PORFLOW
Software Quality Assurance Plan

Approvals:

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1.0 SCOPE

This Software Quality Assurance Plan (SQAP) describes both lifecycle requirements and verification techniques for the application of software tool PORFLOW. This software has been used at SRS for many years for analyses of ground water flow and contaminant transport in the vadose zone and underlying aquifer across the site. PORFLOW is developed and marketed by Analytic & Computational Research, Inc. (ACRi) to solve problems involving transient and steady-state fluid flow, heat and mass transport in multi-phase, variable saturation conditions, porous or fractured media flow, and dynamic changes in phases. The porous/fractured media may be anisotropic and heterogeneous. Arbitrary sources (injection or pumping wells) may be present and chemical reactions or radioactive decay may take place in the model.

The PORFLOW software used for ground water and contaminant transport analyses is classified as Level C, per E7, Procedure 5.05. This SQAP is prepared to meet the E7 Procedure 5.03 requirements.

2.0 ROLES AND RESPONSIBILITIES

2.1 Organization

2.1.1	Owner:	CS&T/EA&P
	Technical Contact:	B.T. Butcher
2.1.2	Maintainer/User:	CS&T/EA&P
	Technical Contact:	L.B. Collard
2.1.3	Design Agency:	CS&T/EA&P
	Technical Contact:	L.B. Collard
2.1.4	Design Authority:	Manager, CS&T/EA&P
	Technical Contact:	B.T. Butcher
2.1.5	Cognizant Quality Function:	Quality Engineering
	Technical Contact:	S. R. Loflin

2.2 Tasks and Responsibilities

2.2.1 Owner: The Owner has the responsibility for defining the requirements for the software and authorizing any future changes or enhancements to the system. The Owner shall ensure all required documentation is placed within an approved Document Control facility. The Owner approves the following:

- SQAP
- Test results
- All software revisions
- Accepts the software for operational use

2.2.2 Design Agency: The Design Agency defines the scope of this SQAP and prepares the SQAP in accordance with QAP 20-1 and E7 Manual Procedure 5.05.

2.2.3 Maintainer/User: the Maintainer has the responsibility for the test, maintenance and retirement phases of the software. The Maintainer will perform periodic software verification checks. The Maintainer is responsible for software maintenance, when requested by the owner, during the Operation and Maintenance phases. At the Owner's request, the Maintainer shall ensure that the retired software is not made available for unrestricted use.

2.2.4 Design Authority: The Design Authority has the responsibility to assign a functional classification to the software. The Design Authority also ensures all required reviews/analyses are performed. The Design Authority will assign personnel to oversee the operation of the software. The assigned personnel shall serve as the Design Authority contact. The Design Authority approves the following:

- SQAP
- Software requirements
- Software test documents
- Test results

2.2.4 Cognizant Quality function: The CQF reviews and approves the SQAP.

3.0 ACQUIRED SOFTWARE

The PORFLOW software is developed by an outside software vendor Analytic & Computational Research, Inc. and is classified as an Acquired Software. This software has been successfully used in the past to support SRS operations. PORFLOW 5.97 is the currently used version. New versions shall be procured in a manner similar to the Commercial Grade Item Dedication Program since PORFLOW is Commercial Off-The-Shelf (COTS) software. Future versions will be tested per Test Plan prior to use for applications other than scoping calculations.

4.0 EXISTING SOFTWARE

SRNL personnel have created a set of verification test cases that are relevant to Performance Assessment (PA) modeling at the Savannah River Site. The test cases are composed of problems that include variably saturated groundwater flow and transport of parent and progeny radionuclides in the vadose and aquifer zones underlying the SRS. The PORFLOW Testing and Verification Document (Aleman, 2007) provides detailed discussions of these test cases and how they were compared to closed-form analytical solutions and to results from other well-recognized computer programs. The suitability of PORFLOW for specific modeling applications was previously documented (Collard, 2002).

5.0 LIFECYCLE ACTIVITIES

5.1 Requirements

A Requirements Specification for the software shall be completed in accordance with Manual E7, Procedure 5.10 and accompany this plan as an attachment. The Design Authority is responsible for preparing the Requirements Specifications. This task may be delegated. The Owner shall review and approve the Requirements Specifications which for existing software shall serve to document that the software meets the required functionality.

5.2 Design

Software design for this Commercial Off-The-Shelf (COTS) software is by vendor and as such, a Requirements Traceability Matrix (RTM) or Design Description for Software (DDS) will not be required.

5.3 Implementation, Testing, Acceptance, and Installation

The software shall be implemented with adequate Configuration Management controls as described later in this document. A test plan shall be prepared in accordance with E7, Procedure 5.40. The results of the test plan shall be documented in a Software Evaluation Package to ensure that the software meets the intent of the Requirements Specifications. This test plan will serve as a means to assure and document adequacy of the selected software product for subsequent use in creating complex ground water and contaminant transport models on which calculations are to be performed. The following testing and associated documentation guidelines are proposed for PORFLOW:

1. Creation of test models simulating the various flow and transport conditions, boundary conditions, a range of options for verifying software functionality to adequately model the present needs of the SRS. Planned test cases for these models shall be selected in agreement with the Design Authority.

2. Test documentation shall contain sufficient documentation (geometry, clearly defined problem specifications, and boundary conditions) of discrete steps that can be later repeatable by an independent reviewer.

3. All files used in the test, including the input files, along with generated output files, will be stored in a protected file repository.

4. The software applications and all files to be used for testing shall be placed under configuration control per Section 7.0 of this document.

5. Upon completion of the software test cases, the completed test document and input/output data shall be submitted to the Design Authority for evaluation and acceptance. Installation shall be completed on the target computer(s) after acceptance of the software. The successful completion of these activities will

serve as fulfillment of the software lifecycle Test, Installation, and Acceptance phases.

5.4 Operation and Maintenance

The software shall be re-baselined, if necessary, per Section 7.0 prior to entry into the Operation and Maintenance phase of the software lifecycle. Any revisions by the vendor to the software modeling products – upgrades, patches, maintenance releases, etc. - will be reviewed by the Owner for impact prior to installation. Application software upgrades shall not be installed unless approved by both the Owner and the Design Authority. If a software upgrade is desired following testing, the completed test document shall be reviewed to determine whether partial or complete retesting is required.

5.5 Software Retirement

If the Design Authority decides that this software is not needed, the aforementioned software shall no longer be governed by this Software Quality Assurance Plan. At this time the software shall be considered Level E software.

6.0 REVIEWS / ANALYSES

A Type 1 Independent Review (IR-1) is required for the modeling software requirements (see Manual E7, 5.03, Section 3.0: Definitions). The IR-1 Independent Reviewer reviewing and approving this SQAP shall complete this review.

A test plan documented in Reference 3 shall be used for testing this software. The test cases shall be documented in that plan and must be subjected to a Type 2 Independent Review (IR-2), with results documented, including identification of the reviewer. Design Authority per Manual E7, Procedure 5.40, must also approve the test results.

Test results must be followed by an IR-2 review to ensure the test requirements have been satisfied. IR-2 review results must be documented, including identification of the reviewer.

Verification of the deliverables for each lifecycle phase fulfills validation that the previous phase has been completed.

7.0 CONFIGURATION MANAGEMENT / BASELINE CONTROL

The software shall be installed by the \\tegu4 system administrator. During installation, file permissions shall be set such that non-administrative users cannot delete, alter or create any files in the installation directories. The exception to this is the network license file LENCOLLA_2.acr who's time stamp updates with each execution of PORFLOW. Changes to the application installation (as well as operating system changes) shall be documented in accordance with the Information Technology Department configuration

management procedures. For the purpose of Configuration Management, four types of software files should be distinguished:

1) the application software executable file and all associated licensing and initialization files
2) analytical solution numerical source code, input and output files
3) COMSOL Earth Science Module input and output files (where appropriate)
4) PORFLOW input and output files.

The first file set must be baselined prior to testing. This shall be accomplished by documenting the full version number, including release sub-numbers, etc. in the Test Plan at the outset of testing, along with identification of supporting file time/date stamps.

The second, third and forth file sets described above used during completion of the Testing shall be stored electronically as a baseline in a controlled, protected location.

8.0 PROBLEM REPORTING AND CORRECTIVE ACTION

The Owner is responsible for notifying the software vendor(s) of significant deficiencies encountered with the purchased software product, followed by notification of the Design Agency with a proposed remediation strategy. The Design Agency shall approve the selected remediation strategy.

The Owner shall contact the software vendor to determine a method for reporting errors and controlling software fixes (patches, updates, etc.) deemed necessary by the vendor. Usually, minor releases (e.g., 5.xx) are typically to correct errors. So they will be reviewed to determine whether test cases need to be rerun.

9.0 TOOLS, TECHNIQUES, METHODS, STANDARDS, PRACTICES and CONVENTIONS

No special tools, techniques, methods, standards, practices, or conventions other than described here are envisioned at this time for implementing the software engineering process for this software.

10.0 QUALITY ASSURANCE RECORDS / DOCUMENTATION

All documents generated by this SQAP are quality assurance records and shall be handled in accordance with Manual 1Q, Procedure 17-1, Quality Assurance Records Management.

11.0 TRAINING

The Owner shall decide whether available vendor training is required prior to utilizing the software products as modeling tools.

12.0 REFERENCES

1. Aleman, S.E., 2007. *"PORFLOW Testing and Verification Document,"* WSRC-STI-2007-00150, June, 2007.
2. Collard, L.B., 2002. *"Software Quality Assurance Plan for the PorFlow Code,"* WSRC-SQP-A-00028, September 20, 2002.

3. G-STP-A-00009, *"PORFLOW Software Test Plan,"* June 2007.

13.0 ATTACHMENTS

13.1 Requirement Specification for Software (RSS)

ATTACHMENT 13.1
Requirement Specification for Software (RSS)

Reference: PORFLOW Software

The following requirements apply to this software that is used in the ground water and contaminant transport modeling applications. The requirements are based on historical analytical environmental services supplied by SRNL to the site.

Requirement # 1 Priority: High

Function: Software must be able to execute on one of SRNL multi-platforms of choice using the current operating sysytem of choice. At present the platform of choice is PC workstation running Windows 2000 or XP operating system.

Acceptance Criteria: The results must be reproducible on this platform.

Requirement # 2 Priority: High

Function: The software must be able to solve steady-state and transient 1D, 2D and 3D flow and transport problems in Cartesian and cylindrical coordinates by numerical methods.

Acceptance Criteria: The software must be able to provide correct or reproducible solution for these problems.

Requirement # 3 Priority: High

Function: Accuracy of solution should be within 5% for well-known analytical verification problems and within 10% for problems in comparison with solutions from commercially accepted codes. The variables of significance such as flow velocities, contaminant concentrations are to be compared in each verification problem. The comparison will be shown graphically and in tabular form. No RMS errors will be reported in the verification report.

Acceptance Criteria: The software must be able to reliably produce results within the specified accuracy.

Requirement # 4 Priority: High

Function: The code should allow for the following options:

a. steady-state or transient variably saturated groundwater flow
b. transient, variably saturated groundwater transport with first order radioactive decay
c. Cartesian, 1D radial or axisymmetric geometry
d. volumetric and nodal contaminant sources

e. boundary conditions applicable to geometry or volume elements
   - Dirichlet
   - Neumann
   - Mixed or Cauchy

Acceptance Criteria: The software must be able to produce results that utilize the code features above.