Department of Energy
Washington, DC 20585

December 27, 2011

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue NW, Suite 700
Washington, DC 20004

Dear Mr. Chairman:

This letter transmits to the Defense Nuclear Facilities Safety Board (Board) a report on safety software quality assurance (SSQA) practices involving the computer program System for Analysis of Soil-Structure Interaction (SASSI). On July 29, 2011, the Department of Energy (DOE) transmitted to you the report entitled *U.S. Department of Energy Report on Technical and Software Quality Assurance Issues Involving the System for Analysis of Soil-Structure Interaction*, which detailed seven corrective actions DOE will undertake in response to the Board's April 8, 2011, letter regarding SASSI technical and SSQA issues. The enclosed report summarizes DOE's corrective action #4, *Office of Environmental Management and National Nuclear Security Administration complete the review and evaluation of responses from the SSQA information request and generate a summary report.*

DOE developed a comprehensive information request (see Appendix B of the report) for the 10 projects listed below and in the Board letter under the purview of the Office of Environmental Management (EM) and the National Nuclear Security Administration (NNSA):

1. Chemistry and Metallurgy Research Replacement project at Los Alamos National Laboratory;
2. Device Assembly Building at the Nevada National Security Site;
3. Highly Enriched Uranium Materials Facility at the Y-12 Security Complex;
4. Pantex Bays and Cells at the Pantex Plant;
5. Pit Disassembly and Conversion project at the NNSA Savannah River Site Office;
6. Plutonium Facility at Los Alamos National Laboratory;
7. Salt Waste Processing Facility at Savannah River Site;
8. Sodium-Bearing Waste Treatment Plant at the Idaho National Laboratory;
9. Uranium Processing Facility at Y-12 Security Complex; and the
10. Waste Treatment and Immobilization Plant at Hanford.

EM and NNSA each reviewed the responses from their respective projects and evaluated those responses using the criteria in Appendix C of the report. The responses were evaluated for consistent understanding of the topics, completeness, compliance with DOE's safety SQA requirements, and confirmation that the responses were comparable from project to project. Several of the projects were evaluated by an onsite team for adequacy of implementation. The report concludes with future actions that EM and NNSA will take in connection with this issue.

If you have any questions on this report, please contact me, at (202) 586-0799, or Debra Sparkman of my staff, at (202) 586-3974.

Sincerely,

Richard H. Lagdon, Jr.
Chief of Nuclear Safety
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U.S. Department of Energy

Report to Defense Nuclear Facilities Safety Board on System for Analysis of Soil Structure Interaction (SASSI) Software Quality Assurance Practices

December 2011

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Background

The System for Analysis of Soil Structure Interaction (SASSI) is a computer code for performing finite element analyses of soil-structure interaction (SSI) during seismic ground motions. SASSI (Refs. 1, 2) has become the *de facto* industry application used in the analysis of most seismic SSI problems. For that reason, having and maintaining confidence in the accuracy and applicability of its solution algorithms is essential. SASSI was first developed in 1981 at the University of California (UC) at Berkeley, and several modified, proprietary variations are now available.

In the early years, SASSI was commonly executed with a flexible volume method, also known as the direct method, in which every finite element node within and on the perimeter boundary of the excavated soil volume is treated as an interaction node that couples the free-field soil system and the excavated soil volume. In 1998, a more computationally efficient method known as the subtraction method was developed for SASSI execution (Ref. 3). During a recent analysis of several DOE projects, DOE contractors identified computational results using the subtraction method that deviate significantly from those of the direct method.

In late 2010, the Defense Nuclear Facilities Safety Board (DNFSB) staff sent requests for information on the use of SASSI to four DOE projects/sites that have recently used, or plan to use, SASSI. These projects/sites are the Waste Treatment and Immobilization Plant (WTP), Pit Disassembly and Conversion Facility (PDCF), Uranium Processing Facility (UPF), and Los Alamos National Laboratory (LANL). The responses to these requests raised concerns within the DNFSB staff regarding the implementation of safety software quality assurance (SSQA) requirements in the use of SASSI across these projects. The DNFSB staff shared the responses from the projects with DOE Headquarters offices, specifically, the Chief Nuclear Safety (CNS), the Office of Environmental Management (EM), and the National Nuclear Security Administration (NNSA). DOE Headquarters reviewers noted inconsistencies in the responses to Board staff questions between one project's response and another's. In addition, most responses to questions were not detailed enough to determine compliance with SSQA requirements

On April 8, 2011, the DNFSB submitted to DOE a letter and technical report to express its concerns with SASSI technical and SSQA issues and to request from DOE a report and briefing on how the Department intended to address these concerns. The DNFSB letter listed five specific concerns and topics. DOE committed to address these concerns in its July 29, 2011, response to the DNFSB letter and technical report (Ref. 4). This report summarizes DOE's actions for Issue #2, *Address the need for a complex-wide assessment of software quality assurance as it relates to SASSI***.**

Department's Approach

Based upon the DNFSB's request for SQA information to the four DOE projects from late 2010, DOE developed a comprehensive information request for the 10 projects identified in the DNFSB's April 8, 2011 letter. Appendix B contains that information request. NNSA distributed an earlier revision of this information request to some of its projects. The major difference was the addition of Question #16. Thus, some NNSA projects did not respond to this question. The 10 projects were:

1. Chemistry and Metallurgy Research Replacement (CMRR)
2. Device Assembly Building (DAF)
3. Highly Enriched Uranium Materials Facility (HEUMF)
4. Pantex Bays and Cells
5. Pit Disassembly and Conversion (PDC) Project
6. Plutonium Facility (PF-4)
7. Salt Waste Processing Facility (SWPF)
8. Sodium-Bearing Waste Treatment Plant (SBWTP)
9. Uranium Processing Facility (UPF)
10. Waste Treatment and Immobilization Plant (WTP)

EM and NNSA personnel each reviewed the responses from their respective projects and evaluated those responses using the criteria in Appendix C. The responses were evaluated for consistent topical understanding, completeness, adequate implementation of DOE's SSQA requirements, and confirmation that the responses were comparable from project to project.

Summary of SSQA Responses

Variations of SASSI

In general, the responses from the ten EM and NNSA projects identified four variations from the original University of California (UC) at Berkeley SASSI V1.0 developed in 1981 and its direct descendants, UC Berkeley SASSI V1.0 (circa 1988), UC Berkeley SASSI2000 V1.0 and UC Berkeley SASSI2000 V2.0. Figure 1 provides the best information as of the issuance date of this report on the ancestry of these variations. As with other tasks associated with DOE's response to the DNFSB's April 8, 2011 letter, this Figure will be updated and maintained as a separate document until it is no longer needed to support DOE's actions as stated in the July 29, 2011, response to the DNFSB. Each of the four variations is discussed briefly in Table 1 below.

Application of Software Quality Practices

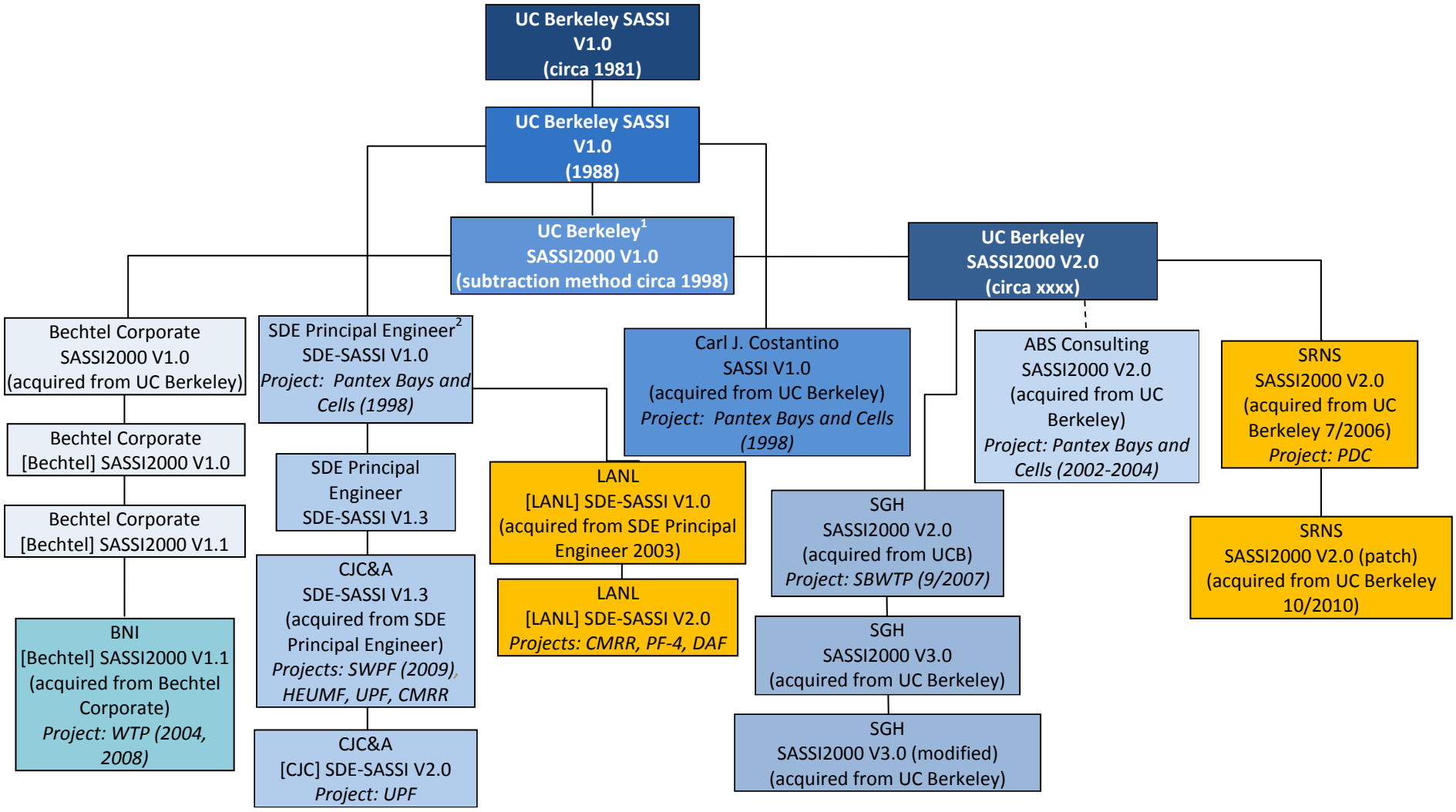
As per DOE O 414.1C/D, *Quality Assurance*, and its associated Guide, DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A,* Quality Assurance Requirements, *and DOE O 414.1C,* Quality Assurance (Ref. 5), the software quality assurance (SQA) practices are applied using a graded approach and based upon the software type. Of the ten DOE projects reviewed, six contracted with engineering service providers to perform SSI analyses using the provider's computer program. Using DOE's safety software types from DOE G 414.1-4, those six instances of the SASSI computer program are considered Commercial Design and Analysis safety software. Two of the remaining projects acquired their variations of SASSI from another entity. In those two instances, their variations of SASSI are considered Acquired Safety and Hazard Analysis Software and Design Software, respectively. One project acquired the original variation of SASSI and then modified the source code, resulting in its current variation of the SASSI and then modified the source code, resulting in its current variation of the SASSI computer program to be Custom Safety and Hazard Analysis Software and Design Software.

Table 1. Variations on UC Berkeley SASSI2000V1.0

Acquiring Company	SASSI Version	Comments
Bechtel Corporate	SASSI 2000 V1.1	Bechtel National, Inc. (BNI) acquired this variation and version directly from Bechtel Corporate. Bechtel Corporate obtained UC Berkeley SASSI2000 V1.0 directly from UC Berkeley. Bechtel Corporate modified the UC Berkeley version twice resulting in the variation and version [Bechtel] SASSI2000 V1.1[1] used for the WTP.
Carl J. Costantino & Associates (CJC&A)	CJC SDE-SASSI V2.0	CJC&A has performed engineering services for five of DOE's projects: SWPF, UPF, CMRR, Pantex Bays and Cells, and HEUMF. The current variation and version used by CJC&A is [CJC] SDE-SASSI V2.0[2]. CJC&A obtained SDE-SASSI V1.3 directly from the Structural Dynamics Engineering principal engineer. SDE-SASSI V1.0 (SDE-SASSI V1.3's parent) is a direct descendant of UCB SASSI V1.0. CJC&A has subsequently modified SDE-SASSI V1.3 to produce [CJC] SDE-SASSI V2.0.
Los Alamos National Laboratory	SDE-SASSI V2.0	Los Alamos Nuclear Solutions (LANS) obtained the SDE-SASSI V1.0 software, including source code, through the employment of a Structural Dynamics Engineering (SDE) principal engineer. LANS subsequently modified the code and applied software quality controls and practices to develop LANL SDE-SASSI V2.0 that has been used for the CMRR, DAF, and PF-4 projects.
Savannah River Nuclear Solutions	SASSI2000 V2.0	Savannah River Nuclear Solutions (SRNS) obtained the original UC Berkeley SASSI2000 V2.0 through the previous DOE management and operating (M&O) contractor. This version of the original UC Berkeley SASSI code was used in preliminary studies for the Pit Assembly and Conversion (PDC) project. Subsequently, SRNS obtained a module update. SRNS has identified this module update version as [SRNS] SASSI2000 V2.0 (patch)[3].

[1] The use of [Bechtel] is used in this report solely to distinguish between the different variations and to denote modification of the software by Bechtel Corporation.
[2] The use of [CJC] is used in this report solely to distinguish between the different variations and to denote modification of the software by Carl J. Costantino & Associates.
[3] It is unknown at the time this report was issued if the module update for [SRNS] SASSI2000 V2.0 (patch) was obtained as an official product release from UC Berkeley. Thus, for the purposes of this report, this variation branch is identified to include [SRNS].

Figure 1. SASSI Genealogy



Notes:
Dotted lines are assumptions of acquisition.
Gold boxes indicate DOE contractor ownership of variations of SASSI.
Dates by projects reflect dates of use.

[1] *The assumption is made that SASSI2000 V1.0 is derived from UC Berkeley SASSI V1.0 (1988).*
[2] *UC Berkeley SASSI V1.0 (1988) was updated to include the subtraction method, which resulted in SDE SASSI V1.0.*

Although the SASSI computer program was used by an engineering service provider for preliminary studies, changes in the PDC project direction resulted in the discontinued use of SASSI. Even though SASSI has not yet been used for PDC, the SSQA practices for SRNS were reviewed and found to be adequate. If a SSI-related calculation is needed for PDC, it will be performed by SRNS. Additionally, very limited SQA implementation information was provided for the HEUMF project. For the final project, DAF, LANL reported that, although it used SASSI for the project, it did not use the results of the SASSI computer program for any SSI-related analysis.

For CMRR, LANL reported that SASSI was used in a CMRR Structural Stiffening Study (scoping use only) and a CMRR preliminary analysis was run, but the results were not used. Subsequently, LANL contracted with CJC&A to continue the support of the SSI-related analysis.

In 1998, SSI-related analysis was performed by CJC&A for the Pantex Bays and Cells project. Later, in 2002 -2004, another engineering service provider, ABS, was used to perform the SSI analysis. Limited information was available related to the 1998 SSQA practices. Thus, all references to the Pantex Bays and Cells analysis is associated with work performed by ABS.

The review team determined that SQA practices were adequately implemented for five projects (WTP, UPF, CMRR-LANS, PDC, and Pantex Bays and Cells). These five projects included those where the SASSI computer program was classified as Acquired, Custom, or Commercial Design and Analysis software types based on the individual site procurement type, as defined by DOE G 414.1-4. The effectiveness of the engineering service providers' SQA programs used for the SWPF and SBWTP projects could not be adequately determined at this time due to the lack of detail provided in response to the SASSI SSQA Information Request. Each of the SQA programs is discussed in more detail in the subsequent sections of this report. As noted in this report, both EM and NNSA are continuing to obtain information where information was unavailable or inconclusive to adequately perform the review.

Verification and validation (V&V) activities for the projects included the execution of a core set of test problems widely accepted in the industry. This core set was frequently supplemented by additional test cases to increase the confidence in the correctness of the SASSI computer program being used and to verify reasonableness of results when using a test case that bounded the problem being analyzed. In two projects, SWPF and SBWTP, the documentation was not adequate to determine whether the testing parameters bounded the problem being solved. For one project, WTP, the V&V documentation indicated that tests were performed to properly bind the analysis conditions. The other projects did not explicitly provide information regarding bounding of test cases to the SSI-related analysis being performed.

Oversight activities of the engineering service providers by the DOE contractors were performed, but they did not always address SQA practices. The majority of the oversight activities were for including or maintaining the engineering service provider on the DOE contractor's qualified or approved supplier list. In one instance, oversight of the prime contractor by the Y-12 Site Office enhanced the NNSA prime contractor's surveillance of, and subsequent corrective action by, the engineering service provider.

Flowdown of SQA Requirements to Engineering Service Providers

The flowdown of the specific SQA requirements is dependent upon the requirements DOE has imposed on the contractor designing, constructing, or operating the facility. DOE O 414.1A was in place when at least one SSI analysis was performed. Most SSI analyses were performed while DOE O 414.1C and various editions of the American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance standard (NQA-1) were being implemented by DOE's contractors. Of the ten projects reviewed, six projects used three engineering service providers: Carl J. Costantino & Associates (CJC&A) provided services for CMRR, SWPF, Pantex Bays and Cells, HEUMF, and UPF; Simpson Gumpertz & Heger (SGH) for SBWTP; and ABS Consulting for Pantex Bays and Cells. Of these six projects, UPF and CMRR properly included the applicable requirements in the agreements with the engineering service provider, and two projects—SWPF and SBWTP—did not flow down all the applicable requirements. Information from the Pantex Bays and Cells and HEUMF projects was not complete enough to determine the adequacy of requirements flowdown. The SSI-related analyses for the remaining three projects—WTP, PF-4, and PDC—were performed in-house by the various DOE contractors; thus, no flowdown of SQA requirements was necessary.

Environmental Management Projects

EM was responsible for reviewing the following projects:

1. SWPF
2. SBWTP
3. WTP

EM personnel reviewed the responses to the information requested from the three projects. As needed, EM interfaced with the respondents to complete missing and unclear information. The responses were evaluated to ensure a consistent understanding of the topics and to confirm that the responses are comparable from project to project. Responses were also reviewed for completeness and for adequate implementation of DOE's SSQA requirements.

The following table illustrates when SASSI was run for each of the three projects.

Project	Date SASSI Run
SBWTP	September 2007
SWPF	2009
WTP	2004, 2008

EM concluded that the SASSI analysis contractors for the SWPF and SBWTP had a software quality control program in place at the time of the SSI-related analyses, but the effectiveness of the software controls as applied to SASSI could not be sufficiently determined. The SWPF engineering service provider was the same as for CMRR and UPF. A CMRR surveillance in May 2011 (two years after the SWPF analysis) identified weaknesses in the engineering service provider's SQA program. Based upon the information received to date, EM concluded that an onsite visit to SGH and CJC&A will be needed to complete an adequate review of the software

quality control program implemented. The quality assurance program for WTP has been updated since the time SASSI was used for that facility; however, based upon a review of the documentation controlling the SASSI computer program at the time the analysis was performed, EM concluded that the SSQA program was adequate.

As depicted in the SASSI genealogy chart (Figure 1), the software versions used by SBWTP, SWPF, and WTP are all traced to SASSI version 1.0 developed by UC Berkeley.

Based upon the software types in DOE G 414.1-4, the SASSI software used for both the SWPF and SBWTP, by CJC&A and SGH respectively, is considered Commercial Design and Analysis safety software. The SASSI software used at WTP by Bechtel Corporation is considered Acquired safety software.

For each of the three projects, validation was performed using existing test cases chosen based either on the project bounds or on an understanding of the project site conditions. As discussed above, WTP and SBWTP both indicated that anomalous results were encountered with their SASSI applications when the number of soil layers was greater than 40. The analysis for WTP did not exceed this threshold. CJC&A did not indicate whether the number of soil layers used for the SWPF was below the 40-layer threshold. Information describing the number of soil layers used in the SWPF analysis has been requested and will be addressed in a follow-up project visit by EM[4].

Each of the EM projects relied on its primary project contractor, CH2M-WG Idaho, LLC (CWI), Parsons, or BNI to oversee the acquisition and use of the various SASSI applications.

Overall, the assessment and oversight processes used by the three EM projects for the structural analysis were typical of the supplier qualification processes in place at EM projects at that time. The assessment and oversight programs used by the prime contractors demonstrated that each organization performing the SSI analysis had software control programs in place, but the degree of program implementation was not subject to detailed assessment by the qualification and oversight process.

Sodium-Bearing Waste Treatment Plant

The DOE Idaho Operations Office (DOE-ID) and its contractor CWI responded to the 18 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. CH2M-WG's subcontractor, SGH, which was responsible for the SASSI computer program used in the SBWTP analysis, also provided responses to the 18 questions. The documentation submitted indicates that SGH had an SQA program in place, but the effectiveness of the software controls as applied to SASSI2000 version 2.0 could not be conclusively determined. Based upon the information received to date, EM has determined that an onsite visit by EM or CWI to SGH is needed to complete an adequate review of SGH's SQA program.

[4] Subsequent to this report being finalized, CJC&A verbally provided information indicating that SDE-SASSI V1.3 had been modified to address the anomalies in cases having large number of soil layers. SDE-SASSI V1.3 was used for the SWPF SSI analysis.

Origin and Applicability of SQA Requirements

The UC Berkeley SASSI2000 version 2.0 used by SGH on the SBWTP project was purchased directly from ISATIS, LLC, which is a commercial arm of UC Berkeley that sells SASSI to industry. UC Berkeley SASSI2000 version 2.0 was used for the SBWTP project without further modification.

CWI indicated that the UC Berkeley SASSI2000 version 2.0 was acquired and owned by SGH. All use of the computer program was performed by SGH on its hardware and under the control of SGH's SQA program. Thus, UC Berkeley SASSI2000 version 2.0 is identified as Commercial Design and Analysis safety software as per DOE G 414.1-4.

At the time of the SBWTP SSI analysis, the overarching document controlling SASSI2000 version 2.0 and other software was the SGH Quality Assurance Manual for Nuclear Facility (QANF) Work, Revision 4. CWI operated under the Quality Program Plan for the Integrated Waste Treatment Unit Project (IWTU) Revision 4 during this period. The IWTU is also known as the SBWTP. Based upon available procurement documents, ASME NQA-1-2000 Part II Subpart 2.7 and DOE O 414.1C requirements did not appear to be completely flowed down to SGH.

Implementation of SQA Requirements

For the SBWTP SSI analysis, SGH used the QANF and the SBWTP Quality Assurance Plan Version 10. Based upon the responses received to date, the initial review of the SGH program has been indeterminate because the information received was not sufficient to address the criteria used to evaluate field responses (Appendix C). Further review or a follow-up visit by EM or CWI to SGH will be necessary to determine if SGH's SQA program applied to SASSI provides assurance that the software was adequately controlled for use at SBWTP.

Many of the implementation records of the SASSI2000 version 2.0 execution and testing by SGH were not provided to EM. These records were requested, but have not yet been received. Examination of these records would be the primary focus of a follow-up visit to SGH.

SGH indicated that anomalous results were identified using the UC Berkeley SASSI2000 version 3.0 SITE module with large numbers of soil layers. UC Berkeley, through ISATIS, LLC, subsequently corrected this issue with the issuance of a new SITE module executable.

SGH indicated it has a number of test cases that are chosen based upon the nature of the project. SGH currently possesses 50 separate test cases. It was unclear from the information provided to date how the test cases were selected or how well those test cases bounded the SSI analysis for SBWTP. Verifying the applicability of these test cases may require follow-up at SGH.

Levels of Oversight

CWI did not provide direct oversight of SGH's acquisition, testing, or execution of the UC Berkeley SASSI computer program, but the response from DOE-ID described a number of audits

and surveillances of SGH that were performed that were subsequently used to support approving SGH as an engineering service provider for the SBWTP project.

- The first audit was performed in March 2006 by SBWTP construction subcontractor, CH2M-Hill-Washington Group International (WGI). This assessment report does not describe whether it was a desk audit or onsite visit. No deficiencies were reported, but the report is limited in detail.

- A second audit in March of 2007 by Thor Treatment Technologies (TTT), a SBWTP project team member, audited the SGH program for compliance with ASME NQA-1-2000 and the TTT QA program. This audit did include ASME NQA-1-2000 Requirement 3, *Design Control*, but did not include Part II, Subpart 2.7 in the lines of inquiry (LOIs).

- A surveillance of SGH software controls performed in April 2007 by WGI concluded that the SGH SQA program complied with all of the requirements in ASME NQA-1-2000, Part II, Subpart 2.7 applicable to the SBWTP. However, it was not clear from the surveillance report whether the implementation of the SQA activities was reviewed during the surveillance.

- SGH conducted an internal audit in October 2008 that was based upon Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix B. This audit included a check of software control and noted one finding in the software program related to multiple versions of codes in the baseline list.

- A comprehensive ASME NQA-1 audit of SGH was performed by Battelle Energy Alliance, the Idaho M&O contractor, in November 2008. This audit concluded that SGH had implemented software controls in accordance with the requirements of ASME NQA-1-2000 Part II Subpart 2.7, and evaluated the V&V processes for software used in design analysis under ASME NQA-1 Requirement 3, including analysis for the SBWTP.

CWI used the reports of the above previous assessments, combined with a review of the SGH QA Manual, to include SGH on the CWI Qualified Supplier List (QSL) in January 2009. SGH was retained on the CWI QSL in February 2010 and February 2011, based on past performance and review of the SGH QA Manual.

Salt Waste Processing Facility

DOE-SWPF Project Office and Parsons, the SWPF prime contractor, responded to the 18 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. The documentation provided demonstrated that CJC&A did have a software quality control program in place, but the program did not appear to be fully compliant with the SQA requirements contained in ASME NQA-1-2004 and DOE O 414.1C. The primary issues identified were: 1) flowdown of requirements and 2) oversight of the analysis contractor, CJC&A, in 2007. The contract specification sent to CJC&A by Parsons referenced DOE O 414.1C and ASME NQA-1-2004, Part II Subpart 2.7, but also referenced International Organization for Standardization (ISO)-9000 as a quality standard. The QA applicability matrix included with the procurement documentation did not clarify which of the above standards was to be applied to any given

topical area, such as Design Control or Software Control. Therefore, it is not clear from the service provider agreement documents which of the referenced standards were the controlling standard within each of those topical areas. The supplier assessments included in the response did not address all the ASME NQA-1-2004, Part II Subpart 2.7 requirements.

EM requested additional documentation, particularly regarding the applicability of the V&V testing performed on SDE-SASSI version 1.3 for the SWPF SSI analysis. Depending on the content of the information that has been requested and yet to be received, EM or Parsons may perform a follow-up assessment of CJC&A within the next six months.

Origin and Applicability of SQA Requirements

The SASSI code used by CJC&A for the SWPF was SDE SASSI version 1.3. SDE-SASSI V1.3 was managed and executed on CJC&A hardware in its offices under the control of the CJC&A SQA program. The principal engineer for SDE purchased UC Berkeley SASSI version 1.0. SDE developed SDE SASSI version 1.3 from the acquired UC Berkeley SASSI V1.0 and then provided SDE-SASSI V1.3 to CJC&A for use on the SWPF project. CJC&A subsequently modified SDE-SASSI V1.3 for the UPF project.

The SASSI software at SWPF is identified as Vendor-Owned Commercially Available software. This is analogous to Commercial Design and Analysis safety software, as per DOE G 414.1-4.

The approved SWPF Project Quality Assurance Plan (V-QP-J00001, revision 2) was in place during the period SASSI2000 was used on the SWPF project. The CJC&A Quality Assurance Manual, Rev. 0 and Software Quality Assurance Plan (SQAP), Rev. 0 were in place. The SQAP did not address all requirements contained in ASME NQA-1-2004 Part II Subpart 2.7 and DOE O 414.1C, such as baseline and configuration control, but did show that CJC&A had a SQA program in place that required software maintenance and validation. CJC&A performed validation testing for SDE-SASSI V1.3. EM is still evaluating information from the SWPF project to determine if CJC&A's SQA program properly validated the SDE-SASSI V1.3.

Implementation of SQA Requirements

Quality documents for CJC&A, including the Quality Assurance Manual and the Software Quality Assurance Plan, were both identified as Rev. 0 documents and were prepared to meet the requirements of the SWPF project.

The records associated with the execution and testing of SDE SASSI V1.3 for SWPF were provided by CJC&A. The testing records that were provided to date do not illustrate how the bounds of analysis were determined and do not address all of the necessary elements of testing documentation required in DOE O 414.1C and ASME NQA-1-2004 Part II Subpart 2.7. If subsequent information shows that the V&V performed by CJC&A for SASSI supported its use for SWPF, then the CJC&A controls applied to SASSI would be considered adequate in this case.

CJC&A indicated that it did not encounter any problems during its use of SDE-SASSI on the SWPF project.

CJC&A indicated that it performed a number of parametric studies to bind its results and then used 10 separate validation problem sets to verify the data. The applicability of the SDE-SASSI V1.3 validation testing done by CJC&A to the SWPF analysis is still under review, awaiting additional information.

Levels of Oversight

Parsons added CJC&A to its Approved Supplier List (ASL) in April 2007 as part of the process for awarding the structural analysis contract. This assessment included a review of the CJC&A quality manual and implementing procedures and discussions with CJC&A personnel via telephone. Parsons also considered past performance by CJC&A on other DOE and industry nuclear projects. A second surveillance specific to software controls was performed by Parsons in May 2007. This desktop/telephone surveillance concluded that an acceptable software program was in place at CJC&A, but that V&V reports for SDE-SASSI version 1.3 were still being prepared. Parsons conducted a follow-up desktop audit of CJC&A in June 2008 to assess its QA program. The audit was primarily a review of CJC&A's Quality Manual and implementing procedures to determine compliance with ASME NQA-1-2004 requirements, and did not include a specific Part II Subpart 2.7 review. Based upon the information provided to date there is no evidence of additional oversight audits of CJC&A by Parsons prior to award or after the one documented desktop audit.

Waste Treatment and Immobilization Plant

The DOE Office of River Protection (ORP) and its contractor BNI responded to the 18 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. Based upon the review of the response and an additional onsite review on July 11-15, 2011 of the WTP SQA program applied to the SASSI code (EM-PA-11-16), it was determined that the WTP software quality control program for SASSI was adequately implemented.

Origin and Applicability of SQA Requirements

The software used by Bechtel Corporation for BNI at the WTP was [Bechtel] SASSI2000 version 1.1, which was modified from [Bechtel] SASSI2000 version 1.0 to incorporate the code for RMOTION. [Bechtel] SASSI2000 version 1.1 was included in the BNI safety software inventory in November 2003.

At WTP, the SASSI software used for SSI analysis was owned and controlled by BNI's parent company, Bechtel Corporation. BNI therefore considers the SASSI software to be Acquired Analysis and Design safety software as per DOE G 414.1-4. [Bechtel] SASSI2000 version 1.1 was executed at Bechtel Corporation in San Francisco, California, but it was under the control of the BNI SQA program and its set of SQA procedures. In addition, [Bechtel] SASSI2000 version 1.1, resided on hardware dedicated to the BNI project.

During the timeframe in which [Bechtel] SASSI2000 was used by BNI at the WTP, approved Quality Assurance Manuals 24590-WTP-QAM-QA-01-001 Rev. 4B and 24590-WTP-QAM-

QA-06-001 Rev. 3A were in place to control the software. These manuals were reviewed by EM during audit EM-PA-11-16 and found to adequately address the control of software at the WTP.

Implementation of SQA Requirements

The procedures and plans in place for control of execution and maintenance of SASSI by BNI for the WTP facility were well established before the use of [Bechtel] SASSI2000 V1.1. The maturity of the procedure set used to control execution and maintenance of the software was reviewed by EM during review EM-PA-11-16 and determined to be sufficient to meet the SQA requirements of ASME NQA-1-2000 and DOE O 414.1C.

Bechtel Corporation maintains all records associated with the execution and testing of the SASSI code for WTP. Although Bechtel Corporation maintains some of these records as proprietary, the records associated with the execution of the code were provided for review. WTP testing and execution records were reviewed by EM (including the proprietary records) and were found to be acceptable to meet ASME NQA-1-2000 and DOE O 414.1C requirements.

The following issues affecting the execution of [Bechtel] SASSI2000 V1.1 were identified by Bechtel Corporation for consideration during execution:

- The number of soil layers over 40 could result in erroneous results. Bechtel Corporation limited the number of soil layers to 40 to alleviate the condition. On WTP, 37 soil layers were used.

- In 2007, NRC staff identified a concern regarding incoherency-based analysis in an Interim Staff Guidance. Incoherency-based analysis is not used on the WTP project.

The WTP contractor, BNI, provided evidence that the V&V tests for [Bechtel] SASSI2000 Version 1.1 adequately bounded the WTP analysis.

Levels of Oversight

Bechtel Corporation staff responsible for coding and testing [Bechtel] SASSI 2000 was trained to BNI procedures to ensure that the code was tested in accordance with BNI procedures.

National Nuclear Security Administration Projects

This report summarizes the NNSA Team's review of the responses to the SASSI SQA Questionnaire, received from four NNSA sites, covering seven NNSA projects:

Y-12
1. UPF
2. HEUMF

Savannah River Site Office
3. PDC

Pantex
4. Pantex Bays and Cells

Los Alamos
5. CMRR
6. PF-4
7. DAF

NNSA formed a team of SQA experts from various NNSA sites and Headquarters elements (the Assistant Deputy Administrator for Infrastructure and Construction (NA-16) and the Nuclear Safety Support Division (NA-SH-31)), which were chartered to evaluate the responses received from each of the sites. The review approach included document reviews and limited interviews. The NNSA review team's inputs with recommendations are documented within the following pages by site and by facility.

Generally, the responses included various procurement, project, and quality assurance documents related to the use of SASSI by the individual sites and projects. The Nevada Site Office also sent a letter indicating that SASSI was not used to support the DAF safety basis.

SQA has been applied to differing degrees to the versions of SASSI used by NNSA projects. SQA controls have been very recently applied to the SASSI computer programs at several NNSA sites. It is important that NNSA adopt an approach that deals with the current issue of the subtraction method in SASSI and address the broader issue of addressing SQA application to those codes that support the NNSA safety bases at individual facilities.

The SASSI SSQA Information Request process did not provide a detailed listing of corrective actions underway, nor did it provide an overall description of the SQA controls currently in place. However, each of the impacted sites has identified corrective actions and is in the process of implementing them. Most sites have established at least basic configuration controls for their variations of the SASSI computer program and assessed the potential risks associated with the use of the subtraction method. No NNSA projects are currently reporting an issue with the use of the subtraction method.

The acquisition and recordkeeping processes must be sufficiently robust to provide clear histories of the calculations that have been performed with which variation and version of the SASSI computer program. An evaluation is needed to determine if changes are necessary to ensure that the bases and results of engineering calculations using computer codes are documented in sufficient detail after procurement records are dispositioned. The extent of implementation of existing requirements for the development of subcontracted safety software lists needs to be verified.

Uranium Processing Facility and Highly Enriched Uranium Materials Facility

UPF has adequately responded to the 17 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. This preliminary review concluded that the processes in place are

satisfactory to ensure that subcontractors have applied software requirements necessary for the use of SASSI in safety software applications. UPF has taken steps to ensure that there is no negative impact to the project from the use of the SASSI subtraction method. Additionally, the use of the SASSI computer program on the HEUMF was acknowledged and evaluated using the nonconformance process, and it was concluded that the use of the subtraction method resulted in a conservative calculation. No further reference to HEUMF is made in this report.

Origin and Applicability of SQA Requirements

CJC&A, the engineering service provider, has identified the software type as being Acquired safety software. However, CJC&A personnel indicate that SDE-SASSI V2.0 was developed by CJC&A from SDE-SASSI V1.3. SDE-SASSI V1.3 was derived from SASSI V1.0 developed by UC Berkeley. Based on this information, SDE-SASSI V2.0 is considered to be CJC&A Custom software. CJC&A has designated its variations of SASSI as Design Safety Software, Non-Structure, System, and Component (SSC), Level B. Based upon the software types in DOE G 414.1-4, SDE-SASSI V1.3 and V2.0 would be considered Commercial Design and Analysis software.

Implementation of SQA Requirements

The quality assurance requirements flowed down to the engineering service provider in SW-ES-801768-A001 are ASME NQA-1 2004 (or later), Part I and Part II Subpart 2.7. CJC&A indicates that it is implementing ASME NQA-1a-2009 and DOE O 414.1C. The current version of SDE-SASSI V2.0 is the baseline version. This software is now under configuration management.

The SASSI software being used on the UPF project was developed, and is maintained, by CJC&A. Software control is governed by the CJC&A Quality Assurance Procedure 2, revision 4. CJC&A has undergone three recent QA audits reviewing the updated software implementation procedures (B&W Y-12, LANL CMRR Project, and Idaho National Laboratory). Although the B&W Y-12 audit in January 2011 indicated that the CJC&A SQA program was adequate, the subsequent CMRR surveillance in May 2011 identified weaknesses. The 10 SSQA work activities are specifically addressed in CJC&A Form QAP 2-1, revision 2, *Software Quality Assurance Plan.*

CJC&A indicates that its QA program has always had strong procedures for error reporting to clients. In the updated software control procedures (QAP 2), suspected errors are first identified as "bugs" or "errors." Bugs are defined as glitches that do not result in a program producing erroneous results that cause the software not to meet its intended safety function. Errors do affect the software's safety function. Each type of error has separate handling procedures according to QAP 2, which includes requirements on version control and retirement. Errors take on the reporting requirements of QAP 8 R1, *Handling of Computer Program Errors*. If the CJC&A Manager for Quality determines that the error "is a potential condition adverse to quality," QAP 7 R1, *Potential Conditions Adverse to Quality,* is invoked.

CJC&A implements a Software Configuration Management system with controlling procedures that define implementation consistent with Subpart 2.7 of NQA-1a-2009. The current SDE-

SASSI version (v. 2.0) is the baseline version in the configuration management system. Software development procedures of QAP 2 implemented for the CJC&A SCM controls roles and responsibilities during development, project creation and lifecycle control, user change requests, unit testing requirements, access control and concurrent development, required documentation and specifications, handling of acquired code, and release control.

Members of the CJC&A team were the original identifiers of the subtraction method error and notified clients as per CJC&A corrective action procedures. Also, the report originally identifying the error was forwarded to the American Society of Civil Engineers (ASCE) 4 committee, which is composed of many of the key SASSI users within the DOE complex. No other problems with the use of SASSI were reported.

All of the acceptance test problems used for SDE-SASSI are defined in the CJC internal document CJC-VAL-V-001R3. Each problem references technical literature or hand calculations generated based on technical literature. The document provides solutions for a range of sites and structures consistent with those encountered in the analysis of nuclear facilities. These problems are surface-founded structures, embedded structures, structures of various shapes, layered and homogenous soil sites, and site response computations, as well as finite element and structural response. CJC&A indicated that the acceptance test plan developed in CJC-VAL-V-003 addresses all the requirements defined in Section 400 of Requirement 11 of NQA-1a-2009.

The NNSA review determined that the test problem set document CJC-VAL-V001R3 addresses the following topics regarding acceptance testing for SDE-SASSI: required tests and test sequence; required ranges of input parameters; identification of the stages at which testing is required; criteria for establishing test cases; anticipated output values; and acceptance criteria. There is no indication that the software was dedicated in accordance with Subpart 2.14 of NQA-1a-2009.

Level of Oversight

The Y-12 Site Office has conducted audits and assessments, and corrective actions are being implemented.

Pit Disassembly and Conversion Project

Savannah River Nuclear Solutions, the M&O contractor for the Savannah River Site Office, has adequately responded to the 17 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. Although the SASSI computer program was used in preliminary studies, changes in project direction resulted in a different scope for PDC, which did not require the use of SASSI. This preliminary review concluded that SRNS has not used SASSI for any design analysis activities in support of PDC.

Origin and Applicability of SQA Requirements

SASSI2000 V2.0 was acquired from UC Berkeley in July 2006. The review team considered this to be commercial-off-the-shelf (COTS) software. Based upon the software types in DOE G

414.1-4, UC Berkeley SASSI2000 V2.0 would be identified as Safety Software Analysis and Design Safety software. Information provided as documented evidence is consistent with the response received.

Implementation of SQA Requirements

SRNS has a SQA program in place that includes the 10 SSQA Work Activities defined by DOE O 414.1C/D. UC Berkeley SASSI2000 V2.0 is being managed under the SRNS SQA program as an Acquired software application.

The SRNS grading methodology was found to be consistent with, and in some cases more rigorous than, what is recommended in the safety software guide DOE G 414.1-4.

A copy of the safety software inventory list was provided. SRNS classifies the software as Safety Software, Level B. The version of UC Berkeley SASSI2000 in use is consistent with the purchase order provided as documented evidence.

SRNS has a process in place to describe how it manages UC Berkeley SASSI2000 V2.0 and its successor, UC Berkeley SASSI2000 V2.0 (patch). The process described in the SRNS response addresses the management of COTS. SRNS' process includes version control, user acceptability testing, and verification testing upon installation. SRNS has an error reporting process in place for UC Berkeley SASSI2000. UC Berkeley SASSI2000 V2.0 was acquired, and configuration is being accomplished based on version control.

SASSI is managed under a standard SQAP used for all Design Engineering software that is purchased as "licensed, existing commercial, and off-the shelf": B-SQP-G-00007. Under this SQAP, only one version of any specific software can be active at one time. Upon completion and approval of a Computer Resource Request (CPC-16) form, SASSI users are provided access only to the documented current version. Per E7 Procedure 2.31, *Engineering Calculations*, any software used in calculations must be identified on the calculation cover sheet and comply with 1Q QAP 20-1 and E7 Section 5.0, *Software Engineering and Control*. Software not meeting these requirements must be independently verified. Section 5.7.10 of the SQAP addresses upgrades to software. In summary, all authorized computer program users will be promptly notified that a new release version is available for exchange. Users have 20 working days to exchange, load, and perform the user software verification test cases on the new release.

SRNS has not encountered problems with its use of the SASSI computer program that would prompt an investigation and subsequent corrective actions. SRNS personnel have had, and continue to have, a professional, cooperative, and supportive relationship with the primary SASSI representative for UC Berkeley and Bechtel Corporation, as well as with many other users in the Bechtel Corporation and DOE communities. These sources have been used by the Savannah River Site Office as a general knowledge base whenever questions arise regarding the SASSI computer program and SSI analysis in general.

There is a process in place for periodic testing, retesting, and testing after installation. SRNS presently uses a suite of 29 V&V problems for SASSI. Combined, the suite of V&V problems evaluates the technical adequacy of the SRNS SASSI computer program through multiple

means, including comparing results with those from hand calculations, closed-form solutions, comparable programs, and published solutions available in the literature. As UC Berkeley does not provide a V&V package, the suite of 29 problems was developed from the following: 1) eighteen problems were purchased from the Bechtel Corporation in 1990; 2) four problems are examples provided in the UC Berkeley SASSI 2000 User's Manual; 3) six problems are reruns of the previously mentioned problems using the modified subtraction method instead of the direct method; and 4) one problem was developed for the Savannah River Site soil profile. Prior to the release of UC Berkeley SASSI2000 V2.0 for use, satisfactory results from the 29 V&V problems must be obtained and documented.

The Review Team reviewed *Project Specific Master Quality Assurance Plan for the Pit Disassembly and Conversion (PDC) Project*, Document No. G-QP-K-00001, R/0 and found that it addresses SQA.

Level of Oversight

The Assistant Deputy Administrator for Fissile Materials Disposition (NA-26) provided objective evidence that it conducted audits or assessments on various QA and SQA activities. Sample reports were provided to the NNSA review team as objective evidence. Given the scope of this activity, the reports were not reviewed as part of this effort. NA-26 has clarified that even though it has not performed an SQA audit related to SRNS's use of UC Berkeley SASSI2000, QA and SQA processes and procedures that are used to manage the SASSI computer program are reviewed periodically.

Pantex Bays and Cells

Pantex Site Office (PXSO) and BWXT have responded to the 17 questions referenced by the DOE letter to the DNFSB dated July 29, 2011. A preliminary review concluded that the processes in place are satisfactory to ensure that subcontractors have applied SQA requirements necessary for the use of SASSI in safety software applications. BWXT has taken steps to ensure that there is no negative impact to the project from the use of the SASSI subtraction method.

Origin and Applicability of SQA Requirements

BWXT has employed two engineering service providers to conduct seismic analysis: Mr. Carl Costantino in 1998, and ABS Consulting in 2002-2004. Information from CJC&A indicates that UC Berkeley SASSI V1.0 and SDE-SASSI V1.0 was used in the 1998 analysis. The BWXT response indicates that ABS used UC Berkeley SASSI 2000 V2.0. Much of the original procurement documentation for these efforts was destroyed in accordance with records management requirements.

The NNSA review team considered the UC Berkeley SASSI computer program used by BWXT as Commercial Design and Analysis Level B safety software, as recommended under DOE G 414.1-4. Applying this definition is consistent with the information received from BWXT. The CJC&A software would also appear to be Commercial Design and Analysis software.

Implementation of SQA Requirements

The SSI analyses for Pantex Nuclear Explosive and Nuclear Material Facilities were conducted by two subcontracted engineering service providers using their SASSI applications and associated User's Manual, *A System for Analysis of Soil-Structure Interaction*, Rev. 1, November 1999. DOE O 414.1C was not applicable to the work during this time. The tasks involving SSI were contracted as services under DOE O 414.1A, *Quality Assurance*, which did not contain a safety software designation.

The quality assurance requirements are flowed down in the Request for Proposal (RFP) and the draft Statement of Work (SOW). The official contract and procurement-related documents can no longer be provided. The documents were retained for disposition consistent with requirements of DOE O 243.1, *Records Management*, under the General Records Schedule Administrative Records Schedule, section ADM 3.3.a.(1)(a). This disposition schedule states: "Destroy 6 years and 3 months after final payment." Audit documentation for the ABS Consulting contract was recovered and the documentation contains, along with appropriate audit evidence, the RFP as well as the draft SOW.

Information regarding the quality assurance practices performed under the Costantino efforts was not available. The ABS Consulting quality assurance program was demonstrated as being compliant with ANSI/ISO/ASQC Q9001-1994, *Quality Systems*, and ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications.* There were no specifics provided with regard to SQA.

Since the SSI-related analysis were performed prior to DOE's safety software quality assurance requirements being issued, there was no information provided to address how the safety software work activities were implemented by Costantino or ABS Consulting. The audit described above did not address SQA or the 10 SSQA work activities as they relate to the use of SASSI. The audit focused on qualifying ABS Consulting as having a QA program in place to support the RFP and draft SOW (which did not specifically identify SASSI). There was no information provided regarding V&V for the Costantino or ABS Consulting efforts.

Level of Oversight

BWXT recently conducted a thorough review of the ABS Consulting data to V&V the past results (Idaho Spent Fuel Seismic Analysis). PXSO performed an Assessment of STAAD.Pro in 2005.

Chemistry and Metallurgy Research Replacement, the Plutonium Facility, and the Device Assembly Facility

LANS used its SASSI computer program for the CMRR Structural Stiffening Study (scoping use only) and a CMRR preliminary analysis, but the results were not used. Subsequent to this analysis, CMRR contracted with CJC&A for engineering services associated with SSI-related analysis. LANS reports that the preliminary SSI analysis was completed by CJC&A in August 2011. The LANL peer review of CJC&A's product is ongoing.

Reference documents indicate that SSI-related calculations using the SASSI computer program were performed by LANS for CMRR, PF-4, and DAF. DAF is located at the Nevada National Security Site. Correspondence from the Nevada Site Office indicated that use of the SASSI computer program had been initiated in support of the 10-year review of the Design Safety Basis for DAF, but it was halted when the subtraction method issue was identified.

Origin and Applicability of SQA Requirements

LANL reports that the preliminary CMRR SSI-related analysis was accomplished under a LANS subcontract with CJC&A. The subcontract documentation provided was limited to Exhibit D-Task 1: *CMRR Support*, dated 2/10/11, and Exhibit H: *QA Requirements*, dated 1/20/11. Exhibit H states that "…all work activities will be governed by the LANL Quality Assurance (QA) Program as defined in document SD330, *LANL QA Program*." The LANL QA Program meets the requirements of DOE O 414.1C, *Quality Assurance* and 10 CFR Part 830 Subpart A, *Quality assurance requirements*. The original purchase order date was not provided.

Presumably, after letting this subcontract, CMRR sponsored an independent surveillance of CJC&A on 5/17/11. The scope of the assignments was to "compare CJCA's SQAP against the 10 work activities of DOE O 414.1C, Attachment 5 and any applicable parts of NQA-1, Part II, Subpart 2.7, or other consensus codes CJCA uses to implement the analysis." The surveillance found that the CJCA SQAP was in need of revision to comply with these requirements. Subsequently, LANS modified the subcontract, as a revised Exhibit H was provided that better articulated QA requirements flowdown; this version was dated 6/24/11.

CJC&A Form QAP 2-1 R2 – *Software Quality Assurance Plan*: SDE-SASSI dated 7/20/11 indicates that:

> The original source code [SASSI] was obtained by Thomas Houston from UC Berkeley [the SDE principal engineer] (SASSI2000)[5] and modified to run on PC's. Between 1999 and 2009 the code underwent little changes. The module analys was modified in 2009 for modernization (updated matrix solver and constraints were added) by CJCA. This source code is now taken under QA control in this baseline version 2.0.

Implementation of SQA Requirements

CJC&A provided a copy of the software QA procedure QAP2 Rev. 4, *Software Quality Assurance*, dated 7/19/11. Unfortunately, it states that it implements "requirements of ASME NQA-1a-2009, *Addenda to NQA-1-2008 Quality Assurance Requirements for Nuclear Facility Applications*." There is no reference to DOE O 414.1C as specified in the subcontract, Exhibit H, dated 6/24/11. .

CJC&A considers SDE-SASSI Version 2.0 as Acquired software for the purpose of this subcontract and states that it has not modified SDE-SASSI Version 2.0. CJC&A establishes this

[5] Subsequent to this report being finalized, DOE was provided information that Ton Houston provided UC Berkeley SASSI V1.0 (circa 1988) rather than SASSI2000.

pedigree through Form QAP2-2R2, *Software Evaluation/Dedication Report,* dated 7/20/11. The document states that

> CJC-VAL-V-001R3 defines the range of appropriate test problems that are typical of facilities encountered in the analysis of nuclear facilities. Section 4 of this document identifies the following test requirements:
>
> - Required tests and test sequence
> - Required ranges of input parameters
> - Identification of the stages at which testing is required
> - Criteria for establishing test cases
> - Anticipated output values
> - Acceptance criteria

The document appears to reasonably address NQA-1, Part II, Subpart 2.7, Section 302, *Otherwise Acquired Software*. A review of CJC&A-provided Form QAP 2-3R1 – *Software Acceptance Test Report* and Chapter 4 of CJC-VAL-V-001 Revision 3, dated 7/20/11, indicates that testing was successful.

With CJC&A's update of ANALYS09 for SDE-SASSI V2.0, an new user's manual specific for ANALYS09 was generated, ANALYS09 User's Manual, Version 2.0 R2. The document states, under Limitations:

> (b) The current version does not recognize NIMP=1 in module house. To run the direct method of analysis in anal09 input NIMP=3 in module house and identify each of the excavated soil nodes as an interaction node.

This is in contrast to SDE-SASSI V1.3 and previous versions which identifies in the CJC&A User's Manual Chapter 4, pages 4-11, the use of the input parameter NIMP=1 as the direct method and NIMP=3 as the subtraction method.

Level of Oversight

Only one surveillance was received relevant to this subcontract, as indicated above.

Future Actions

DOE believes that its recent actions related to conducting the Information Request evaluation have identified strengths in some SSQA practices as well as weaknesses in others. As described below, both EM and NNSA will continue to evaluate and improve the SSQA practices at the facilities reviewed for this report. Status updates on these future actions will be provided during DOE's periodic QA Briefings to the DNFSB. DOE's Action #4 in response to the DNFSB Board April 8, 2011, letter includes ensuring that SSQA practices are applied during the tasks to develop and generate additional V&V problems to assist SASSI users.

Environmental Management Actions

EM will:

1. Perform additional evaluations of the SBWTP and SWPF SQA programs upon receipt of additional data.
2. Consider conducting an onsite evaluation of SGH's SQA program as it relates to the use of SASSI for the SBWTP project.
3. Work with NNSA to ensure a review of CJC&A's SQA program is performed to ensure its SQA program meets the requirements for the SWPF project.

National Nuclear Security Administration Actions

NNSA will:

1. Ensure that all projects using SASSI have applied SQA practices to their current effort and utilize a V&V practices for its use.
2. Conduct a follow-up assessment with CJC&A, the major service provider of SASSI analysis for NNSA projects, to ensure that corrective actions have been identified and are successfully implemented. This follow-up assessment will be coordinated with EM.
3. Ensure that SQA is included as part of the Chief of Defense Nuclear Safety (CDNS) Biennial Reviews, Detailed SQA Criteria and Review Approach Document will be developed for this effort.
4. Evaluate contracting and procurement records retention schedules for engineering service providers using safety software in design and analysis activities that supports a facility safety bases. Provide follow-up recommendations based on that evaluation.
5. Review LANL and LASO SASSI SQA program implementation to fully understand the use of SASSI and to identify any corrective actions needed to address any deficiencies noted.
6. Ensure all Sites have implemented DOE O 414.1D, Attachment 4, *Safety Software Quality Assurance Requirements for Nuclear Facilities*, and the Contractors Requirements Document attached to the Order. NNSA/DOE personnel perform a shadow baseline SQA assessment to ensure that SQA practices have been implemented at each of the sites.

Appendix A. References

1. F. Ostadan, *SASSI2000 - A System for Analysis of Soil-Structure Interaction, User's Manual*, Ver. 3, August 2009.
2. J. Lysmer, M. Tabatabaie-Raissi, F. Tajirian, S. Vahdani, and F. Ostadan, *SASSI – A System for Analysis of Soil-Structure Interaction*, Report No. UCB/GT/81-02, Department of Civil Engineering, University of California, Berkeley, April 1981.
3. C. C. Chin, *Substructure Subtraction Method and Dynamic Analysis of Pile Foundations*, Ph.D. Dissertation, Department of Civil Engineering, University of California, Berkeley, 1998.
4. U.S. Department of Energy, *U. S. Department of Energy Report on Technical and Software Quality Assurance Issues Involving the System for Analysis of Soil-Structure Interaction*, July 29, 2011 (Response to Defense Nuclear Facilities Board Letter dated April 8, 2011).
5. U.S. Department of Energy, DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A,* Quality Assurance Requirements*, and DOE O 414.1C,* Quality Assurance, June 2005.

Appendix B. Questions for SSQA Information Request

Questions for DOE Prime Contractors and Subcontractors:

Software Identification

1. Provide a copy of the safety software inventory list. If the inventory list does not include the following, identify the: a) complete name of the SASSI software; b) version identifier; c) provider organization or company name; d) date of acquisition used for this project, e) grading level of safety software, and f) facility hazard category of the facility/project where SASSI was used. Please ensure the date of the safety software inventory is included. If SASSI is not considered safety software in your project, describe why it does not meet the definition of safety software as described in DOE O 414.1C.

Procurements

2. If SASSI was acquired, identify the organization and describe the process used to obtain your version of SASSI. Provide the procurement documents associated with the acquisition of SASSI. Identify which of the 10 safety software work activities were flowed down to the supplier. If not all 10 were flowed down, state why those not flowed down were not applicable. Include the procurement document(s) that specifies the level of control DOE and/or its contractors have on the quality of the software for SASSI use.
3. If SASSI is being used by an engineering service provider who owns this software for your site/facility, identify the quality assurance requirements flowed down to the service provider. Provide the procurement, statement of work, and any other contractual agreements. Identify which of the 10 safety software work activities were flowed down to the engineering service provider. If not all 10 were flowed down, state why those not flowed down were not applicable. Include the procurement document(s) that specifies the level of control DOE and/or its contractors have on the quality software service for SASSI use.

SQA Work Activities and Procedures

Please respond to the questions in this section (#4-#16) for custom, acquired, or engineering service provider as they relate to development, modification, or use of SASSI.

General

4. Identify all software consensus standards; include editions (e.g., ASME NQA-1-2000, IEEE-730-2002, and ISO 9000-3-2004) that are related to SASSI on your project. If a mapping of the consensus requirements to company procedures exists, please provide this mapping. If a mapping does not exist, please provide information regarding if all or portions (and what portions) of those consensus standards are being met.
5. Identify the type of software (e.g., custom or acquired) that SASSI is considered to be in your project.
6. Describe the process for the software development, modification, acquisition, and/or use of SASSI. Additionally, provide a list, including document identifier and title, for all company software procedures that apply SASSI in your project.
7. Describe how the 10 safety software work activities in DOE O 414.1C were implemented for SASSI.

8. Provide a list, including document identifier and title, and a brief description of all software life cycle documentation associated with SASSI in your project.

Change Management

9. Describe the strategy for managing and controlling the version of SASSI used in your project.
10. If SASSI is characterized as custom software, describe how changes are initiated, evaluated, and approved. Include how changes are controlled prior to approval of the change.
11. Describe the process and documentation maintained for reporting and tracking to resolution any suspected errors related to the use of SASSI. If a problem has been identified, provide the documentation associated with reporting and tracking it.
12. Provide a list of all problems encountered with SASSI along with the investigative and corrective actions taken to resolve those problems; including who or what entity has been consulted to date. Provide copies of all documentation associated with the subtraction method problem.

Verification and Validation

13. Describe how the test process provides for evaluating technical adequacy through comparison of test results from alternative methods such as hand calculations, calculations using comparable proven programs, or empirical data and information from technical literature. Include in the descriptions the steps used in verifying safety software requirements and validating proper installation, correct functioning, accurate results of SASSI use.
    a. Describe any limitations, constraints, restrictions in using SASSI for the analysis of the project/facility.
    b. Describe the sensitivity analysis performed to ensure the use of SASSI and the results are within a well-defined area of the phenomena investigated.
    c. Describe the set of test problems used to validate each functional capability of SASSI and the rational for selection.
    d. Describe the set of test problems used to verify of SASSI.
14. Describe the process for retesting SASSI. Include the criteria used to determine when and what level of retesting is required. Describe the circumstances when such testing is necessary.
15. Describe the testing process used to approve SASSI for use.

Personnel Training

16. Describe the process for defining and ensuring the appropriate level of qualification of the users of SASSI including the disciplines of soil-structural engineering and software quality assurance.

Questions for DOE/NNSA Site Offices:

17. Provide a copy of the approved Quality Assurance Program (QAP) with approval signatures that governs any development, acquisition and/or use of SASSI for this project. If the QAP has not been formally approved, provide documentation of the QAP submittal to the appropriate approval authority, including the QAP submitted. If the QAP is proprietary, provide a copy of DOE approval authorizing its use on your project.

18. Describe what the reviews, surveillances, assessments or other oversight activities performed by a) DOE/NNSA HQ, b) field offices, and/or c) prime contractor organization, which activities were performed to ensure that the QA activities associated with the development, acquisition and/or use of SASSI were implemented in accordance with the QAP or other requirement. Include dates, summary reports, and qualification of reviewers for these reviews, surveillance, assessments or other oversight activities.

Appendix C. Criteria Used to Evaluate Field Responses to SSQA Information Request

Project Name: _____

Site: _____

SASSI Product Name and Version ID: _____

The purpose of this checklist is to assist in consistent evaluation of information received from the sites in response from the SSQA Information Request. The checklist is based upon the Information Request Final Rev. 3 and the EM Standard Review Plan SQA Review Module. The SRP SQA RM identifier is included in the LOI descriptions.

Note: the following LOIs should be applied according to the contractor's graded approach. Thus, if the contractor's graded approach does not include traceability to lifecycle documents, this should be noted in the comments for that LOI.

Questions for DOE Prime Contractors and Subcontractors:

Question ID	LOI	Meets	Doesn't Meet	Comments
#01 Software Identification	Is SASSI included in the safety software inventory list and does the entry include the following: unique identifier, software name, version identifier, safety software designation, any grade level description, and responsible individual? (CD-2.41)			
#02 Procurements	If SASSI was procured or otherwise obtained from another organization or company, what is the name of that organization/company?			
#02 Procurements and #03 Procurements	If SASSI was procured, otherwise obtained from another organization or company, or used by an engineering service provider do contractual documents (i.e. procurement or service agreements) identify the			

Question ID	LOI	Meets	Doesn't Meet	Comments
	requirements for purchasers to report problems to the supplier, the method for the purchasers to report problems to the supplier, and any required supplier response? (CD-2.10) Note: Work Activity #9 Problem Reporting and Corrective Action.			
#02 Procurements and #03 Procurements	If SASSI was procured, otherwise obtained from another organization or company, or used by an engineering service provider do contractual documents (i.e. procurement or service agreements) include the technical and quality requirements for the safety software? (CD-2.11) Note: Work Activity #5 Software Requirements Identification and Management.			
#02 Procurements and #03 Procurements	If SASSI was procured, otherwise obtained from another organization or company, or used by an engineering service provider do contractual documents (i.e. procurement or service agreements) were the remainder of the applicable safety software work activities flowed down? If not, why? a) Work Activity #1 Software Project Management and Quality Planning b) Work Activity #2 Software Risk Management c) Work Activity #3 Software Configuration Management d) Work Activity #6 Software Design and Implementation e) Work Activity #7 Software			

Question ID	LOI	Meets	Doesn't Meet	Comments
	Safety f) Work Activity #8 Verification and Validation g) Work Activity #10 Training of Personnel			
#03 Procurements	If SASSI was used by an Engineering Service provide, what is the name of that service provider?			
#04 SQA Work Activities: General	Do the consensus standard(s) are being/were applied to SASSI that was developed, maintained, or procured and used during the project design and construction phases meet DOE's requirements for safety software? (CD-2.43) For safety software, the consensus standard must be either ASME NQA-1-2000, ASME NQA-1-2008, or other DOE approved consensus standard.			
#05 SQA Work Activities: General	Identify the type of software (e.g., custom or acquired) that SASSI is considered to be in your project.			
#06 SQA Work Activities: General	Does the process/procedures for the software development, modification, acquisition, and/or use of SASSI comply with the DOE approved consensus standard(s) for safety software?			
#07 SQA Work Activities: General	Were all appropriate safety software work activities implemented correctly for SASSI? Including the following: 1. Does the Risk Management Plan or other software specific risk management plan include risks and their			

Question ID	LOI	Meets	Doesn't Meet	Comments
	mitigation approaches? (CD-2.4) 2. If applicable, are software configuration management work activities for SASSI applied at the point of the contractor's control of the software? (CD-2.5) 3. For DOE contractors, suppliers/service providers that develop SASSI, is a baseline labeling system uniquely identify each configuration item, changes to configuration items by revision, and provide the ability to uniquely identify each configuration been implemented? (CD-2.6) 4. For DOE contractors, suppliers/service providers that develop SASSI, are software verification activities performed after a change to SASSI to ensure the change was implemented correctly? (CD-2.7) Note: verification should include changes to the software documentation. 5. Were procurement documents assessed for completeness, and to ensure the quality of the software being purchased? (CD-2.12) 6. Do software requirements identify functional; performance; security (including user access control); interface and safety requirements; and installation considerations and design constraints where appropriate? (CD-2.13)			

Question ID	LOI	Meets	Doesn't Meet	Comments
	7. Are the contractor's requirements for SASSI traceable to software procurement documents? (CD-2.14)			
#08 SQA Work Activities: Software Life Cycle Documents	Were all the applicable SASSI software lifecycle documents provided?			
#09 SQA Work Activities: Change Management	Does the strategy for managing and controlling the version of SASSI used in your project comply with the Contractor's procedures?			
#10 SQA Work Activities: Change Management	For DOE contractors, suppliers/service providers that develop SASSI, do the software change procedures require that proposed changes to SASSI be documented, evaluated, and approved for release? (CD-2.7)			
#11 SQA Work Activities: Change Management	Are suspected errors reported and tracked to resolution?			
#12 SQA Work Activities: Change Management	For any problems encountered with SASSI, do the investigative and corrective actions taken to resolve those problems meet the Contractor's procedures?			
#13 Verification & Validation	Do procedures require validation activities to be performed at the end of the software development or acquisition processes to ensure the software meets the intended requirements? (CD-2.27)			
#13 Verification & Validation and #07 SQA Work Activities: General	Are V&V activities performed by competent staff other than those who developed the item being verified or validated (CD-			

Question ID	LOI	Meets	Doesn't Meet	Comments
	2.28)?			
#13 Verification & Validation and #07 SQA Work Activities: General	Are software tests described in test plans containing objective acceptance criteria? (CD-2.31)			
#13 Verification & Validation and #07 SQA Work Activities: General	Are test activity documents placed under configuration management? (CD-2.32)			
#13 Verification & Validation	Is the testing process adequate to evaluate the technical correctness of SASSI?			
#14 Verification & Validation	If changes were made to SASSI, was the retesting adequate?			
#15 Verification & Validation	Was the testing of SASSI meet the Contractor's procedures?			
#16 Verification & Validation	Have the users of SASSI been appropriately trained for is use?			
#17 QAP	Does the Contractor's approved QAP comply with DOE's requirements for safety software?			
#18 Oversight	Have reviews, surveillances, assessments or other oversight activities been performed to ensure that the QA activities associated with the development, acquisition and/or use of SASSI were implemented in accordance with the QAP?			