Boston Government Services, LLC

SCALE 6.2.2 SOFTWARE QUALITY ASSURANCE PLAN

BGS-SQAP-04 **Revision 0**

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1 M = major change, mc = minor change, N = new

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ACRONYMS

Term	Definition
ASME	American Society of Mechanical Engineers
BGS	Boston Government Services, LLC
D&D	Deactivation and Decommissioning
DOE	Department of Energy
FRNP	Four Rivers Nuclear Partnership
NCS	Nuclear Criticality Safety
NCSE	Nuclear Criticality Safety Evaluation
ORNL	Oak Ridge National Laboratory
PGDP	Paducah Gaseous Diffusion Plant
QA	Quality Assurance
QAP	Quality Assurance Plan
QL	Quality Level
QLD	Quality Level Determination
RSICC	Radiation Safety Information Computation Center
SCCM	Software Configuration Control Manager
SIPM	Software Implementation Project Manager
SQAP	Software Quality Assurance Plan
V&V	Verification and Validation

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EXECUTIVE SUMMARY

This software quality assurance plan (SQAP) supplements BGS-QAP-01, *Corporate Quality Assurance Plan*, BGS-SQ-02, *Software Management*, and BGS-PQAP-FRNP-01, *Project Quality Assurance Plan and Implementation Guide for the Four Rivers Nuclear Partnership, LLC, Group of Contracts.*

BGS staff and subcontractor staff will be performing safety-related computations for nuclear facilities at the Paducah Gaseous Diffusion Plant (PGDP) managed by Four Rivers Nuclear Partnership (FRNP). For these calculations, the most recent version (with any required patches to be applied as determined in accordance with this SQAP) of the SCALE code system that is developed and maintained by the Oak Ridge National Laboratory (ORNL) is used for the safety-related computations.

BGS *Corporate Quality Assurance Plan*, BGS-QAP-01, and BGS *Software Management* procedure, BGS-SQ-02, define the institutional requirements and systems that apply to safety-related software.

This document supports implementation of BGS-PQAP-FRNP-01, and BGS safety-related software requirements by:

- documenting software categorization,
- identifying relevant requirements for software use,
- identifying software documentation,
- describing initial requirements for initial testing and post-installation retesting of installed software,
- describing how authorized software or hardware changes are managed, and
- describing how unauthorized software or hardware changes are prevented.

1. PURPOSE

The purpose of this SQAP is to define the requirements for software management and use of the SCALE code package that is used to perform safety-related calculations for nuclear facilities at PGDP.

2. APPLICABILITY

This SQAP applies to each version of the SCALE software package that has not been developed in accordance with the American Society of Mechanical Engineers (ASME) NQA-1 standard, *Quality Assurance Requirements for Nuclear Facility Applications* (2008 Edition with 2009 addenda).

The scope of this SQAP excludes non-safety-related software that may be used to support project objectives. The following examples of non-safety-related software that are exempt under BGS-SQ-02 include but are not limited to:

- standard word processing software (e.g., Microsoft Word);
- standard spreadsheet software for which results may be easily verified by alternate means (e.g., Microsoft Excel);
- graphical software that may be used for generation of report graphics or inspection of models (e.g., KENO-3D, FULCRUM);
- simple executable script files used to manage execution of calculations or consolidation of output results; and,
- other radiation transport codes which may be used only for comparison purposes.

Proper use of non-safety related software for project objectives is determined through computational checks or technical review activities, as covered by project-specific procedures CP4-NS-1101, *Nuclear Criticality Safety Evaluations*, and CP5-NS-1251, *Guidelines for Nuclear Criticality Safety Documentation*. These procedures provide specific guidance on technical reviews of inputs and outputs for this code whether or not other software is used to develop those inputs or process the outputs.

3. SOFTWARE DESCRIPTION AND PROJECT COMPUTER

The safety-related software is SCALE code version 6.2.1 with an update to version 6.2.2, as obtained from the Radiation Information Computational Center (RSICC). Prior to the final runs of the verification and validation (V&V) sequences to support the Commercial Grade Dedication, the system will be patched with the latest patches available as recommended by the Software Implementation Project Manager. A user manual is included with the distributed software. The SCALE 6.2.2 code system contains a large variety of

sequences (sets of computer modules) for various types of nuclear engineering calculations. The primary sequence to be used for this project for safety-related calculations is CSAS5. CSAS5 will be used to analyze fissionable material operations needed to support deactivation and decommissioning (D&D) of the PGDP. These nuclear criticality safety (NCS) calculations will be used to analyze fissionable material configurations under normal and postulated abnormal conditions.

The computer upon which the safety-related software will be installed is a Dell PowerEdge R430 with service tag no. 4B2KXM2. The Terminal Server name is "Windows Server 2012 R2 Standard" which utilizes Microsoft Windows Server Version 6.3 (Build 9600). The code will be run in a virtual session on this server.

4. SOFTWARE TYPE AND QUALITY-LEVEL DETERMINATION

A quality level determination (QLD) was performed on the SCALE 6.2.2 software package in accordance with BGS-SQ-02. The SCALE 6.2.2 QLD is documented in BGS-QAF-03.1 Rev 1 QLD-16 *SCALE Quality Level Determination Meeting (February 21, 2018)*. Based on the QLD, the use of the software package is determined to have a category of "DOE Safety Software, Quality Level (QL) 2" and designated software type "acquired" as defined by BGS-SQ-02.

The basis for the determination is due to the nature of the calculations, failure or misuse of this software might not readily be detectable by the software user or by technical reviewers, and failure of software use could contribute to loss of life, disability, or serious injury. Also, failure or misuse of this software could result in non-compliance with federal regulations or nuclear-safety-related contractual requirements.

5. SOFTWARE AND PROJECT COMPUTER ROLES AND RESPONSIBILITIES

5.1 Quality Assurance Manager

5.1.1 Concurs on the SQAP.

5.1.2 Concurs on the Commerical Grade Dedication (CGD) Plan and Package.

5.2 Senior Vice President

5.2.1 Serves as the Paducah NCS Project Manager.

5.2.2 Approves the SQAP.

5.2.3 Assigns Paducah NCS project tasks, including the performance of safety-related calculations based on the staff experience and qualifications for the Paducah NCS Project.

5.3 Software Configuration Control Manager (SCCM)

5.3.1 Software owner for the SCALE 6.2.2 code system on the project computer.

5.3.2 Ensures that unauthorized changes to the SCALE 6.2.2 code system installed on the project computer do not occur.

5.3.3 Ensures that unauthorized changes to the project computer operating system do not occur.

5.4 Software Implementation Project Manager (SIPM)

5.4.1 Develops the project SQAP and CGD Plan and Package.

5.4.2 Ensures that the CGD Plan is executed and the CGD Package is created.

5.4.3 Ensures the SCALE 6.2.2 code system is under configuration management prior to dedication.

5.4.4 Ensures the V&V tasks defined in Section 7 for SCALE 6.2.2 are completed and documented.

5.5 V&V Engineer

5.5.1 Assists the SIPM in performing V&V tasks and preparing the CGD Package.

5.6 Vice President of Operations

5.6.1 Approves the SQAP and the CGD Plan and Package.

6. REQUIREMENTS SPECIFICATION

This section describes requirements for using software on the project computer.

6.1 Requirements for Software Use

In general, all software use will be in compliance with applicable BGS procedures and polices.

Performance of safety-related calculations for this project will be by individuals designated by the Senior Vice President as being suitably experienced and qualified for the requirements for the types of calculations being performed.

Review of project safety-related calculations for this project will be by individuals designated by the Senior Vice President as being suitably experienced and qualified.

The SCCM is responsible for ensuring that unauthorized changes to the SCALE 6.2.2 code system installed on the project computer do not occur.

6.2 Reporting of Software Errors and Deficiencies

Any errors or deficiencies identified in the SCALE 6.2.2 software installed on the project computer will be reported to the Senior Vice President, Paducah NCS Project Manager, and to the SCALE Project Team at ORNL. Investigation and resolution of identified software problems will be as directed by the Senior Vice President. These deficiencies will be tracked and managed according to BGS-QA-15, *Nonconformances.*

6.3 Software Requirements Definition

In accordance with BGS-SQ-02, the software requirements for acquired software are to be provided in the procurement or acquisition documentation. The SCALE code package is acquired software, and the software requirements needed for safety-related calculations are documented in the software procurement documentation.

7. VERIFICATION AND VALIDATION

The terms “verification” and “validation” have specific meanings for purposes of this SQAP; these meanings may differ from other usages encountered in software development or use.

“Verification” refers to determination that acquired software is properly installed and functional on a specific computer system. “Validation” refers to documentation, via modeling of experimental tests and results, that the software can reasonably predict results for non-experiment (facility application) conditions.

7.1 Post-Installation Verification Testing

Following installation of the SCALE 6.2.2 code system on the project computer, but prior to performance of safety-related calculations, proper installation of the software will be verified by the SIPM.

Installation of the SCALE 6.2.2 software will be performed consistent with guidance issued with the software package. For verification, the entire suite of test cases issued with the software will be performed, and results compared to the sample results issued as part of the SCALE 6.2.2 package and documentation.

A report describing the software installation and initial verification will be documented as noted in Section 10. The report will be archived as a controlled project record in the Paducah NCS Project repository.

7.2 Periodic Reverification Testing

The verification testing described in Section 7.1 will be performed:

- on a frequency not to exceed 100 calendar days between verification tests; and

- at/near closure of the project, following completion of all safety-related computations and prior to transmittal of the final project report(s) to FRNP.

For reverifications, the test cases may be a select subset of the initial verification cases. At a minimum, all SCALE 6.2.2 modules used for the project work will be tested during reverification.

Documentation requirements for reverifications are the same as for the initial verification.

7.3 Validation

As part of the project work, a set of criticality benchmark experiments will be modeled so as to demonstrate the adequacy of the SCALE 6.2.2 CSAS5 sequence for the Paducah NCS project objectives. Specifically, validation cases that are documented in FRNP report NCSR-FPDP-17-004, Rev 0, *Validation of SCALE 6.1 and the 238 Energy Group ENDF/B-VII Library for FPDP*, will be selected for validating the SCALE 6.2.2 code system.

The SCALE 6.2.2 validation will be documented in a project validation report as noted in Section 10. The report will be archived as a controlled project record in the Paducah NCS Project repository.

This validation will be performed to meet the requirements of ANSI/ANS-8.1-1998 and ANSI/ANS-8.24-2007. Additional guidelines may be found in ANSI/ANS-10.4-1987.

8. CONFIGURATION MANAGEMENT

The purpose of software configuration management is to ensure that only authorized and verified changes are made to the computer hardware or installed software.

8.1 Software Version Identification and Control

The specific version of the SCALE 6.2.2 code package installed on the project computer will be the public-release version of SCALE 6.2.2, as issued by RSICC. The software and data media supplied by RSICC will be retained as project records. Module and Library filenames and date/time stamps are provided on result output files generated by the code that allow the user to verify that the various modules and libraries used by the code package have not changed and can be verified with those documented in the Validation Report as being the latest approved versions for use.

8.2 Management of Authorized Software Changes

Subsequent to initial installation of the SCALE 6.2.2 code package on the project computer, it is possible that RSICC or the SCALE developers may issue public-release “patches” (corrections or updates) for SCALE 6.2.2. Prior to CGD, any

SCALE 6.2.2 patches may be applied as determined by the SIPM and Senior Vice President.

The SIPM is responsible to monitor for notices of SCALE 6.2.2 patches and to evaluate the need for application of such public-release patches. Some patches may not affect SCALE 6.2.2 modules or data used for project work. Therefore, installation of such software patches is not essential and may be undesirable.

If the SIPM and Senior Vice President determine that a public-release patch is needed, the SCCM will install the software update. Subsequently, a reverification will be performed prior to performance of safety-related calculations. If test cases for the patch are issued, a subset of the original verfication cases (covering all SCALE 6.2.2 cases used for project work) will be used for the reverification. In addition, the SIPM will determine the impact of the software patch on the SCALE 6.2.2 validation, and the validation will be repeated and documented.

Documentation requirements for reverification and revalidation for software patches are the same as for the initial V&V reports.

8.3 Commercial Grade Dedication and Authorization for Safety-Related Calculations

The verification and validation calculations as specified in Section 7 will be used as the basis and completion of the CGD specified in BGS-QA-28, *Commercial Grade Dedication of Computer Programs and Software Services*. The SCALE 6.2.2 software cannot be used for safety-related calculations until the CGD is completed; however, the SCALE 6.2.2 software can be installed and used for testing and scoping calculations on the project computer specified in Section 3. Once the CGD is complete and SCALE 6.2.2 is determined to be suitable for safety-related calculations, the SIPM will send an email to authorized SCALE 6.2.2 users on the project team documenting that the SCALE 6.2.2 CGD is complete, with completion date. Once the CGD is complete, the SCALE 6.2.2 software is authorized for safety-related calculations. For the purposes of the project analysis work, the date of the CGD completion will serve as the start date for use of SCALE 6.2.2 for safety-related calculations. All project NCS users and reviewers shall adhere to the CGD completion date for beginning safety-related calculations. During the Nuclear Criticality Safety Evaluation (NCSE) peer-review process, all peer NCS peer reviewers shall confirm that no safety-related calculations were performed before the CGD completion date. Furthermore, the NCS peer reviewers shall confirm that only the authorized version of the SCALE 6.2.2 software, as maintained per Sections 8.1 and 8.2, is used for safety-related calculations.

9. REFERENCES

1. BGS-PQAP-FRNP-01, *Project Quality Assurance Plan and Implementation Guide for the Four Rivers Nuclear Partnership, LLC, Group of Contracts.*
2. BGS-QA-03, *Graded Approach.*
3. BGS-QAF-03.1, Rev 1 QLD-16 *SCALE Quality Level Determination (QLD) Meeting (February 21, 2018)*.
4. BGS-QA-28, *Commercial Grade Dedication of Computer Programs and Software Services*.
5. BGS-QAP-01, *Corporate Quality Assurance Plan*.
6. BGS-SQ-02, *Software Management*.
7. CP4-NS-1101, *Nuclear Criticality Safety Evaluations*, FRev. 1, FRNP.
8. CP5-NS-1251, *Guidelines for Nuclear Criticality Safety Documentation*, FR1, FRNP.
9. Code of Federal Regulations 10 CFR 830 Subpart A, *Quality Assurance.*
10. DOE O 414.1C, *Quality Assurance*.
11. American Society of Mechanical Engineers (ASME) NQA-1, Quality Assurance *Requirements for Nuclear Facility Applications (2008 Edition with 2009 addenda).*
12. ANSI/ANS-10.4-1987, *Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry*.
13. ANSI/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.*
14. ANSI/ANS-8.24-2007, *Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations*.
15. NCSR-FPDP-17-003, *Verification of the SCALE 6.1 NCS Code System for FPDP*.
16. NCSR-FPDP-17-004, *Validation of SCALE 6.1 and the 238 Energy Group ENDF/B-VII Library for FPDP.*

10. RECORDS GENERATED

The following records are generated and maintained as records according to BGS-RM-01, *Quality Assurance Records*:

- BGS-QAF-28.1, *Commercial Grade Dedication Plan*
- BGS-QAF-28.2, *Commercial Grade Dedication Package*
- SCALE 6.2.2 Paducah NCS Project verification report
- SCALE 6.2.2 Paducah NCS Project reverification report(s)

- SCALE 6.2.2 Paducah NCS Project validation report
- SCALE 6.2.2 Paducah NCS Project revalidation report(s)

11. ATTACHMENTS

- None