

**Key Words:**  
**Performance Assessment**  
**Low-Level Waste**  
**Software Quality Assurance**

**Retention: Permanent**

**Software Quality Assurance Plan for the  
Hydrologic Evaluation of Landfill Performance (HELP) Model**

**Author: Mark A. Phifer**

**OCTOBER, 2006**

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Prepared for the U.S. Department of Energy Under  
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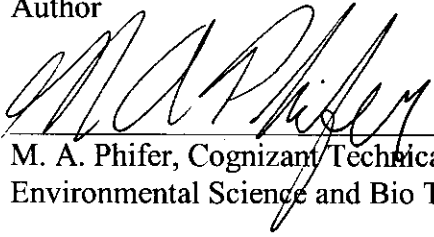
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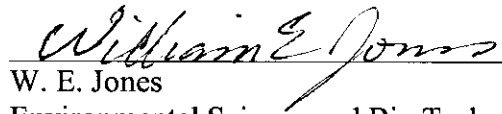
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10/11/06  
Date

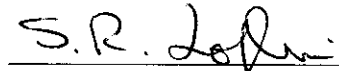
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## LIST OF ACRONYMS

### ACRONYMS

CQF	Cognizant Quality Function
CTF	Cognizant Technical Function
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
HELP	Hydrologic Evaluation of Landfill Performance
PA	Performance Assessment
SQAP	Software Quality Assurance Plan
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
USACE	United States Army Corps of Engineers
WES	Waterways Experiment Station
WSRC	Washington Savannah River Company

## 1.0 INTRODUCTION

The Environmental Analysis and Performance Modeling group of Savannah River National Laboratory (SRNL) conducts Performance Assessments (PA) of the Savannah River Site (SRS) low-level waste facilities to provide a reasonable assurance that the Performance Objectives of DOE Order 435.1 will be met. Each PA includes an analysis of the groundwater exposure pathway, which requires an estimate of water infiltration through the facility closure cap. This closure cap infiltration estimate is generated using the Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model is a quasi-two-dimensional water balance model designed to conduct landfill water balance analyses. The model requires the input of weather, soil, and design data. It provides estimates of runoff, evapotranspiration, lateral drainage, vertical percolation (i.e. infiltration), hydraulic head, and water storage for the evaluation of various landfill designs. United States Army Corps of Engineers (USACE) personnel at the Waterways Experiment Station (WES) in Vicksburg, Mississippi developed the HELP model, under an interagency agreement (DW21931425) with the U.S. Environmental Protection Agency (EPA). HELP model version 3.07, issued on November 1, 1997, is the latest version of the model. It is public domain software available from the WES website at:

<http://el.erc.usace.army.mil/products.cfm?Topic=model&Type=landfill>.

## 2.0 SCOPE

This document describes the Software Quality Assurance Plan (SQAP) for the HELP model. This SQAP follows the guidelines and minimum content requirements specified in Washington Savannah River Company (WSRC) 1Q, Quality Assurance Manual, Procedure 20-1, Revision 8, Software Quality Assurance (QAP 20-1). The HELP model has been classified as Level “C” software per QAP 20-1 Attachment 1, which classifies “software applications used to comply with regulatory laws, environmental permits or regulations and/or commitments to compliance” as Level “C” software. The HELP model together with other PA software is used to provide a reasonable assurance that the Performance Objectives of DOE Order 435.1 will be met and to establish radionuclide limits for the various waste disposal units. This SQAP addresses the life cycle requirements for the HELP model as Level “C” software.

## 3.0 ROLES AND RESPONSIBILITIES

Oversight and assignment of all PA related work, including HELP modeling, is provided by the Manager, Environmental Analysis & Performance Modeling. The Cognizant Technical Function (CTF) associated with HELP modeling is Mark Phifer of the Environmental Science and Bio Technology section of SRNL. The Cognizant Quality Function is Steve Loflin of the Quality Engineering group in SRNL.

## 4.0 SOFTWARE LIFE CYCLE

### 4.1 FUNCTIONAL PHASE

The functional requirements phase defines the software capabilities required to perform the simulations of interest that will be designed into the software by in-house or vendor software designers. The HELP model has been classified as Level “C” software, and WSRC 1Q, Procedure 20-1, Attachment 2 states that functional requirements are to be applied on a graded approach for Level “C” software.

The HELP model is public domain software previously designed by USACE personnel at the WES under an interagency agreement with the EPA. As such, definition of functional requirements for design as part of a software development process is not directly applicable to SRNL for use of the HELP model. However Schroeder et al. 1994b (Engineering Documentation) provides information that addresses the functional requirements in a graded approach sufficient to support SRNL use of the HELP model in the PA process. Schroeder et al. 1994b (Engineering Documentation) Section 2 provides an overview of the HELP model design and its functional requirements. Essentially the HELP model was designed to provide estimated average water budgets for landfills (i.e. water movement across, into, through, and out of landfills) by combining and improving existing algorithms that describe various hydrologic processes.

### 4.2 DESIGN PHASE

The design phase prescribes and documents the design activities that allow the design process to proceed and that allow verification that the design requirements have been met. The HELP model has been classified as Level “C” software, and WSRC 1Q, Procedure 20-1, Attachment 2 states that software design phase requirements are to be applied on a graded approach.

The HELP model is public domain software previously designed by USACE personnel. As such, the software design phase as part of a software development process is not directly applicable to SRNL for use of the HELP model. However Schroeder et al. 1994b (Engineering Documentation) provides information that addresses the design phase requirements in a graded approach sufficient to support SRNL use of the HELP model in the PA process. Schroeder et al. 1994b (Engineering Documentation) provides the source language used to write the code (Section 1), the hardware necessary to operate the code (Section 1), data generation methodologies available for use (Section 3), and the methods of solution (Section 4).

### 4.3 IMPLEMENTATION PHASE

The software implementation phase results in a copy of the software, identification and correction of errors, instructions for computer program use, software design documentation, and production of test cases with criteria traceable to the software requirements. The HELP model has been classified as Level “C” software, and WSRC 1Q, Procedure 20-1,



Attachment 2 states that the implementation phase requirements are to be applied on a graded approach.

The HELP model is public domain software previously designed by USACE personnel. As such, the software implementation phase as part of a software development process is not directly applicable to SRNL for use of the HELP model. However the USACE has produced the following that address the implementation phase requirements in a graded approach sufficient to support SRNL use of the HELP model in the PA process:

- HELP model version 3.07, issued on November 1, 1997, is the latest version of the model. It is public domain software available from the WES website at:  
<http://el.ercd.usace.army.mil/products.cfm?Topic=model&Type=landfill>.
- Within Schroeder et al. 1994a (User's Guide) Section 2 and Schroeder et al. 1994a (Engineering Documentation) Section 1.1 the development of Versions 1, 2, and 3 are briefly discussed along with the enhancements made to each version.
- WES provides a listing of the revisions made from Version 3.01 through 3.07 along with the executable HELP Model software when the document file, "zhelp3p.exe", is downloaded from the WES web site.
- Instructions for HELP model use are provided in Schroeder et al. 1994a (User's Guide).
- Schroeder et al. 1994b (Engineering Documentation) provides information on the source language used to write the code (Section 1), the hardware necessary to operate the code (Section 1), data generation methodologies available for use (Section 3), and the methods of solution (Section 4).
- The USACE performed the following tests as verification of HELP Model Version 1.0:
  - Schroeder et al. 1987a reports on verification tests of the HELP Model Version 1.0 drainage layer estimates to the results of large-scale physical models.
  - Schroeder et al. 1987b reports on a study to verify the HELP Model Version 1.0 water balance estimates to "field data from a total of 20 landfill cells at 7 sites in the United States".
- WES provides a test case along with the executable HELP Model software when the document file, "zhelp3p.exe", is downloaded from the WES web site. This test case can be utilized to ensure that the executable HELP Model software has been downloaded successfully.

#### **4.4 TEST PHASE**

Verification testing demonstrates that the software is functioning as intended by comparing results from the software to applicable results produced by a second method (e.g. hand calculations, experimental data, and field data) using test cases representative of the range of conditions expected in the actual analysis. The HELP model has been classified as Level "C" software, and WSRC 1Q, Procedure 20-1, Attachment 2 states that the verification testing is to be applied on a graded approach.

The HELP model is public domain software previously designed by USACE personnel. As such, the software verification testing as part of a software development process is not directly applicable to SRNL for use of the HELP model. However the USACE has produced

the following that address verification testing in a graded approach sufficient to support SRNL use of the HELP model in the PA process:

- Schroeder et al. 1987a reports on verification tests of the HELP Model Version 1.0 drainage layer estimates to the results of large-scale physical models.
- Schroeder et al. 1987b reports on a study to verify the HELP Model Version 1.0 water balance estimates to “field data from a total of 20 landfill cells at 7 sites in the United States”.
- Within Schroeder et al. 1994a (User’s Guide) Section 2 and Schroeder et al. 1994a (Engineering Documentation) Section 1.1 the development of Versions 1, 2, and 3 are briefly discussed along with the enhancements made to each version. WES provides a listing of the revisions made from Version 3.01 through 3.07 along with the executable HELP Model software when the document file, “zhhelp3p.exe”, is downloaded from the WES web site.

#### **4.5 USER INSTRUCTIONS**

User instructions provide a description of the user’s interaction with the software, input/output specifications and formats, approved operating systems, etc. Schroeder et al. 1994a (User’s Guide) and Schroeder et al. 1994b (Engineering Documentation) provide the necessary user’s instructions sufficient to support SRNL use of the HELP model in the PA process. The User’s Guide and Engineering Documentation are also included with the software download from the WES web site.

#### **4.6 INSTALLATION AND ACCEPTANCE PHASE**

Acceptance testing of the installed HELP Model version 3.07 software shall be conducted upon initial installation on each computer system with which the software is to be used. The acceptance testing shall consist of running the USACE test case that is provided with the software download from the WES web site upon initial installation on each computer system. The USACE test case shall be run on the installed HELP Model software using the following files provided with the download:

- Precipitation data file: RCRA.d4
- Temperature data file: RCRA.d7
- Solar radiation data file: RCRA.d13
- Evapotranspiration data: RCRA.d11
- Soil and design data file: RCRA.D10

The “number of years to simulate” for the USACE test case shall be three (3). Results vary depending upon the number of years simulated; therefore three (3) must be used in order to have a valid comparison.

The output from the USACE test case run with the installed HELP Model software shall be compared to the 11/1/1997 output file, “RCRA.OUT” provided with the software download from the WES web site. The comparison is considered acceptable and the software is ready

for use, if the values in the “Average Annual Totals ... for Years 1 through 3” for the test case output is identical to that of the WES 11/1/1997 output file, “RCRA.OUT”. Table 1 provides the “Average Annual Totals ... for Years 1 through 3” from the WES 11/1/1997 output file, “RCRA.OUT”.

As an alternative acceptance testing of future HELP Model version 3.07 installations may be conducting utilizing a model run obtained from a previously accepted version 3.07 installation on a computer system as the test case.

Acceptance testing of any future versions of the HELP model will be documented in a separate report.

Table 1 “Average Annual Totals ... for Years 1 through 3” from the WES 11/1/1997 output file, “RCRA.OUT”

Parameter	Inches
Precipitation	54.52
Runoff	2.374
Evapotranspiration	34.046
Lateral drainage collected from layer 2	19.16763
Percolation/leakage through layer 4	0.32661
Average head on top of layer 3	5.158
Lateral drainage collected from layer 7	0.12868
Percolation/leakage through layer 8	0.14760
Average head on top of layer 8	0.000
Lateral drainage collected from layer 9	0.14751
Percolation/leakage through layer 11	0.00001
Average head on top of layer 10	0.001
Change in water storage	-1.344

**4.7 OPERATION AND MAINTENANCE PHASE**

Operation of HELP Model version 3.07 in support of PAs will be overseen by the Manager, Environmental Analysis and Performance Modeling, who will assign tasks as needed, and by the CTF, who will ensure assigned tasks are consist with the model capabilities. Access to the software, User’s Manual, and Engineering Documentation are through the WES website.

Since the HELP model is public domain software designed by USACE personnel and available from the WES website, any maintenance of the software (i.e. correction of errors, implementation of new requirements, adaptation to different operating systems), would be made by the USACE personnel rather than by SRS personnel. Any new versions of the HELP Model produced by WES will have to undergo acceptance testing documented in a separate report.

## **4.8 RETIREMENT PHASE**

If and when it is determined that use of HELP Model version 3.07 in support of PAs should be discontinued, support for the HELP model shall be terminated and routine use of the software shall be prevented in association with PA related work.

## **5.0 CONFIGURATION CONTROL**

Configuration control is a method established to control, uniquely identify, describe, and document the configuration of each version of a computer program. Since the HELP model is public domain software designed by USACE personnel and available from the WES website, configuration control in large part is the purview of WES. HELP model version 3.07, issued on November 1, 1997, is the latest and only version of the model available from the WES website. However, configuration control will be initiated locally to ensure that SRNL personnel, utilizing the HELP Model in support of PAs, are using version 3.07. This shall be done by verifying that HELP Model version 3.07 was used during the design review process.

## **6.0 PROBLEM REPORTING AND CORRECTIVE ACTION**

Since the HELP model is public domain software designed by USACE personnel and available from the WES website, any problems or errors requiring corrective action to the software would have to be made by the USACE personnel rather than by SRNL personnel. Therefore any problems or errors detected in the HELP model by SRNL personnel shall be reported to the Manager, Environmental Analysis and Performance Modeling and the CTF. The Manager and CTF will determine if the error precludes the proposed use of the HELP model or not. SRNL users will be notified of any problems or errors that preclude particular uses of the HELP model, by the Manager and /or CTF.

## **7.0 ACCESS CONTROL**

HELP model version 3.07, issued on November 1, 1997, is the latest and only version of the model available from the WES website at:

<http://el.erdc.usace.army.mil/products.cfm?Topic=model&Type=landfill>.

Any installation of the HELP Model in support of PAs will require acceptance testing as outlined in Section 4.6.

## 8.0 REFERENCES

Schroeder, P. R. and Peyton, R. L. 1987a. Verification of the lateral Drainage Component of the HELP Model Using Physical Models. EPA/600/2-87/049. Office of Research and Development, United States Environmental Protection Agency (EPA), Cincinnati, Ohio. July 1987.

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Schroeder, P. R., Dozier, T. S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L. 1994b. The Hydrologic Evaluation of Landfill Performance (HELP) Engineering Documentation for Version 3. EPA/600/R-94/168b. Office of Research and Development, United States Environmental Protection Agency (EPA), Cincinnati, Ohio. September 1994.

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