corey exponent,EN	--		CONSTANT	0.500	-999.	0.000E+00	10.0	
ALFA coefficient	1/cm		CONSTANT	0.900E-02	-999.	0.000E+00	1.00	
Van Genuchten exponent, ENN	--		CONSTANT	1.23	-999.	1.00	5.00	

(continued)

TABLE 7-9. (Continued)

UNSATURATED ZONE TRANSPORT MODEL PARAMETERS

NLAY	-	Number of different layers used	1
NTSTPS	-	Number of time values concentration calc	20
DUMMY	-	Not presently used	1
ISOL	-	Type of scheme used in unsaturated zone	1
N	-	Stehfest terms or number of increments	18
NTEL	-	Points in Lagrangian interpolation	3
NGPTS	-	Number of Gauss points	104
NIT	-	Convolution integral segments	2
IBOUND	-	Type of boundary condition	1
ITSGEN	-	Time values generated or input	1
TMAX	-	Max simulation time --	0.0
WTFUN	-	Weighting factor --	1.2

OPTIONS CHOSEN

Stehfest numerical inversion algorithm
Nondecaying continuous source
Computer generated times for computing concentrations

DATA FOR LAYER 1

VADOSE TRANSPORT VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	STD DEV	LIMITS MIN	MAX
Thickness of layer	m	CONSTANT	6.10	-999.	0.100E-08	-999.
Longitudinal dispersivity of layer	m	CONSTANT	0.400	-999.	0.000E+00	0.100E+05
Percent organic matter	--	CONSTANT	0.260E-01	-999.	0.000E+00	100.
Bulk density of soil for layer	g/cc	CONSTANT	1.45	-999.	0.100E-01	5.00
Biological decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.

1

(continued)

TABLE 7-9. (Continued)

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Base catalyzed hydrolysis rate	l/M-yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Reference temperature	C	CONSTANT	25.0	0.000E+00	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	140.	0.000E+00	0.000E+00	-999.
Distribution coefficient	--	DERIVED	0.219	0.000E+00	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	0.000E+00	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	0.645E-02	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	0.000E+00	0.000E+00	0.000E+00	100.
Molecular weight	g/M	CONSTANT	-999.	0.000E+00	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	-999.	0.100E-01	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	-999.	0.230E-01	0.000E+00	100.
Henry`s law constant	atm-m^3/M	CONSTANT	-999.	0.000E+00	0.100E-09	1.00
RFD value for drinking water	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00
ADIF value for fish consumption	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00
CCC for aquatic organisms	mg-kg/day	CONSTANT	1.00	0.000E+00	0.000E+00	1.00

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.700E-02	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	400.	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	-999.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.160E-01	-999.	0.100E-09	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Near field dilution		CONSTANT	0.000E+00	0.000E+00	0.000E+00	0.000E+00

(continued)

TABLE 7-9. (Continued)

AQUIFER SPECIFIC VARIABLES

VARIABLE

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.630E-03	-999.	0.100E-08	100.
Aquifer porosity	--	DERIVED	-999.	-999.	0.100E-08	0.990
Bulk density	g/cc	DERIVED	-999.	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	78.6	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	DERIVED	-999.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.306E-01	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	-999.	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	NORMAL	160.	15.0	50.0	200.
Transverse dispersivity	m	CONSTANT	15.2	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	CONSTANT	8.00	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	14.4	-999.	0.000E+00	100.
pH	--	UNIFORM	-999.	-999.	5.80	6.90
Organic carbon content (fraction)		CONSTANT	0.315E-02	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	152.	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

1 0 Values generated which exceeded the specified bounds.

1 ---- RESULTS -----

SATURATED ZONE TRANSPORT

Example 3 input

Subtitle D application

90. PERCENT CONFIDENCE INTERVAL

N	=	500		
MEAN	=	0.573E-03		
STANDARD DEVIATION	=	0.346E-04		
COEFFICIENT OF VARIATION	=	0.604E-01		
MINIMUM VALUE	=	0.475E-03		
MAXIMUM VALUE	=	0.657E-03		
50th PERCENTILE	=	0.573E-03	0.570E-03	0.576E-03
80th PERCENTILE	=	0.602E-03	0.599E-03	0.605E-03
85th PERCENTILE	=	0.608E-03	0.605E-03	0.614E-03
90th PERCENTILE	=	0.619E-03	0.614E-03	0.623E-03
95th PERCENTILE	=	0.634E-03	0.626E-03	0.640E-03

(continued)

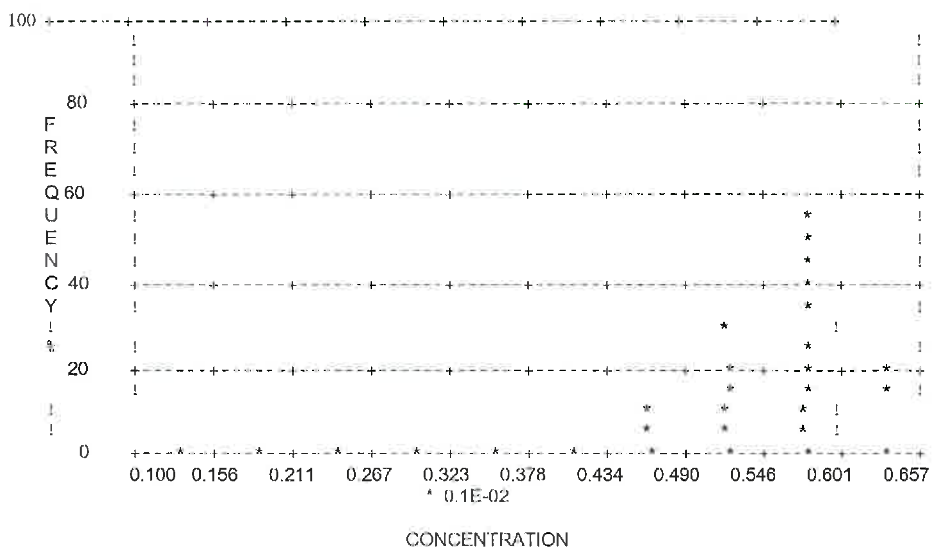
TABLE 7-9. (Continued)

-999 UNABLE TO COMPUTE CONFIDENCE BOUND DUE TO INSUFFICIENT DATA

VALUE	% OF TIME EQUALLED OR EXCEEDED	% OF TIME IN INTERVAL
0.100E-03	100.000	
		0.000
0.156E-03	100.000	
		0.000
0.211E-03	100.000	
		0.000
0.267E-03	100.000	
		0.000
0.323E-03	100.000	
		0.000
0.378E-03	100.000	
		0.000
0.434E-03	100.000	
		0.800
0.490E-03	99.200	
		21.400
0.546E-03	77.800	
		56.800
0.601E-03	21.000	
		20.800
0.657E-03	0.200	

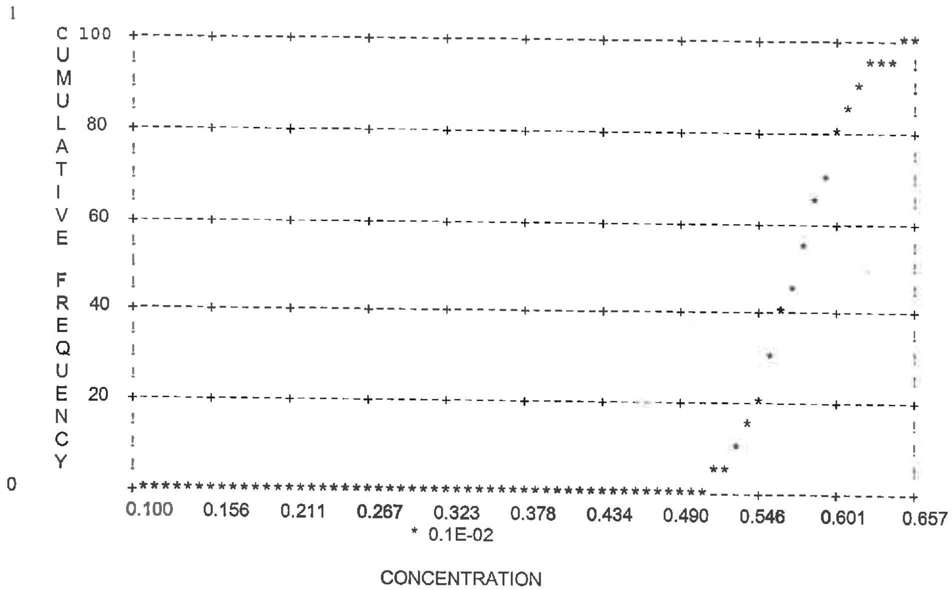
(continued)

TABLE 7-9. (Continued)



(continued)

TABLE 7-9. (Continued)



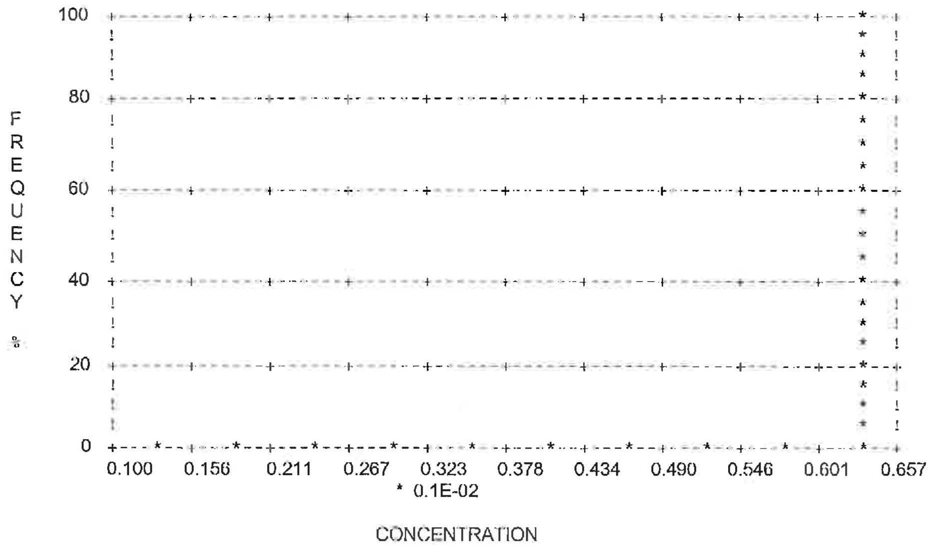
14
9

(continued)

1

FOLLOWING GRAPHS ARE FOR THE TOP 20% OF THE RESULTS

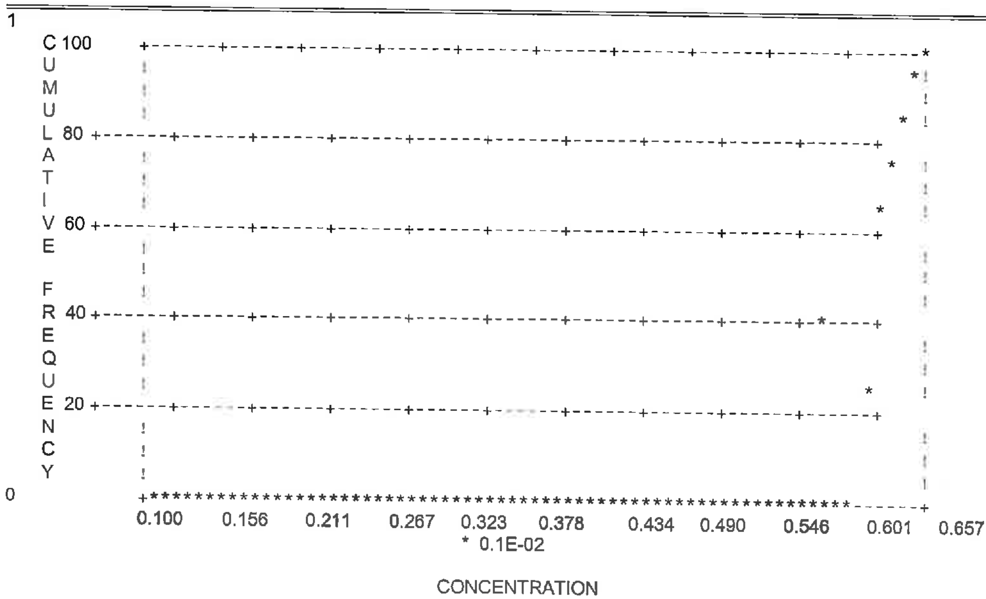
1



15
()

(continued)

TABLE 7-9. (Continued)



15

1

TABLE 7-10. FIRST PAGE OF THE SAT1.OUT FILE FOR EXAMPLE 3.

0.47457E-03
0.47974E-03
0.48608E-03
0.48800E-03
0.49012E-03
0.49224E-03
0.49897E-03
0.49929E-03
0.49976E-03
0.50186E-03
0.50328E-03
0.50413E-03
0.50599E-03
0.50715E-03
0.50830E-03
0.50845E-03
0.50892E-03
0.50896E-03
0.50899E-03
0.50927E-03
0.50953E-03
0.51086E-03
0.51110E-03
0.51265E-03
0.51344E-03
0.51375E-03
0.51534E-03
0.51589E-03
0.51801E-03
0.51807E-03
0.51846E-03
0.52211E-03
0.52246E-03
0.52261E-03
0.52275E-03
0.52347E-03
0.52361E-03
0.52425E-03
0.52430E-03
0.52450E-03
0.52490E-03
0.52494E-03
0.52552E-03
0.52583E-03
0.52599E-03
0.52603E-03
0.52615E-03
0.52751E-03

TABLE 7-11. STATS.OUT FILE FOR EXAMPLE 3.

1

---- RESULTS ----

SATURATED ZONE TRANSPORT

Example 3 input
Subtitle D application

90. PERCENT CONFIDENCE INTERVAL

N	=	500		
MEAN	=	0.573E-03		
STANDARD DEVIATION	=	0.346E-04		
COEFFICIENT OF VARIATION	=	0.604E-01		
MINIMUM VALUE	=	0.475E-03		
MAXIMUM VALUE	=	0.657E-03		
50th PERCENTILE	=	0.573E-03	0.570E-03	0.576E-03
80th PERCENTILE	=	0.602E-03	0.599E-03	0.605E-03
85th PERCENTILE	=	0.608E-03	0.605E-03	0.614E-03
90th PERCENTILE	=	0.619E-03	0.614E-03	0.623E-03
95th PERCENTILE	=	0.634E-03	0.626E-03	0.640E-03

-999 UNABLE TO COMPUTE CONFIDENCE BOUND DUE TO INSUFFICIENT DATA

VALUE	% OF TIME EQUALLED OR EXCEEDED	% OF TIME IN INTERVAL
0.100E-03	100.000	
	0.000	
0.156E-03	100.000	
	0.000	
0.211E-03	100.000	
	0.000	
0.267E-03	100.000	
	0.000	
0.323E-03	100.000	
	0.000	
0.378E-03	100.000	
	0.000	
0.434E-03	100.000	
	0.800	
0.490E-03	99.200	
	21.400	
0.546E-03	77.800	
	56.800	
0.601E-03	21.000	
	20.800	
0.657E-03	0.200	

SECTION 8

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