

QA: QA

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
OFFICE OF QUALITY ASSURANCE**

**REPORT FOR AUDIT OQAP-BSC-03-07
OF SOFTWARE AND SOFTWARE ACTIVITIES AT
BECHTEL SAIC COMPANY, LLC,
LAWRENCE BERKELEY NATIONAL LABORATORY, AND
LAWRENCE LIVERMORE NATIONAL LABORATORY
IN LAS VEGAS, NEVADA,
BERKELEY, CALIFORNIA, AND
LIVERMORE, CALIFORNIA**

JUNE 3 - 13, 2003

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EXECUTIVE SUMMARY

Auditors representing the Office of Civilian Radioactive Waste Management (OCRWM) conducted a performance-based audit of the quality-affecting software activities performed by Bechtel SAIC Company, LLC (BSC) and supporting national laboratories. The audit was conducted from June 3 to 13, 2003. The limited-scope audit was performed to evaluate the implementation of the requirements contained in the DOE/RW-0333P, Revision 13, *Quality Assurance Requirements and Description* (QARD), and the processes used to develop, qualify, and control software associated with the Yucca Mountain Project License Application (LA).

Except as noted, the audit team concluded that the software procedures and processes are adequate (i.e., upper-tier requirements are identified in the implementing procedures), that the implementation of the procedures is marginally satisfactory, and the processes are marginally effective in producing software documentation and software controls that will meet LA requirements.

The audit team reviewed the results from all phases of the software development life-cycle. These included requirements, design, implementation, testing, installation and checkout, O&M, and retirement. It was determined that all phases of the life-cycle are being addressed. Some deficiencies were noted and are documented in the applicable section of this report along with the identification of the associated deficiency report or quality observation.

Several of the noted conditions adverse to quality could affect confidence in an adequate defense of the software because the deficiencies are in critical areas of the software development life-cycle processes. Confidence in the software to achieve its intended function should be further evaluated during assessments of the legacy software retest activities. Additional assessments should be conducted when more samples of software activities and processes are available for review.

It is important to note that the majority of the software reviewed by the audit team had not gone through an independent verification and validation (IV&V) process. The IV&V process was added to ensure that many of the types of conditions noted by the audit team would be identified and corrected prior to submittal of the LA. In no case were conditions adverse to quality identified where the audit team was able to determine that the software would not meet its intended function. While the IV&V process is essential at this point in time, the need for IV&V indicates a lack of previous compliance with procedures related to planning and implementing software processes.

Five software sub-processes were determined to be ineffective: 1) technical review, 2) software categorization, 3) planning, 4) design, and 5) testing. The effectiveness of two of the software sub-processes (implementation and legacy software) were considered to be indeterminate due to the lack of sufficient numbers of Level A software that have completed the software development and IV&V processes as well as the legacy software retest process. The legacy software retest has not been fully implemented. In addition, the sub-process related to the

Requirements Phase is considered to be indeterminate for Revisions 4 and 5 of Administration Procedure (AP)-SI.1Q, *Software Management*, due to the limited number of software codes developed. The remaining 20 sub-processes were all determined to be effective.

Note: “Marginal” is a subjective term that is intended to reflect the condition of less than perfect, but better than a condition that requires extensive improvements. In any of the designations, identified conditions adverse to quality are documented on Condition Reports, regardless of the rating.

The audit team identified procedural inadequacies in the areas of 1) technical reviews, 2) planning, and 3) the design and implementation phases of the life-cycle processes. The implementation of procedural requirements was determined to be unsatisfactory for several of the sub-processes: 1) categorization, 2) the implementation and testing phases, and 3) software documentation.

Eight conditions adverse to quality (documented in Deficiency Reports [DR]) and five isolated conditions (Quality Observations) were identified. In addition, the audit team provided 17 recommendations for management consideration to improve processes. These conditions are summarized in Sections 4.3, 4.4, and 4.5.

The DRs detail; deficiencies in:

1. Status accounting activities
2. Software technical reviews
3. Software categorization and planning processes
4. In-use tests for continuous data acquisition software
5. Software Configuration Control Requests
6. Design phase documentation
7. Software implementation phase
8. Testing documentation

The five Quality Observations involve isolated deficiencies in the use of software and in the software documentation. The remaining sub-processes were determined to be adequate, satisfactorily implemented, and effective, except as noted.

The audit team strongly recommends that the detailed and specific planning activities eliminated from the current revisions of the software procedures be reinstated. Many of the deficiencies identified in this report reflect a lack of effective initial planning.

It is important to note that recently implemented corrective actions may help to preclude the occurrence of repetitive conditions. The corrective actions include: 1) the identification of new software processes, 2) increased management emphasis on the proper implementation of procedures, and 3) improved definitions of the roles, responsibilities, authority, and accountability of personnel involved with the software process. The effectiveness of these corrective actions could not be thoroughly assessed due to their recent implementation. Future assessments should address this determination.

The audit team noted a best practice at Lawrence Livermore National Laboratory (LLNL). The LLNL Software Coordinator developed and maintains a color-coded graphical software status list. This provides an effective method to identify the status of software qualifications.

The audit team also identified a second notable practice. Although newly implemented, the IV&V process, controlled by AP-SI.1Q, Revision 5, and AP-SI.3Q, Revision 1, *Software Independent Verification and Validation*, has resulted in improved software qualification results. The IV&V organization continues to improve the evaluation process, and overtime, IV&V should produce positive results in ensuring defensibility of the software development process.

1.0 SCOPE

Representatives of the OCRWM Office of Quality Assurance (OQA) conducted a performance-based audit from June 3 to 13, 2003, of software activities and processes at BSC and supporting national laboratories. The audit team reviewed the adequacy of the applicable software procedures, the software controls, the life-cycle products, and the effectiveness of the associated processes. In addition, the audit team reviewed procedures to provide assurance that the software requirements identified in the QARD have been included and are being effectively implemented.

The audit team evaluated the critical process steps of the development, acquisition, qualification, control, test, use, and documentation of software to be used in products that will support the LA.

The team conducted the audit using a process that divided the overall software processes (software development, acquisition, qualification, use, retirement, and control) into 28 sub-processes (see Attachment 1). Attachment 2, "Example of Software Process Steps and Performance-Based Measurements," provides a description of a representative software sub-process (software design) and the software process steps, performance measurements, and topics.

The audit team evaluated each of the sub-processes from a performance-based perspective, identifying the objective, the importance, the critical steps, and measures to evaluate the end-objectives and end-products of each of the sub-processes. The identified measures formed the basis for the checklist questions used during the audit. Where specific requirements were not identified, the audit team offered improvement recommendations for management consideration.

In addition, the audit team evaluated previous software conditions adverse to quality to determine the effectiveness of the completed corrective actions.

2.0 AUDIT TEAM MEMBERS AND OBSERVERS

Audit Team Members (see Attachment 3, "Audit Team Assignments"):

Marlin L. Horseman, Navarro Quality Services (NQS)/Audit Team Leader, Las Vegas, NV
Samuel E. Archuleta, NQS/Auditor, Las Vegas, NV
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Observers

Ted Carter, U.S. Nuclear Regulatory Commission (NRC)/Observer Team Leader, Rockville, MD
James Firth, NRC, Rockville, MD
Rod Weber, Southwest Research Institute/Center (SRIC) for Nuclear Waste Regulatory
Analyses, San Antonio, TX
Mark Ehnstrom, SRIC, San Antonio, TX
Randy Folck, SRIC, San Antonio, TX

3.0 AUDIT MEETINGS AND PERSONNEL CONTACTED

A pre-audit meeting was held on June 3, 2003, in Las Vegas, Nevada (and at Lawrence Berkeley National Laboratory [LBNL] and LLNL, via telephone). Daily team caucus meetings were conducted to identify the progress of the audit and to discuss audit status, including potential conditions adverse to quality. Daily management meetings were held to inform BSC and laboratory management of audit issues and status. The audit concluded with a post-audit meeting on June 13, 2003, in Las Vegas, Nevada.

Personnel contacted during the audit, including those who attended the pre-audit and post-audit meetings, are listed in Attachment 4, "Personnel Contacted During the Audit."

4.0 SUMMARY OF AUDIT RESULTS

4.1 PROGRAM ADEQUACY, IMPLEMENTATION, AND EFFECTIVENESS

Section 4.2 describes the audit activities in detail. The audit team concluded that the overall software process and products were adequate, but marginally implemented and marginally effective. Sections 4.3 and 4.4 describe the conditions adverse to quality identified by the audit team. Section 4.5 lists audit team recommendations.

4.2 AUDIT ACTIVITIES

The major processes and activities evaluated by the audit team include:

1. Technical reviews
2. Software life-cycle processes

3. Software control processes
4. Related interface processes
5. Software administrative processes
6. Software processes and activities performed at LBNL and LLNL
7. An evaluation of the effectiveness of previous software corrective actions

Attachment 5, “Summary Table of Audit Results,” provides the results for each of the sub-process evaluations. Details of audit activities, including a description of the objective evidence reviewed and the *Performance-Based Audit Worksheets*, are documented in the audit checklist.

The checklist is processed as a QA record in accordance with AP-18.3Q. The software and the related documentation reviewed are identified in Attachment 6, “Software Code and Documentation Evaluated During the Audit.”

4.2.1 Technical Reviews

The audit team evaluated several software review processes including software algorithms, software categorization, and software verification and validation.

Software Algorithms

The algorithms contained in a sample of eight developed or acquired, Level A and Level B codes were reviewed to evaluate the scientific basis, assumptions, conceptual models, and technical adequacy. The assessment included an evaluation of the mathematical core of the software and the test cases used to verify the numerical operations.

The algorithm process was determined to be adequate, implemented, and effective, with the exception of acquired software where the lack of design documentation concealed knowledge of the algorithm. A recommendation to require disclosure of algorithms in the user manuals or another location, as appropriate, has been made (see Section 4.5, items 2 and 10).

Section 2.2.10 of the QARD describes the requirements for performing technical reviews. These requirements were not adequately addressed in AP-SI.1Q and AP-SI.2Q, Revision 1, *Qualification of Level A Software*, nor was the requirement for retention of records to document the review included in the procedures. This condition adverse to quality was previously identified in BSC(O)-02-D-099 (now closed). This appears to be a recurring condition. As a result, the audit team has initiated DR BSC (O)-03-D-173 (see Section 4.3.2).

The audit team concluded that the software process for the technical review of the evaluated codes was not adequately described in the processes. Technical review activities were not effective in ensuring that all technical requirements were met.

Software Categorization

This process requires categorization of the critical nature, function, and complexity of the software. The purpose is to identify the format of the qualification documentation and the timing of the verification activities. Qualification packages for seven codes developed under AP-SI.1Q, Revision 3 (or earlier) and fourteen codes developed under AP-SI.1Q, Revision 4 (or later) were reviewed. The categorization process for codes developed under AP-SI.1Q, Revision 3 (or earlier) was determined to be adequate, satisfactorily implemented, and effective in ensuring that technical requirements were met.

However, there were issues identified that related to the implementation of procedural changes in categorization beginning with Revision 4 of AP-SI.1Q. The new process created issues related to categorization transparency and proper form completion. As a result, DR BSC (O)-03-D-174 (see Section 4.3.3 of this report) was issued along with a recommendation for improvement (see Section 4.5, item 5).

Overall, the audit team concluded that the categorization process was adequate, but unsatisfactorily implemented and not effective in meeting the process goal of ensuring the defensibility of specified software and documentation requirements.

Software Verification and Validation

The audit team evaluated Software Development Packages for the LA to provide assurance that verification and validation activities are being implemented and properly documented.

In addition to the codes identified in Attachment 6, the audit team reviewed a number of other software development packages. Many of these were legacy software developed under previous revisions of the procedures and prior to the formation of the current IV&V organization and the current IV&V processes.

The audit team noticed an obvious improvement of the quality of the legacy software and related documentation that have been through the new IV&V process. Although the sample was somewhat limited, it was sufficient to conclude that the new IV&V function will have a positive impact on the quality of developed software and documentation. The audit team did not identify any recommendations or conditions adverse to quality in this area.

However, the IV&V is a review performed to ensure that the final product is acceptable and that development V&V activities were effective. The audit team recommends that periodic reviews and measurements be made to assess the effectiveness of the developed and acquired software V&V processes, based upon the IV&V findings. Any performance issues should be the subject of a process improvement activity.

Overall, the audit team concluded that the IV&V process is adequate, that the procedural implementation is satisfactory, and that the process is effective. However, the development V&V processes need improvement to preclude the need to inspect quality into the software products by the IV&V organization.

4.2.2 Software Life-Cycle Activities and Processes

The audit team evaluated each of the seven life-cycle phases (Requirements, Design, Implementation, Testing, Operating and Maintenance, Installation and Checkout, and Retirement). In addition, an overall evaluation of the entire life-cycle was made. The following discussions summarize audit team activities, results, and conclusions for each phase.

The Requirements Phase

Requirements are contained in Requirements Documents (RDs), or they are described in the *Description and Testing* sections of Software Management Reports (SMRs). The level of detail in the RD varies depending on the complexity and application of the software.

The ultimate or principal user, who understands both the requirements and the functionality of the product, often prepares the requirements. The primary advantage is that the requirements are clear to that user. However, should the code need modification or its functionality come into question without recourse to the originator, understanding could be difficult. With few exceptions, an audit team review of the full software requirements package provided sufficient confidence that a knowledgeable user could understand and use the software. In the absence of specific guidelines for the creation of requirements, the requirements reviewed by the audit team appear to be satisfactory. However, two recommendations have been identified (see Section 4.5, items 7 and 11).

The determination of effectiveness of the development process used to identify requirements can best be measured in the quality of the Level A RD or the SMR for Level B software. The audit team reviewed numerous requirements and determined that the defined requirements meet the QARD. Current practices are to only trend those software defect notices (SDN), now called Software Problem Reports (SPR), that reflect conditions adverse to quality. To date, only a few SDNs have been determined to reflect conditions adverse to quality. However, in the absence of quality trending of SPRs it is difficult to evaluate the ongoing quality of RDs and other software documentation because defects are only tracked on an individual basis. If additional SPRs are initiated in the future, the audit team recommends that trending be performed. Two recommendations have been identified in this area (see Section 4.5, items 3 and 4).

Overall, the audit team concluded that the Requirements Phase is adequately defined, that procedural implementation is satisfactory for Revision 3 of AP-SI.1Q and indeterminate for Revisions 4 and 5 due to an insufficient number of Level A codes available for review. However, for the available codes the process is effective in specifying software requirements.

The Design Phase

The audit team reviewed 14 software codes to evaluate the software design process. Because only one Level A developed code had completed the IV&V process, design documents were also evaluated that had not yet been through the IV&V process.

The review determined that the design documentation for Level A developed software specifies that the major components of the system be designed in a manner that allows the design to be traced to the system requirements. However, design documentation, allowing the traceability, is not required or available for acquired software. Current procedures do not require the documentation of the architectural design for Level B software as required by the QARD. Although the design documentation did define the theoretical basis, it did not consistently document control flow, data flow, control logic, or input and output ranges.

Some design documentation only addressed design changes incorporated into the revised baseline. Isolated examples of inadequate design traceability, design entity description, and data structures were also identified. DR BSC(O)-03-D-177 documents these conditions adverse to quality (see Section 4.3.4).

Overall, the audit team concluded that the design process is inadequately defined, that procedure implementation is indeterminate, and that the process is not effective in documenting the design basis.

The Implementation Phase

Because only one Level A developed code has completed the IV&V process, additional examples of software and related documentation were also evaluated that had not yet gone through the IV&V process.

The audit team determined that the implementation documentation for Level A and Level B developed software does not properly define coding standards, conventions, or practices. The current procedure identifies “suggested” coding standards for Level A software, but there was no evidence that the suggested practices were implemented. The Level B software procedure does not address QARD requirements for programming standards. As a result, internal code documentation for Level A and Level B codes were incomplete with no consistent definition of code history, naming conventions, or logic flow.

The process for performing and documenting implementation activities was reviewed for 14 codes. Several deficiencies pertaining to inadequate documentation of implementation activities were identified.

AP-SI.1Q and AP-SI.2Q do not specify detailed requirements for documentation of coding standards. As a result, there is a lack of consistency in coding standards for developed software. In some cases, implementation documentation consisted of the source code alone, with no description of how component-level code was integrated or how explicit connections and dependencies within modules was provided. Implementation coding did not, in many cases, provide sufficient reference to design or requirement elements. Implementing procedures should be revised to provide additional guidance in the area of implementation. DR BSC(O)-03-D-178 was initiated to document the conditions adverse to quality (see Section 4.3.5).

Overall, the audit team concluded that the implementation phase is inadequately defined, that procedure implementation is unsatisfactory, and that the process effectiveness is indeterminate.

The Testing Phase

The process for planning, performing, and reporting validation testing activities was reviewed for 24 codes. Because only one Level A and less than 30 Level B developed codes had completed the IV&V process prior to the audit, samples were also evaluated that had not yet been through the IV&V process.

The review determined that testing is the primary method of software validation. Test activities are performed, documented, and verified at the end of the implementation phase. However, the test documentation evaluated by the audit team did not always demonstrate that the software was tested over its full operational range, and the test cases were sometimes limited to a partial set of input ranges.

In addition, test documentation did not always provide quantitative acceptance criteria for the software performance and did not consistently describe the hardware and software configuration used for testing. Isolated examples of inadequate requirement traceability, regression testing, and the documentation of test conclusions were also identified for ACUSOLVE, TOUGH2, and STRAT2AVS. DR BSC(O)-03-D-179 documents the conditions (see Section 4.3.6).

Overall, the audit team concluded that the testing process is adequate, that procedural implementation is unsatisfactory, and that the process is not effective in ensuring acceptable tests.

The Operating and Maintenance Phase

Various software qualification packages were reviewed to confirm that the documentation was acceptable prior to the release of the software for use. No deficiencies were noted. The Software Configuration Management (SCM) organization is responsible for controlling the configuration of all software items. Software can only be used if it has been requested on a Software User Request (SUR) and then issued by SCM. For work controlled directly by BSC, positive controls of the software were determined to be in place.

When software is released to the field, the Software Coordinator monitors the appropriate controls. It is recommended that SCM take a more active role in confirming the configuration of the system in the field (e.g., reviews or other assessments). This would help ensure software status controls are being implemented and are effective. During the audit, several code configurations were examined and no deficiencies were noted other than the improper identification of approved users and environments, which is described in a subsequent paragraph. However, the audit team recommends that SCM conduct similar periodic surveys (see Section 4.5, item 8).

The evaluation of the Operating and Maintenance (O&M) Phase confirmed that O&M requirements are understood and implemented. Interviews conducted with the staff at all three locations determined that personnel understood their roles and responsibilities in relation to O&M and that the O&M requirements were being adequately implemented. A direct

comparison of the directory files of the qualification package was performed against the SCM media, and also against the directory in the field. The files were in agreement, and no deficiencies were noted. The control of continuous operating software was reviewed with several affected organizations.

Continuous operating software is defined as software that is used to continuously collect data or used to monitor process control equipment. This type of software must be periodically checked to confirm proper operation. The implementing procedure contains the appropriate requirements, but it does not tie in well with the processing of the Software Management Report (SMR). Therefore, implementation of the requirements is not consistent. Continuous operating software is not clearly identified by SCM. The recording of periodic checks is not being consistently implemented. This condition is documented in DR BSC(O)-03-D-175 (see Section 4.3.7).

Conditions identified during software O&M are problems that have passed through the rigors of verification and validation and, if not found, could have an adverse impact on the quality of the technical product. When a defect is identified, it is reported and tracked to closure using a SDN or SPR. Part of the SDN process is to perform an impact analysis. Some impact analyses were not performed in a timely manner. Because of the importance of evaluating the impact of past and present product use, the analysis should be performed and documented as quickly as possible. The audit team has identified two recommendations related to SDN timeliness and the performance of impact analyses (see Section 4.5, items 12 and 14).

Each SDN and SPR is evaluated to determine if it is a condition adverse to quality. But, unless a condition adverse to quality is identified, the conditions are not evaluated for trends that could identify an overall indication of problems. While this may be appropriate at the present, due to a limited number of problem documents, in the future the audit team recommends that a periodic trending of SDNs and SPRs be implemented (see Section 4.5, item 13). Overall, the audit team concluded that the O&M phase was adequately defined, that procedure implementation was satisfactory, and that the process was effective.

The Installation and Checkout Phase

The audit team evaluated five of six installation and checkout test plans (ITPs) and Software User Requests (SURs) related to Total System Performance Assessment (TSPA)-LA software and 15 other ITPs approved for use. The dynamically linked libraries (dll) software run with GOLDSIM verified that the ITP included the necessary information to allow users to install the requested code.

In addition, the audit team reviewed the ITP for transparency, detail, instructions, and the proper implementation of the associated SUR process described in AP-SI.1Q. The processes for proving that the correct executable or object was installed, tested, verified, and identified were also reviewed and determined to be effective.

The team verified that one of the five dlls for TSPA was correctly installed on the identified platform and that the user was identified on the SUR. The installation of the other four dlls was indeterminate because the user list and the operating environment identified on the two user lists were not identified on the SUR. DR BSC (O)-03-D-172 (see Section 4.3.8) documents this omission. The baselines that were reviewed by the audit team at LBNL and LLNL were installed correctly.

Overall, the audit team concluded that the installation and checkout phase was adequately defined, that the procedure implementation was satisfactory, and that the process was effective in ensuring that proper installation and checkout activities were performed and documented.

The Retirement Phase

When software is retired, positive controls are required to ensure that the software is removed from the baseline. Electronic-mail is sent to all software users indicating that the retired software is no longer authorized for use. The users are responsible for ensuring that the software is not used and that the software is removed from controlled machines. The use of retired software was discussed with users and directories were reviewed to confirm that retired software is not in use in the field.

AP-SI.1Q, Revision 5, does not address the removal of retired software from the installed platform. One recommendation was issued for the retirement of one code no longer in use (see Section 4.5, item 9). No deficiencies or Quality Observations were identified in this area.

Overall, the audit team concluded that the retirement phase was adequately defined, that the procedure implementation was satisfactory, and that the process was effective in removing software no longer used from the baseline.

The Overall Life-Cycle

The audit team evaluated the collective assessment results of the individual life-cycle phases and concluded that the overall life-cycle processes were adequate, marginally implemented, and that the processes were marginally effective in ensuring the proper execution of all life-cycle processes, except as noted.

4.2.3 Software Control Activities and Processes

The audit team evaluated software control activities, including software procedures, configuration management, error reporting, and the traceability of the software into the technical product.

Software Procedures

The applicable software procedures include AP-SI.1Q, *Software Management*, AP-SI.2Q, *Qualification of Level A Software*, AP-SI.3Q, *Software Independent Verification and Validation*, AP-SI.4Q, *Independent Verification and Validation of Legacy Code*.

A review was performed to assure that appropriate QARD requirements were included in the software implementing procedures. The audit team concluded that, in general, the appropriate QARD requirements were identified in the implementing procedures, except as noted throughout this report.

A large number (15) of changes (revisions and Interim Change Notices) have been made to AP-SI.1Q over the previous five-year period. The impact of making a large number of procedural revisions can make implementation inconsistent due to the changing procedural requirements, even though the upper-tier requirements have not changed. It was noted that several of the major revisions were due to efforts to correct the procedure problems “once and for all.” In general, the drivers for making procedural changes include Document Action Requests, audits, procedure reviews, and changes to interfacing procedures.

The evaluation included a review of deficiency documents to determine if procedural adequacy or implementation was the apparent causes of deficiencies. The review of 86 software-related deficiency documents issued over the last four years indicated that only four were indicative of procedural content problems. Several had to do with specifically not following procedures and many others could certainly be put into that category.

During the course of the audit, the team identified five recommendations related to the adequacy and implementation of the software procedures (see Section 4.5, items 1, 3, 4, 5, and 15).

Overall, the audit team concluded that the software procedures are adequate (except as noted). Implementation of the procedures, as indicated by implementation results in other audited areas, is marginally satisfactory. The procedural process is marginally effective in identifying the processes used to develop, qualify, and use software.

Configuration Management

The audit team evaluated 35 of over 600 codes qualified by Software Configuration Management (see Attachment 6). The audit team also reviewed the steps required to allow users to install the requested software. In addition, the audit team reviewed the SCM processes for configuration identification, control, status accounting, and authentication, including the processes for 1) identifying how input and output files are controlled, 2) the control of the source code, and 3) the control of executables and objects.

The audit team determined that the approved user list was not accurate, resulting in an inability to verify installations of the hardware identified on the SUR. DR BSC (O)-03-D-172 (see Section 4.3.8) documents this omission. A missing page 3 of the Software Configuration Control Request (SCCR) for the FLOWCON code was identified and documented on DR BSC (O)-03-D-176 (see Section 4.3.9). In addition, two recommendations (see Section 4.5, items 8 and 16) address field integrity of the baseline and Control Point B activities.

Overall, the audit team concluded that the software configuration controls were adequately defined, that procedure implementation was marginal, and that the processes were marginally effective in ensuring effective software controls.

Error Reporting

The software error reporting process was evaluated. This process requires that software problems be reported, that the associated impacts be assessed, and that the identified problems be corrected in a timely and controlled manner. At the time of the audit, 37 open and 35 closed SDNs or SPRs were recorded. The audit team reviewed six open and seven closed reports. No conditions adverse to quality were identified.

The audit team made three recommendations to improve process effectiveness (see Section 4.5, items 12, 13, and 14). The audit team feels that appropriate consideration of the recommendations pertaining to error reporting would significantly improve process effectiveness.

Overall, the audit team concluded that the error reporting process was adequately defined, satisfactorily implemented, and marginally effective in meeting the process goal of documenting, communicating, and correcting software problems.

Traceability of Software into the Technical Product

The traceability of software products referenced in analysis model reports (AMR) was assessed. A total of 53 unique codes were identified in 3 AMRs (MDL-NBS-HS-000012, Revision 00; MDL-NBS-HS-000004 Revision 02; and MDL-NBS-GS 000005, Revision 00). A sample of 10 codes were selected from the 53 and traced to SURs. Software listings were also compared with Document Input Reference System (DIRS) database entries. Each software listing in the AMRs was supported by a database listing. An additional eight AMRs were reviewed to trace software references to the software baseline. The traceability was confirmed.

Overall, the audit team determined that traceability in technical products was adequately defined, satisfactorily implemented, and effective in meeting the process goal of identifying codes used in support of Project activities.

4.2.4 Related Processes

The audit team evaluated the processes for software identified as management tools and the related software activities, including software acquisition and procurement, spreadsheets, and the proper categorization of the software.

Acquired (Procured) Software

The audit team evaluated 4 of the 76 codes identified as procured software, and another 10 identified as acquired software to ensure that the procured or otherwise acquired software included all of the necessary requirements needed to obtain non-Q software that will be qualified in accordance with AP-SI.1Q or AP-SI.2Q upon receipt.

The procurements evaluated by the audit team were provided by Golder Associates, Inc.; Itasca Consulting Group, Inc.; Pacific Engineering and Analysis; and Meta Power Company, respectively, for the following software: GOLDSIM, FLAC3D, INTERPOL (BASE4, DUR, SPCTLR, RASCALFS, and NFITM) and CAPS. The acquired software codes included FLUENT, GOLDSIM, INTERPOL, TOUGHREACT, EARTHVISION, NUFT, ANSYS, EQ3/6, and FLAC3D. The software reviewed at LBNL included FLAC3D and WINGRIDDER. At LLNL the baselines reviewed included NUFT 3.0S and EQ 3/6.

In addition, the audit team reviewed the processes used for the evaluation of the different types of software and their procurement (i.e., commercial off-the-shelf software, government off-the-shelf, contracted vendor software, numerical modeling software, etc.). The procurement process does not allow Q software to be purchased. All software is procured as non-Q and then qualified in accordance with AP-SI.1Q as acquired software.

Two recommendations (see Section 4.5, items 2 and 10) were identified in relation to changes made to acquired software and the access to the design information of procured software that would allow the determination of the technical adequacy.

In addition, the audit team reviewed the processes for evaluating the adequacy of the baseline during the O&M Phase identified in AP-SI.1Q. No conditions adverse to quality were identified.

Overall, the audit team concluded that acquired software requirements were adequately defined, that procedural implementation was satisfactory, and that the process was effective in ensuring that acquired software was properly procured and qualified.

Spreadsheets and Software Used as Management Tools

The use of spreadsheets and other software considered exempt from QARD software requirements was evaluated. The evaluation consisted of examining published AMRs and reviewing how the software was used in producing the technical product output. A total of eight AMRs were reviewed. Seven of the AMRs identified exempt software. The software designations and use were appropriate for the exemptions noted in the AMRs. No conditions adverse to quality were identified.

The audit team evaluated three codes to determine if codes used as management tools were developed in accordance with governing directives. Of the three codes assessed, two were determined to be adequately documented. The third, ARCINFO, included test documentation that did not adequately demonstrate that all systems requirements had been tested. DR BSC(O)-03-D-179 (see Section 4.3.6) documents this deficiency.

Overall, the audit team concluded that the use of spreadsheets in technical products and software management tools was adequately defined, satisfactorily implemented, and effective in meeting the process goal of ensuring that the QARD exemption for the software was properly implemented.

4.2.5 Software Administrative Activities and Processes

The audit team evaluated software administrative activities including the training and qualification of personnel, software planning activities, and software documentation.

Training and Qualification of Personnel Performing Software Activities

The audit team evaluated the qualifications and training records for ten software personnel. In addition, the technical qualifications of personnel were reviewed and determined to be acceptable. The team did note that personnel performing software technical reviews, in some cases may not be fully qualified to perform the technical review. This item has been included on DR BSC(O)-03-D-173 (see Section 4.3.2).

Overall the audit team concluded that the process for the training and qualification of personnel performing software related activities, except as noted, was adequate and satisfactorily implemented. The process was effective in ensuring that the required training was delivered.

Software Planning Activities

The audit team evaluated the process used to identify and document software QA planning activities prior to the start of the software life-cycle.

AP-SI.1Q, Revision 5, Section 5.2 states, in part: “The planning requirements for software quality assurance are incorporated into this procedure by the process described for each software product. . . .” The audit team concluded that this approach does not properly address the planning of work as described in Section I.2.2 of the QARD: “A plan addressing software quality assurance (QA) shall be in existence for each new software project at the start of the software life cycle.”

The current approach fails to implement many of the essential elements of planning in advance of the start of work. As a result, critical activities are not always incorporated into the software project. Throughout the audit, deficiencies were noted that might have been avoided if a more robust planning process had been carried out prior to the start of the software project.

The audit team concluded that planning activities need improvement to ensure that the software process is effective and that future deficiencies are avoided. This determination is documented as a recommendation (see Section 4.5, item 1).

Overall, the audit team concluded that the planning process was inadequately defined, but that the defined procedure approach was being satisfactorily implemented. Because of the lack of specific planning, the team concluded that the process was not effective in precluding failures.

Software Documentation

The audit team evaluated the preparation and control of software documentation. Four Quality Observations have been identified related to the preparation and control of documentation.

Software qualification packages were reviewed for completeness and accuracy. Records management practices related to media were also reviewed. Several anomalies were observed and were documented as Quality Observations (see Quality Observations BSC(O)-03-O-101, BSC(O)-03-O-102, BSC(O)-03-O-103, and BSC(O)-03-O-105 as described in Sections 4.4.1 and 4.4.2 of this report). In addition, one recommendation is offered (see Section 4.5, item 17).

The audit team also reviewed the SCM process for storing and protecting 30 software records. The audit team concluded that the SCM process was effective. The code is stored on media located in the central software library of SCM. This location is accessible only by authorized personnel and the media is stored in fire-resistant file safes. In addition, all codes on the baseline are uploaded into the SCM on-line tool. This tool is an electronic media library that contains all the files necessary to install and run the controlled codes. Since the SCM tool is electronic, it falls under the protective sphere of the OCRWM server. To ensure code integrity, SCM requires that, once a code is distributed, the user send objective evidence from the directory file listing of the installed code and the machine.

Overall, the audit team determined that the software documentation area was adequate. However, procedure implementation was unsatisfactory and therefore marginally effective in ensuring that activities were properly documented and that the records were properly maintained.

4.2.6 Software Activities and Process Implementation at the National Laboratories

The audit team evaluated software activities being performed at LBNL and at LLNL.

The audit team reviewed Level A and Level B software documents maintained at LBNL and LLNL. The reviews involved tracing the documents from the requirements through testing and use. Minor anomalies were noted and documented as Quality Observations (see Sections 4.4.1 and 4.4.2).

To confirm that documentation in the field matched the information maintained by SCM, the auditee was asked to provide evidence that a comparison between the test results from software package 2kgrid8 V1.0 and the SCM test results were in agreement. An SUR was initiated and electronic mail was provided from SCM that contained the content of the media. File comparisons were made both for bit size and file comparison. The files were in agreement.

SDNs were reviewed to evaluate the effectiveness of the impact analysis process. The evaluated SDNs described minor issues and the impact analyses were acceptable and timely.

Several staff members were interviewed in relation to the required initial and periodic training. Training records corroborated that the required training had been completed.

The validation of software changes is generally determined by the results of test cases used to validate the previous versions. A trace was performed of NUFT 2.0h to identify where test case results from a previous version were not used to do the validation. The review of NUFT 2.0h indicated that some test cases had also been properly confirmed via independent calculation. No conditions adverse to quality were identified.

Overall, the audit team concluded that the software, processes, and activities evaluated at LBNL and LLNL were adequately defined and satisfactorily implemented, and that the processes were effective.

The Use of Software

The audit team assessed software use, as applied to issued AMRs. A total of 53 unique codes were identified in 3 AMRs (MDL-NBS-HS-000012, Revision 00; MDL-NBS-HS-000004, Revision 02; and MDL-NBS-GS-000005, Revision 00). These 53 codes contained 3 unqualified codes each with a "To Be Verified" (TBV) status. All codes were successfully compared with the Software Baseline List and the TBVs had been properly removed in accordance with AP-SI.1Q requirements.

The records indicated that a sample of 10 codes was properly installed under controlled conditions. However, one Quality Observation (BSC(O)-03-O-104, see Section 4.4.1) was identified during the audit. In addition, one deficient condition, DR BSC (B)-03-D-170 related to the use of software had already been identified by BSC previous to the audit. This condition involved the reference to unqualified software in in-process AMRs that had entered into the checking process.

Overall, the audit team determined that software use was adequately defined, marginally implemented, and marginally effective.

4.2.7 Evaluation of Previous Deficiency Corrective Actions

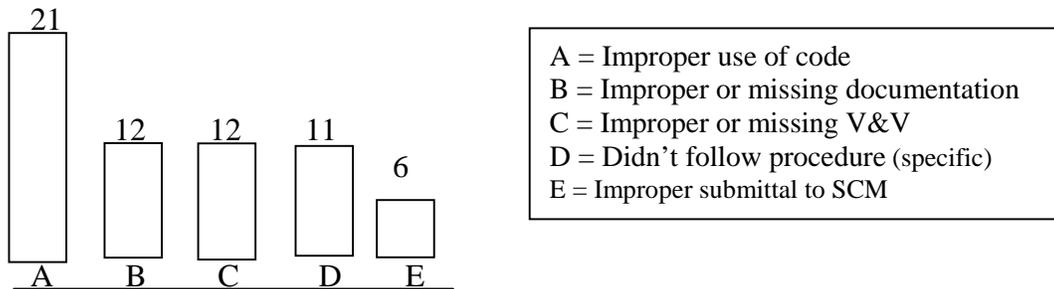
During the audit, 16 previously closed DRs were evaluated. The audit team determined that the actions to preclude recurrence were ineffective for DRs BSC(O)-02-D-099 (Technical Reviews not performed), BSC(B)-03-D-114 (incomplete SCCR), and BSC(B)-03-098 (Software use outside of the qualification parameters). The following paragraphs describe the ineffective DRs.

BSC(B)-D-098 documents the use of software outside its parameters and was closed 04/22/03. A similar adverse condition was discovered during the audit. This condition has been identified as a Quality Observation (see Section 4.4.1).

BSC(B)-02-D-099, closed 03/24/03, identifies the performance of inadequate technical reviews during software development. The audit team identified and documented the same type of condition on DR BSC(O)-03-D-173 (see Section 4.3.2).

BSC(B)-03-D-114, closed 05/28/03, identified incomplete SCCR documentation and noncompliance to AP-S.I.1Q. During the audit, similar conditions were identified and documented as DR BSC(O)-03-D-174 (see Section 4.3.3).

The audit team also analyzed software Corrective Action Requests (CAR) and DRs issued from January 1998 to April 2003. The Pareto chart of the major causes indicates that most conditions adverse to quality, directly or indirectly, were the result of a failure to follow procedures



Pareto Chart of Major Software Deficiencies

As previously discussed, the effectiveness of recent corrective actions taken since 1) the identification of new software processes, 2) increased management emphasis on the proper implementation of procedures, and 3) improved definitions of the roles and responsibilities and the authorities and accountability of personnel involved with the software process, may help to preclude the noted repetitive conditions. The effectiveness of these corrective actions could not be properly assessed due to their recent implementation. Future assessments should address this determination.

In addition, the audit team evaluated 39 DRs and Quality Observations issued since the software CAR (BSC-01-C-002) was initiated. Several of the deficiencies noted in this audit are similar to previous deficiencies (see Attachment 7). The corrective actions to the DRs identified in this report need to address any repetitiveness of the conditions adverse to quality.

4.3 SUMMARY OF CONDITIONS ADVERSE TO QUALITY

The audit team identified eight conditions adverse to quality.

4.3.1 Deficiency Reports

The following sections summarize the DRs issued as a result of this audit.

4.3.2 Technical Review Adequacy – DR BSC(O)-03-D-173 Requirement:

Documents that specify technical requirements shall be reviewed. Such reviews shall be performed by technically competent individuals using review criteria that considers technical adequacy (QARD, Section 2.2.10, and AP-SI.1Q, Section 5.2.1).

Condition:

Reviews of software documentation performed by the developing organization do not address technical adequacy:

- The roles and responsibilities for the performance of technical reviews are not clearly defined.
- The corrective actions for DR BSC(O)-02-099 did not adequately address the technical review of software documentation. In addition, the verification reviews identified in AP-SI.2Q, Revision 1, do not specifically include reviews for technical adequacy.
- Software categorization determination was prepared and reviewed by the same individual.
- In some cases the software coordinators may not be qualified to perform the technical reviews.
- The SZ-CONVOLUTE, V.3.0 qualification package did not include evidence of RD and DD review comments and resolution.

4.3.3 Software Classification – DR BSC(O)-03-D-174

Requirement:

Software shall be categorized based on the nature, function, and complexity of the software (AP-SI.1Q, Revision 4, Sections 5.2, 5.2.1.1, and 5.2.1.2).

Condition:

Based on the evaluation of 33 samples of software developed under AP-SI.1Q, Revision 4 (or later), the audit team concluded that the software categorization procedure was unsatisfactorily implemented and that the process was ineffective. Examples of conditions adverse to quality include:

- Categorization justifications did not support category assignments without recourse to the originator.
- The audit team determined that the category justifications and rationale were not available for two codes.
- The audit team did not receive objective evidence of any independent review of the software category determinations made by the CWD V 2.0 developing organization.
- Software Configuration Control Request Form completion errors were identified.

4.3.4 Design Phase – DR BSC(O)-03-D-177

Requirements:

Section I.2.2.B, “Design Documentation,” of the QARD states the requirements for software design documents. AP-SI.1Q, Revision 5, contains the requirements for software documentation for Level B software. AP-SI.2Q, Revision 1, contains the requirements for software documentation for Level A software.

Condition:

The audit team identified the following conditions:

1. Failures to consistently define relationship between design elements and system requirements.
2. Failures to define the mathematical model, control flow, data flow, control logic, and data structure.
3. Failures to specify the major components of the system design as they relate to software requirements.
4. Failure to specify the allowable ranges of inputs and outputs as described in AP-SI.1Q, Revision 5, and AP-SI.2Q, Revision 1, and the documentation for major components as they relate to system requirements.

4.3.5 Implementation Phase – DR BSC(O)-03-D-178

Requirements:

Section I.2.3C of the QARD contains the requirements for software implementation activities.

Condition:

The audit team identified examples of:

1. Inadequate documentation of implementation activities (the DR provides three examples).
2. A failure to adequately specify coding standards, conventions, and techniques (three examples are provided).
3. Inadequate documentation controls for implementation and verification activities.

4.3.6 Testing Phase – DR BSC(O)-03-D-179

Requirements:

AP-SI.1Q, multiple revisions, *Software Quality Management*, Section 5.3.1 b) 2), fourth paragraph, states in part that “. . . appropriate tests for each platform and or operating system shall be included.”

AP-SI.2Q, Rev 1, Qualification of Level A Software, Section 5.2.2 VTP: “2) The acceptance/rejection criteria for each test case.”

Section I.2.3 D. of the QARD contains the requirements for software testing activities.

Condition:

The audit team identified examples of:

1. A failure to define operational range of software in test documentation.
2. A failure to specify quantitative acceptance/rejection criteria when appropriate. The acceptance criteria for the TOUGH2 V 1.6, Validation Test Plan and Report (VDP and VTR) is stated quantitatively, but it is actually evaluated qualitatively.
3. A failure to define hardware and software configuration in test results.
4. A failure to identify tests for each specified platform and operating system.
5. A failure to address unsuccessful test results.
6. A failure in the test documentation to demonstrate that all system requirements have been tested by the test case.

4.3.7 Operating and Maintenance – DR BSC(B)-03-D-175

Requirements:

AP-SI.1Q, Revision 3, ICN 4, Section 5.12.1:

“Software that is acquired or developed to perform continuous data acquisition or process control functions shall have additional in-use tests in order to provide confirmation of the correct software results.”

- 5.12.1 c) RM: Forward the original or copy of any in-use documentation to the Software Coordinator.
- 5.12.2 Software Coordinator: Submit the in-use test documentation to SCM.

5.12.3 SCM: Submit in-use test documentation to the RPC in accordance with Section 6.0 of this procedure as individual records.

6.1 QA Records: Individual Records:

Condition:

In three of four cases, there was no objective evidence that the Responsible Manager had submitted the results of the in-use test results in accordance with Sections 5.11 and 6.1 of the procedure.

4.3.8 Software Controls – DR BSC(B)-03-D-172

Requirements:

AP-SI.1Q, Section 5.7.3:

- a) “Establish and maintain centralized software baseline and status accounting records. . . .”
- b) “Inform management and users, upon request, of the software baseline status, including proposed, in-process, or approved changes, through the various SCM reports that comprise Status Accounting.”

AP-SI.3Q, Revision 1, Section 5.3.1.2, states “Complete Control Point B Review for Level A, Developed Software.” Section 5.3.2.2 states “Complete Control Point B for Level A, Acquired Software.” IV&V is to submit the records package to SCM.

Condition:

1. The status accounting records of users and locations is not current.
2. SZ_CONVOLUTE, V2.2 was authorized and indicated as being installed on the User Listing for Laroy Rickertsen and Jeffery Matties. This code has not been installed as indicated.
3. GOLDSIM V7.50.100, authorized and indicated as being installed for John Pelletier. The software is installed, but not on the CPU indicated on the User Listing.
4. Five of the six TSPA-LA codes were reviewed. Four of the five were not on the identified platform or with the identified user. The SURs identified the users, but the software was not installed.
5. The SDN for SEEPAGE.dll, V2 was not distributed to all of the identified users.

4.3.9 Control Point B SCCRs – DR BSC(B)-03-D-176

Requirements:

AP-SI.3Q, Section 5.3.1.2, “Complete Control Point B Review for Level A, Developed Software,” requires that IV&V submit the Control Point B records package and media to SCM. Section 5.3.2.2, “Complete Control Point B Review for Level A, Acquired Software,” requires that IV&V submit the Control Point B records package and media to SCM.

Condition:

FLOWCON, V1.0, SCCR MOL.20030425.0228, page 3, for the baseline edition does not match the SCCR submitted by LBNL to the IV&V organization. The SCCR (page 3) submitted by SCM lacks the limitations on use and memory requirements listed on the LBNL SCCR. The same condition was identified for T2FEHM, V4.0, and GRIDREADER, V1.0.

4.4 QUALITY OBSERVATIONS

The audit team identified the following five isolated conditions as Quality Observations.

4.4.1 Software Use – QO BSC(O)-03-O-104

The operating system that is used to run DICTRA, V 2.0 and THERMA CALC V .M was not the same as the qualified baseline operating system. Solaris 2.6 was identified on the baseline, whereas the software in place was SUN OS 7.7.

4.4.2 Documentation

A. AP-SI.1Q, Revision 3, ICN 4, Section 5.2.3 - QO BSC(O)-03-O-102

Twenty-two references are cited in the design document for ASHPLUME, but the references are not included in the references section.

B. AP-SI.2Q, Section 5.4.2 - QO BSC(O)-03-O-101

One of twenty ITPs had pen and ink changes. The ANSYS, V 5.6.2, ITP 10364-ITP-5.6.2-01, contained changes that were not clear and the pen and ink changes were not signed or they were signed by someone other than the preparer or the approver. The changes appear to be notes made by the installer. These changes had been submitted to the Records Processing Center (accession number of MOL.20030429.0298).

C. AP-SI.2Q, Revision 0, ICN 0, Section 5.1.1.4 – QO BSC(O)-03-O-105

FEHM.dll V 2.20 DD 10086-DD-2.20-01 is mislabeled for the document identifier from page 5 as “00.”

The qualification package needs to be reviewed and corrected for the section break problem and any other problems.

D. AP-SI.3Q, Revision 0, ICN 0, Section 5.2.3 a) - QO BSC(O)-03-O-103

Section 6, *Software Verification and Validation Reporting, for Control Point B Report* (10997-VVBR-4.0-00), Revision 00A and 00B, are the same (i.e., “Fails all the Installation Test Process” and “typographical errors in the supporting document.”). Revision 00B should have corrected the comments and should contain no typographical errors in the supporting document.

4.5 RECOMMENDATIONS

The following recommendations are offered by the audit team for management consideration:

1. AP-SI.1Q, Revisions 4 and 5 deleted the need for a specific Software Plan for each specific code prior to initiating the software activities. A decision was made that allowed the software procedures to serve as the software plan because the procedures describe the life-cycle requirements. While the audit team can understand the basis for the decision, better planning, perhaps as described in Revision 3 of AP-SI.1Q, would have prevented many of the deficiencies identified during this audit.

The audit team therefore strongly recommends, in light of the audit results, that the need to plan each software project prior to starting the project be reevaluated and that the planning process be strengthened.

2. Because a design document is not required for acquired software and this information is sometimes considered to be proprietary (e.g., GOLDSIM 10344-RD-6.04.007-00), the technical adequacy of the software, based upon a knowledge of the algorithm, cannot be determined.

The team recommends that the documentation of the algorithms for acquired software be included in the users’ manual or other location, as practicable.

3. SMRs for CWD, STRETSLOVA-ADAMS, and PREINFIL do not describe the major components of the software design in a sufficient manner to perform proper coding. Control flow, data flow, and control logic are not adequately addressed.

Coding standards for PREINFIL and SZ-CONVOLUTE are limited to the identification of the programming language. The internal coding convention, techniques, and coding protocols are not addressed.

The audit team recommends a procedure revision to require the design and coding standards be identified in more detail.

4. The validation test process definition in AP-SI.3Q, Section 3.17, identifies more criteria than AP-SI.2Q, Section 5.2.2.

The team recommends a procedure revision to address the differences in criteria, and that the validation test process definition in AP-SI.3Q be applicable to the developers using AP-SI-2Q.

5. Revisions 4 and 5 of AP-SI.1Q removed the requirement for completing a Software Categorization Checklist in favor of the SCCR. The SCCR requires a more subjective and variable justification of the software category determination. This change increases the difficulty of defending the category determination and results in inconsistent assignments.

The audit team recommends development and application of more objective criteria for making the determination, beyond the current procedure guidance.

6. Performance requirements such as “machine must be reasonably quick,” which was found in the SMR for RADPRO, V 3.22, should be avoided. Indicating a specific, required processor speed is a more appropriate approach.

The team recommends a better review of performance requirements to ensure that they are clear.

7. The RD for NUFT 3.0 is not sufficiently detailed to understand the functional requirements. Requirements are provided in a little more detail in the VTP and VTR, but they are not detailed enough and include erroneous information. The specified test parameters are difficult to interpret without the technical expert. Other test parameters are specified, but these are irrelevant to the test problem and are not used.

The audit team recommends that the RD, VTP, and VTR for NUFT 3.0 be rewritten to allow a defensible understanding of the functional requirements and to provide more detailed information for accomplishing the tests and interpreting the results.

8. It is not clear how software usage integrity in the field is confirmed against the baseline.

The team recommends that SCM actively conduct periodic evaluations of installed codes in the field to confirm the integrity to the baseline. This process would enhance the defensibility of software use in technical products for LA.

9. CONVERTCOORDS V 1.1 is a code that is no longer needed by the software user.

The audit team recommends the retirement of CONVERTCOORDS to avoid unintended use.

10. It is difficult to verify the change process for GOLDSIM because the code is reacquired with every release and the requested changes are not captured within SCM.

The team recommends that all requested changes for acquired software be documented on the SCCR form when a new version is to be reacquired.

11. The audit team recommends that a statement of untested functions or features or requirements be included in the RDs to inform prospective users of the limitations of the subject baseline.
12. The SDN impact analysis process under AP-SI.1Q, Revision 4 (or earlier), did not require a documented, detailed impact analysis. The results of such an analysis were all that was required. This practice could affect the defensibility of these analyses.

The audit team recommends that SDN documentation generated prior to AP-SI.1Q, Revision 5, be evaluated to assess the defensibility of the impact analysis.

13. The audit team recommends that the analysis of trends of SDNs and problem reports be performed when a sufficient sample can be obtained and that any trends adverse to quality be documented and corrected.
14. The SDN impact analysis for SEEPAGE.dll, V 1.0 and SZ-CONVOLUTE V 2.0 was not performed in a timely manner. This brings into question the impact on other code and previous analyses during this period. The average SDN submittal time is approximately 37 days.

The team recommends that user organizations receive direction in relation to the suitable time frame for submittal of the SDN or problem report and the impact analysis documentation.

15. AP-SI.4Q does not provide for the technical review of software documents. The procedure only requires retesting of the software. This could allow significant documentation problems to be carried through to LA.

The audit team recommends that legacy activities include a review of the technical adequacy in addition to the review of documentation and the retest to detect any latent issues with the codes or with the documentation.

16. Documents that were submitted to Control Point B V&V activities are not signed until V&V comments are incorporated.

The team recommends that the preparer sign the document prior to submittal to Control Point B.

17. Legacy code qualification documentation contains references to documents that may or may not be available in Yucca Mountain project databases and libraries (see Attachment A to Form A for ITOUGH2, V 4.0 in VVR V 3.2 as an example).

The audit team recommends that BSC review legacy qualification documentation to ensure that referenced documents are retrievable through the appropriate databases or libraries (e.g., the Technical Information Center or Records Information System).

5.0 LIST OF ATTACHMENTS

- Attachment 1 Software Development, Acquisition, Qualification, Use, Retirement, and Control Sub-Processes
- Attachment 2 Example of Software Process Steps and Performance-Based Measurements
- Attachment 3 Audit Team Assignments
- Attachment 4 Personnel Contacted During the Audit
- Attachment 5 Summary Table of Audit Results
- Attachment 6 Software Code and Documentation Evaluated During the Audit
- Attachment 7 Software Deficiency Documents Issued Since CAR BSC-01-C-002 Was Initiated (June 2001)

Attachment 1
Software Development, Acquisition, Qualification, Use, Retirement, and Control Sub-Processes¹

| | | | |
|---|------------------------------------|---------------------------------------|---|
| 1 General Software Qualification & Administration | 2 Software V&V | 3 Software Algorithms | 4 Alternate Methods for Technical adequacy |
| A | B | C | C |
| 5A Software Procedures | 6 Classification | 7 Software Activity Plans | 8 Software Life-Cycle |
| E | C | B | B |
| 9 Requirements Phase | 10 Design Phase | 11 Implementation Phase | 12 Software Testing |
| A | B | B | B |
| 13 Operations and Maintenance Phase | 14 Installation and Checkout Phase | 15 Retirement Phase | 16 Software Controls <ul style="list-style-type: none"> • Configuration Management • Baseline Change |
| A | D | D | D |
| 17 Software Use | 18 Error Reporting | 19 Traceability in Technical Products | 20 Acquired Software (Not under the QARD) |
| C | C | C | D |
| 21 Participant Software | 22 Procurement | 23 Spreadsheets | 24 Software Used as Management Tools |
| A | D | B | B |
| 25 Documentation | 26 At the Labs | 27 Legacy Software | 28 Corrective Actions |
| A | D A | B | All |

¹ Sub-teams: A=Moreau/Palay; B=Ailes/Archuleta; C=Dove/Foster; D=Chavez/Doyle; E=Horseman.

Attachment 2 Example of Software Process Steps and Performance-Based Measurements¹

| Step | Objective | Why Important | How to Measure |
|--|--|---|---|
| 1. Scope out what the software will have to do. Define the functionality, goals, aims, etc. First step in the development of the RD. | To clearly identify what the software is to do and to bound the scope of the software at a detailed level. | Part of planning process and provides a basis for acceptance and what is needed during the other life-cycle activities. | There is a TWP technical work plan prepared that initiates the RD. Does it generically describe what is to be done and what is not to be done? |
| 2. Refine the desired Requirements for clarity, uniqueness, and testability | Determine what will be in the design, clarify uniqueness, not redundant, and not contradictory and is testable. | Allows a clear path forward of what is to be developed or acquired. | Are the requirements “testable”, unique, consistent, and relate to procedural standards? Do they relate to the scope? Can software development or acquisition be initiated? |
| 3. The identified requirements are documented in accordance with AP-SI.1Q or .2Q. | Set the baseline and to record the specific requirements. Parallel processing of Level B software. | Allows others to see what the software is supposed to do and provides a written menu for review and further testing. | Is the RD understandable to a qualified third party without recourse to the originator? |
| 4. Review Process by the Software Coordinator and IV&V. Once it has been reviewed by the Coordinator it is baselined and becomes a new draft (e.g., 00A or 00B, etc.). | A systematic process to determine if the requirements are in a format and has the content to allow subsequent steps to be performed. | Provides confidence that the RD will be clear to those involved with the software development or the acquisition of the software. | Are the Software Coordinator comments comparable with those of the IV&VR reviewer? Are the comments identified in an Software Defect Notification? Are they incorporated? Are comments significant to the process as opposed to editorial or minor comments? |
| End-Product A definition and listing of those things the software must perform or ensure. | Identify those things (functionality) that must be met by the software. | It allows us to know where we’re going and what is acceptable. | Have user needs been met? Are the listed requirements comprehensive, and accurate? Does the RD articulate the real functions the software is to perform? Do the requirements readily lend themselves to testing? Is the RD adequate the way it was developed or does it require revisions? A lot of revisions prior to baselining? Are the requirements expressed in such a way as to allow software development or acquisition? |

¹ RD = Requirements Document. (This page is an image.)

Attachment 3
Audit Team Assignments¹

| | | Subject | Comments |
|----|---|--|---|
| 1 | A | General Software Qualification and Administrative Activities | Prior to Use, Documentation, Training, Storage, Access |
| 2 | B | Software Verification and Validation | Independence, Responsibilities, Standards, Reviews, Error Reporting, Corrective Actions, etc. |
| 3 | C | Software Algorithms | Correct Algorithms, No Unintended Functions, Results, Test of Input Range, etc. |
| 4 | C | Alternative Methods for Technical Adequacy | Hand Calculations, Other Methods, etc |
| 5 | E | Software Procedures | Contain Upper-Tier Requirements, QA Controls, Conditions Adverse to Quality Documentation, etc. |
| 6 | C | Software Classification | Type of Software Identified |
| 7 | B | Software Activity Plans | Description, Products, Responsible Organizations. Prior to Start, Identify Required Documents, Reviews, Error Reporting, etc. |
| 8 | B | General Software Life Cycle Activities | Applicability to Acquired, Procured, and Developed Software |
| 9 | A | Requirements Phase | Requirements Document, Functionality, Performance, Constraints, Interfaces, Can Be V&V'd, Traceable, Enough Detail, etc. |
| 10 | B | Design Phase | Design Document, Description of Major Components of the Software, Test Plan Develop, Defined Ranges, Can be Coded, etc. |
| 11 | B | Implementation Phase | Design is Coded, Meets Design Specifications, User Information, etc. |
| 12 | B | Software Testing Phase | Planned with Test Cases, Validation Testing, Modifications, Regression Testing, No Unintended results |
| 13 | A | Operations and Maintenance Phase | Put under Software Configuration Management, Changes get V&V'd, and Controlled, In-Use Tests, Periodic Self-Checks |
| 14 | D | Installation and Checkout Phase | Installation Testing |

¹ Sub-teams: A=Moreau/Palay; B=Ailes/Archuleta; C=Dove/Foster; D=Chavez/Doyle; E=Horseman.

Attachment 3
Audit Team Assignments¹

| | | Subject | Comments |
|----|------|---|--|
| 15 | D | Retirement Phase | Timely Retirement and Closure of Activities for Retired Software, Baseline Changes |
| 16 | D | Software Controls | Change Control, Release and Control of Elements, Control and Documentation of Changes |
| 17 | C | Software Use | User Responsibilities, Training, and Information |
| 18 | C | Error Reporting | User and Developer Organizations Reporting |
| 19 | C | Traceability in Technical Products | Traceability – Forward and Trace-back |
| 20 | D | Acquired Software (Software not developed under the QARD) | Qualification Process and Activities |
| 21 | A | Participant Software | Review of Participant Software and Documentation |
| 22 | D | Procurement of Software | Requirements in Procurement Documents |
| 23 | B | Spreadsheets | Qualification of Spreadsheets that Support License Application |
| 24 | B | Software Used as Management Tools | Verification that the Designated Management Tools Do Not Implement QARD Requirements |
| 25 | A | Documentation and Records | Traceability through Records, Documentation |
| 26 | A& D | At the Labs | Sampling of Codes and Life-Cycle Activities for Software Used to Support the License Application |
| 27 | B | Legacy Software | The Plan and Procedures for the Re-Test of Legacy Software |
| 28 | All | Review Software Deficiency Reports, Corrective Action Requests, Software Defect Notifications | Identify Trends or Areas to Review and Areas for Improvement |

**Attachment 4
 Personnel Contacted During the Audit**

| Name | Organization | Pre-Audit Meeting | Contacted During Audit | Post-Audit Meeting |
|-----------------------|---------------------|-------------------|------------------------|--------------------|
| Aden-Gleason, Nancy | LBNL/EA | ✓ | ✓ | ✓ |
| Andrews, Robert | BSC/PA | ✓ | ✓ | ✓ |
| Barish, Victor Sr. | LLNL/EA | ✓ | ✓ | ✓ |
| Beall, Ken | BSC/CM | ✓ | ✓ | ✓ |
| Bennington, Beth | DOE/OQA | ✓ | | ✓ |
| Bess, Jack | BSC/Licensing | ✓ | ✓ | |
| Boyle, William | DOE/ORD | | | ✓ |
| Brown, R. Dennis | DOE/OQA | ✓ | ✓ | ✓ |
| Bullard, Bryan | BSC/Waste Package | | ✓ | |
| Carter, Ted | NRC | ✓ | ✓ | ✓ |
| Cereghino, Stephen | BSC/LA | | | ✓ |
| Dash, Dora | BSC/LANL | | ✓ | |
| De la Brosse, Valerie | Framatome/ACD | | ✓ | |
| Danise, Adam | BSC/LAP | | ✓ | |
| Dobson, Patrick | LBNL/Scientist | | ✓ | |
| Fei, Duan | BSC/Facility Design | | ✓ | |
| Ehnstrom, Mark | NRC | ✓ | ✓ | ✓ |
| Eshleman, Mike | MTS | | | ✓ |
| Esposito, Joseph | BSC/IV&V | | ✓ | |
| Estill, John | LLNL/Technical Area | ✓ | | |
| Fenster, Richard | BSC/PA | | ✓ | |
| Fissekidou, ViVi | LBNL | | ✓ | |
| Folck, Randy | NRC | ✓ | ✓ | ✓ |
| Gebhart, Judy | BSC/QA | ✓ | ✓ | ✓ |
| Gil, April | DOE/OLAS | | | ✓ |
| Glasser, William | OQA/NQS | | ✓ | |
| Griswold, Lori | BSC/IV&V | | ✓ | |
| Grooms, Kerry | DOE/OQA | ✓ | ✓ | ✓ |

Attachment 4 - Cont.
Personnel Contacted During the Audit

| Name | Organization | Pre-Audit Meeting | Contacted During Audit | Post-Audit Meeting |
|----------------------|----------------------------|-------------------|------------------------|--------------------|
| Habbe, Robert | BSC/QA | ✓ | ✓ | ✓ |
| Han, Lijie | LBNL/QA | | ✓ | ✓ |
| Harris, Steve | BSC/On-site Representative | ✓ | ✓ | ✓ |
| Hartstern, Robert | BSC/QA | ✓ | ✓ | ✓ |
| Hasson, Robert | NQS | ✓ | | ✓ |
| Hoffman, Phyllis | BSC/Software | | ✓ | |
| Hutchins, William E. | BSC/BA/LA | | ✓ | |
| Jacquet, Gwendolyn | BSC | | ✓ | |
| Jaeger, Michael | BSC/PA | ✓ | | |
| Kalinich, Don | BSC/TSPA | | ✓ | |
| Kavchak, Marilyn | NQS | ✓ | ✓ | ✓ |
| Keele, Robert | BSC/QA | ✓ | ✓ | ✓ |
| Kimball, Warner | BSC/QA | ✓ | | |
| Latta, Robert | NRC | ✓ | ✓ | ✓ |
| Lee, Ken | LLNL, Scientist | | ✓ | |
| Levatin, JoAnne | LLNL/Computer Scientist | ✓ | ✓ | ✓ |
| Lu, Guoping | LBNL/Scientist | | ✓ | |
| Lum, Clinton | BSC/PA | | ✓ | |
| Mason, Jeff | BSC/SCM | | ✓ | |
| Mason, Michael | BSC/QA | ✓ | ✓ | |
| Matties, Jeff | TSPA/BSC/Framatome | | ✓ | |
| Matula, Thomas | NRC | | ✓ | |
| McCarty, Mark | BSC/IV&V | | ✓ | |
| McCluing, Ivelena | LBNL/Software | ✓ | ✓ | |
| McGrath, Lawrence | BSC/QE | | ✓ | |
| McNeish, Jerry | BSC/TSPA | | ✓ | |
| Mon, Kevin | BSC/Engineering | | ✓ | |
| Noel, Peter | RDP Automation | | ✓ | |
| Opelski, Edward | NQS | ✓ | | |

Attachment 4 - Cont.
Personnel Contacted During the Audit

| Name | Organization | Pre-Audit Meeting | Contacted During Audit | Post-Audit Meeting |
|-------------------|----------------------------|-------------------|------------------------|--------------------|
| Pan, Lehua | LBNL/Scientist | | ✓ | |
| Pelletier, John | BSC/TSPA | ✓ | ✓ | ✓ |
| Platko, Bret | BSC/CIO | ✓ | ✓ | ✓ |
| Ralston, Judith | BSC/SNL | | ✓ | |
| Rickertsen, Larry | BSC/DSDD | | ✓ | |
| Robinson, Bruce | BSC/LANL | | ✓ | |
| Rutqvist, Johnny | LBNL/Scientist | | ✓ | |
| Schneider, J.T. | SNL/GRAM | | ✓ | |
| Sims, Cherry | BSC/SCM | | ✓ | |
| Sinks, Donna | USGS | | ✓ | |
| Smith, Christine | BSC/SCM | | ✓ | |
| Southworth, Lyle | CIO-SCM | ✓ | ✓ | |
| Splawn, Steve | BSC/IV&V | ✓ | ✓ | ✓ |
| Sutton, Mark | LLNL/PI | | ✓ | |
| Swenning, Steve | BSC/CSO | ✓ | ✓ | |
| Tommela, David | CIO | | | ✓ |
| Tynan, Mark | DOE/OLAS | | ✓ | ✓ |
| Warren, Charlie | BSC/LLNL QA Representative | ✓ | | |
| Watson, William | BSC/PA | ✓ | ✓ | ✓ |
| Weber, Rod | NRC/CNSWR | ✓ | ✓ | ✓ |
| Williams, Ken | LBNL/Scientist | | ✓ | |
| Williams, Nancy | BSC/PM | ✓ | ✓ | ✓ |
| Wolery, Thomas | LLNL/AMR Author | | ✓ | |
| Wooley, Jake | DOE/OPS | | | ✓ |
| Wu, Yu-Shu | LBNL/Scientist | | ✓ | |
| Yunker, Jean | BSC/CSO | ✓ | ✓ | ✓ |
| Zinkevich, Fred | BSC/CM | ✓ | ✓ | |

Attachment 5 Summary Table of Audit Results

| Software Sub-Process | Sub-Teams ¹ | Details on Checklist ² | Deficiency Reports | Quality Observations | Recommendations ³ | Program Adequacy ⁴ | Procedure Compliance ⁴ | Process Effectiveness ⁴ |
|-------------------------------|------------------------|-----------------------------------|------------------------------------|--|------------------------------|-------------------------------|-----------------------------------|------------------------------------|
| 1. General | A | Pages 1-2 | | | | A | S | E |
| 2. V&V | B | Pages 3-10 | | | | A | S | E |
| 3. Algorithm | C | Pages 11-13 | | | 2, 10 | A | S | E* |
| 4. Tech (review) Adequacy | C | Pages 14-15 | BSC(0)-03-D-173 | | | IA | S | NE |
| 5. Software Procedures | E | Pages 16-20 | | | 3, 4, 5, 15 | N/A | N/A | N/A |
| 6. Categorization | C | Pages 21-22 | BSC(0)-03-D-174 | | 5 | A | U | NE |
| 7. Activity Plan | B | Pages 23-29 | | | 1 | IA | S | NE |
| 8. Life-Cycle, General | B | Pages 30-32 | | | | A | M | M |
| 9. Requirements Phase | A | Pages 33-38 | | | 3, 4, 6, 7, 11 | A* | S* | E |
| 10. Design Phase | B | Pages 39-42 | BSC(0)-03-D-177 | | | IA | I | NE |
| 11. Implementation Phase | B | Pages 43-46 | BSC(0)-03-D-178 | | | IA | U | I |
| 12. Testing | B | Pages 47-51 | BSC(0)-03-D-179 | | | A | U | NE |
| 13. Operation & Maintenance | A | Pages 52-60 | BSC(0)-03-D-175 | | 12, 13, 14 | A | S | E |
| 14. Install & Checkout | D | Pages 61-65 | BSC(0)-03-D-172 | | | A | S | E |
| 15. Retirement | A | Pages 66-69 | | | 9 | A | S | E |
| 16. Software Controls | D | Pages 70-81 | BSC(0)-03-D-172 BSC(0)-03-D-176 | | 8, 16 | A | M | M |
| 17. Software Use | C | Pages 82-84 | | QO BSC(O)-03-O-101 | | A | M | M |
| 18. Error Reporting | C | Pages 85-87 | | | 12, 13, 14 | A | S | M |
| 19. Traceability/Tech Product | C | Pages 88-89 | | | | A | S | E |
| 20. Acquired Software | D | Pages 90-94 | | | 2, 10 | A | S | E |
| 21. Participant Software | C | Pages 95-96 | | | | A | S | E |
| 22. Procurement | D | Pages 97-102 | | | | A | S | E |
| 23. Spreadsheets | B | Pages 103-106 | | | | A | S | E |
| 24. Management Tools | B | Pages 108-110 | BSC(0)-03-D-179 | | | A | S | E |
| 25. Documentation | A | Pages 111-116 | | QO BSC(O)-03-O-101 Through – 103 Plus - 105 | 17 | A | U | M |
| 26. At the Labs | A, D | Pages 117-118 | | | | N/A | S | E |
| 27. Legacy Software | B | Pages --- | | | 17 | A | I | I |
| 28. CAQs | All | Pages 119-121 | | | | A | U | NE |
| Totals | All | 121 | 8 | 5 | 17 | A | M | M |

¹ A=Moreau/Palay; B=Ailes/Archuleta; C=Dove/Foster; D=Chavez/Doyle; E=Horseman.

² The checklist is part of the records package for this audit.

³ See Section 4.5.

⁴ A = adequate; E = effective; I = indeterminate; IA = inadequate; M= marginal; N/A = not applicable; NE = not effective; S = satisfactory; U = unsatisfactory; * = partial results.

Attachment 6
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|---------------------|---------|--|
| 2kgrid8 | V 1.0 | Requirements, Documents |
| 3 Baselines at LLNL | Various | Various |
| 6 Baselines at LBNL | Various | Various |
| ACUSOLVE | V 1.4 | Design and Testing |
| ANSYS | V 5.6.2 | Installation and Checkout, Software Configuration Management, Algorithms, Classification, Error Reporting, Acquired Software |
| ASHPLUME | V 1.4 | Algorithms, Classification |
| ASHPLUME.dll | V 1.4 | Installation and Checkout, Algorithms, Classification |
| BASE4 | V 4.0 | Software Controls |
| BOUNDARY_CONDITIONS | V 1.0 | Classification |
| CONVERTCOORDS | V 1.1 | Requirements, Documents |
| CWD | V 1.0 | Design and Testing, Documents |
| CWD | V 2.0 | Design and Testing, Classification |
| DICTRA | V 2.0 | Software Controls |
| DK2ECM_MAT_V0.F | V 1.0 | Requirements Phase, Documents |
| DLECD.FOR | V 1.0 | Error Reporting |
| DUR | V 1.0 | Software Controls |
| EARTHVISION | V 4.0 | Software Controls, Acquired Software |
| EARTHVISION | V 5.0 | Software Controls, Acquired Software |
| EARTHVISION | V 5.1 | Software Controls, Acquired Software |
| EQ 6 | V 7.2 | Acquired Software |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|---------------|------------|--|
| EQ3/6 | V 8.0 | Installation and Checkout, Software Controls |
| EXTRACT | V 1.0 | Software Controls |
| FEHM | V 2.10 | Design and Testing, Algorithm |
| FEHM | V 2.11 | Installation and Checkout |
| FEHM | V 2.12 | Installation and Checkout |
| FEHM.dll | V 2.20 | Software Controls |
| FLAC3D | V 2.0 | Installation and Checkout, Acquired Software |
| FLAC3D | V 2.1 | Software Controls, Acquired Software |
| FLOWCON | V 1.0 | Installation and Checkout, Design and Testing, Software Controls, Classification |
| FLUENT | V 6.0.12 | Installation and Checkout, Software Controls, Acquired Software |
| formView | V 2.10 | Requirements Phase, Documents |
| GAMV | V 2.0 | Error Reporting |
| GENII-S | V 1.4.8.5 | Requirements Phase, Documents |
| GENMESH | V 6.03 | Requirements Phase |
| GENMESH | V 6.08 | Requirements Phase, Documents, Classification |
| GFW | V 1.0 | Requirements Phase |
| GoldSim | V 6.03.000 | Algorithm, Classification |
| GoldSim | V 6.04.000 | Software Controls, Acquired Software |
| GoldSim | V 6.04.007 | Installation and Checkout, Software Controls, Acquired Software |
| GoldSim | V 7.50.100 | Installation and Checkout, Software Configuration Management, Error Reporting, Acquired Software |
| GRIDREADER | V 1.0 | Classification |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|---------------------------|--------------|---|
| GT STRUDL | V2.5 | Error Reporting |
| GTSTRUDL | V 2.6 | Verification and Validation, Design and Testing, Classification |
| HDAS2 | V 2.110 | Requirements Phase, Documents |
| Heatgen_ventTable_emplace | V 1.0 | Software Configuration Management, Algorithm, Classification |
| infil2grid | 1.6 | Classification |
| infil2grid | 1.7 | Documents |
| INJECTION_PUMPBACKVI | V 1.0 | Classification |
| INTERPOL | V 1.0 | Software Controls |
| iTOUGH2 | V3.2 | Requirements Phase, Documents, Error Reporting |
| iTOUGH2 | V4.0 | Requirements Phase, Documents |
| MFD | V 1.01 | Retirement Phase |
| Minipres.f | V 1.0 | Requirements Phase, Documents |
| MK_MESCH.CORRECT.F | V 1.0 | Requirements Phase, Documents |
| MSTHAC | V 7.0 | Installation and Checkout, Software Controls, Documents |
| mView | V 2.10 | Installation and Checkout |
| mView | V 2.20 | Requirements Phase, Documents |
| NFITM | Not Assigned | Software Controls |
| NUFT | V 2.0 | Requirements Phase |
| NUFT | V 2.0h | Installation and Checkout |
| NUFT | V 3.0 | Design and Testing, Requirements |
| NUFT | V 3.0S | Installation and Checkout, Software Controls |
| PERCULATION_CALCULATOR | V 1.0 | Requirements Phase, Documents |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|-----------------------------------|--------------|--|
| PPPTRK | V1.0 | Verification and Validation, Design, Testing |
| PREINFIL | V 1.20 | Design and Testing, Classification |
| RADPRO | V 4.0 | Error Reporting |
| RASCALFS | Not Assigned | Software Controls |
| reformat_EXT_to_TSPA | V 1.0 | General Software Requirements |
| REPOSITORY_PERCULATION_CALCULATOR | V 1.0 | Classification |
| SCCD | V 2.0 | Requirements Phase, Documents, Error Reporting |
| SEEPAGE.dll | V 1.0 | Design and Testing, Documents |
| SEEPAGE.dll | V 2.0 | Requirements Phase, Documents |
| SEEPAGE.dll | V 2.1 | Installation and Checkout, Software Configuration Management, Documents |
| SEEPAGE.dll2 | V 1.0 | Laboratories |
| SPCTLR | V 1.0 | Software Controls |
| STRAT2AVS | V 1.0 | Verification and Validation, Design and Testing, Classification |
| STRELTSOVA-ADAMS.VI | V 1.0 | Design and Testing, Classification |
| SZ_CONVOLUTE | V 2.0 | Requirements Phase, Error Reporting |
| SZ_CONVOLUTE | V 2.2 | Requirements, Design and Testing, Documents, Classification, Error Reporting |
| SZ_CONVOLUTE | V 3.0 | Requirements Phase, Documents, Algorithms |
| SZ_CONVOLUTE.dll | V 2.2 | Installation and Checkout, Software Controls |
| SZ_POST | V 2.0 | Installation and Checkout |
| T2FEHM | V 4.0 | Installation and Checkout, Software Controls, Documents, Algorithms |
| TCODMU | V 1.0 | Requirements Phase, Documents |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|---------------|--------------|---|
| THERMACALC | V .m | Software Controls |
| TIN | V 1.1 | Software Controls |
| TOUGH2 | V 1.4 | Software Controls, Error Reporting |
| TOUGH2 | V 1.6 | Design and Testing, Installation and Checkout, Classification |
| TOUGH2EOS.H | Not Assigned | Software Controls |
| TOUGHREACT | V2.4 | Requirements Phase, Software Controls, Documents |
| TOUGHREACT | V3.0 | Requirements Phase, Software Controls, Documents, Classification, Acquired Software |
| VDT | V 1.0 | Requirements Phase, Software Controls |
| WAPDEG | V 4.0 | Error Reporting |
| WAPDEG | V 4.06 | Requirements Phase, Documents |
| WAPDEG | V 4.07 | Design and Testing, Classification |
| WAPDEG.dll | V 4.0 | Installation and Checkout |
| WAPDEG.dll | V 4.07 | Design and Testing, Software Controls |
| WINGRIDDER | V 1.0 | Error Reporting |
| WINGRIDDER | V 2.0 | Installation and Checkout, Software Controls, Documents, Acquired Software |
| WTRISE | V2.0 | Verification and Validation, Classification |
| XLDTH | V1.0 | Documents |
| XRTRACT2B.f | V 1.0 | Retirement Phase |
| XTOOL | V 1.0.1 | Installation and Checkout, Software Controls |
| XTRACT5.f | V 1.0 | Requirements Phase, Documents |
| Ymesh | V 1.54 | Verification and Validation |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|---------------------------|-----------|-----------------------------------|
| Technical Products | | |
| ANL-NBS-HS-000007 | 00 | Traceability to Technical Product |
| ANL-NBS-HS-000015 | 01 | Traceability to Technical Product |
| ANL-NBS-HS-000033 | 0, ICN 02 | Traceability to Technical Product |
| MDL-NBS-GS-000002 | 01 | Traceability to Technical Product |
| MDL-NBS-GS-000003 | 01 | Traceability to Technical Product |
| MDL-NBS-GS-000004 | 01 | Traceability to Technical Product |
| MDL-NBS-GS-000005 | 00 | Traceability to Technical Product |
| MDL-NBS-HS-000003 | 01 | Traceability to Technical Product |
| MDL-NBS-HS-000003 | 01 | Traceability to Technical Product |
| MDL-NBS-HS-000004 | 02 | Traceability to Technical Product |
| MDL-NBS-HS-000012 | 00 | Traceability to Technical Product |
| MDL-NBS-HS-000014 | 00 | Traceability to Technical Product |
| Software Use | | |
| MDL-NBS-GS-000005 | 00 | Use of the Software |
| MDL-NBS-HS-000004 | 02 | Use of the Software |
| MDL-NBS-HS-000012 | 00 | Use of the Software |
| Databases | | |
| ANL-NBS-HS-000007 | 00 | Database |
| ANL-NBS-HS-000015 | 01 | Database |

Attachment 6 - Cont.
Software Code and Documentation Evaluated During the Audit

| Code/Document | Version | Review Activity |
|----------------------|----------------|------------------------|
| ANL-NBS-HS-000033 | 0, ICN 02 | Database |
| MDL-NBS-GS-000003 | 01 | Database |
| MDL-NBS-GS-000004 | 01 | Database |
| MDL-NBS-HS-000003 | 01 | Database |
| MDL-NBS-HS-000014 | 00 | Database |

Attachment 7
Software Deficiency Documents Issued Since CAR BSC-01-C-002 Was Initiated (June 2001)

| Number | Written | Area | Software Audit Identified Deficiencies | Status/Closed |
|------------------|---------|--|--|---------------|
| BSC(B)-03-D-119 | BSC | Installation and Checkout wrong version installed | Not Applicable | Open |
| BSC(B)-03-D-105 | BSC | Installation and Checkout for platform change | Not Applicable | Open |
| BSC(B)-03-O-099 | BSC | Software Configuration Control Request signing | BSC(O)-03-D-174 | 6/10/03 |
| BSC(B)-03-D-067 | BSC | Software Configuration Control Request not signed by Responsible Manager | Not Applicable | 3/12/03 |
| BSC(B)-03-D-098 | BSC | Use of unqualified software | BSC(O)-03-D-179 BSC(O)-03-O-104 | 4/16/03 |
| BSC(B)-03-O-058 | BSC | User not trained | Not Applicable | 3/13/03 |
| BSC(B)-03-O-068 | BSC | Distribution of unqualified software | Not Applicable | 4/28/03 |
| BSC(B)-03-D-114 | BSC | Did not comply with AP-SI.1Q | BSC(O)-03-D-176 | 5/22/03 |
| BSC(B)-03-D-086 | BSC | Use of unqualified software | Not Applicable | 5/21/03 |
| BSC(B)-03-O-067 | BSC | Use of spreadsheet macro beyond qualified applications | BSC(O)-03-D-179 BSC(O)-03-O-104 | 4/23/03 |
| BSC(B)-03-O-044 | USGS | Software not from Software Configuration Management used | Not Applicable | 1/24/03 |
| BSC(B)-03-O-046 | BSC | Software not from Software Configuration Management used | Not Applicable | 3/13/03 |
| BSC(B)-03-D-083 | BSC | Software beyond Site Recommendation exemption | BSC(O)-03-D-179 | 3/19/03 |
| LANL(B)-02-D-166 | BSC | Technical overestimation of mass flow | Not Applicable | 3/17/03 |
| BSC(B)-02-D-110 | BSC | Used before Control Point 1 was baselined | Not Applicable | 3/19/03 |
| BSC(O)-02-D-099 | OQA | Independent review records for software development | BSC(O)-03-D-177 | 3/06/03 |
| BSC(B)-03-O-052 | BSC | Software beyond Site Recommendation exemption | Not Applicable | 3/14/03 |
| BSC(B)-02-D-133 | BSC | Software not from Software Configuration Management used | Not Applicable | 2/25/03 |
| BSC(B)-01-D-088 | BSC | Software not submitted to Software Configuration Management | Not Applicable | 2/13/03 |
| BSC(B)-03-O-029 | BSC | Software beyond Site Recommendation exemption | Not Applicable | 1/07/03 |
| BSC(B)-03-O-026 | BSC | Software beyond Site Recommendation exemption | Not Applicable | 11/26/02 |

Attachment 7 - Cont.
Software Deficiency Documents Issued Since CAR BSC-01-C-002 Was Initiated (June 2001)

| Number | Written | Area | Software Audit Identified Deficiencies | Status/Closed |
|------------------|---------|---|--|---------------|
| LBNL(B)-02-O-007 | LBNL | Test cases prior to Control Point 1 | Not Applicable | 5/06/02 |
| LBNL(B)-02-O-006 | LBNL | Test cases prior to Control Point 1 | Not Applicable | 5/06/02 |
| BSC(O)-02-O-002 | OQA | Review of AP-SI.1Q | Not Applicable | 4/03/02 |
| BSC-02-D-058 | OQA | Software Defect Notifications not in timely manner | Not Applicable | 3/25/02 |
| LBNL(B)-03-O-022 | LBNL | Developed Software stated as acquired Software | Not Applicable | 12/16/02 |
| LBNL(B)-02-O-064 | LBNL | Lack of procedural document reviews | Not Applicable | 8/08/02 |
| LANL(B)-02-O-062 | LANL | Incorrect Test Code version submitted to Software Configuration Management | BSC(O)-03-D-179 | 8/21/02 |
| LANL(B)-02-O-061 | LANL | Software Activity Number not obtained from Software Configuration Management for Software Activity Plan | Not Applicable | 8/08/02 |
| LANL(B)-02-O-060 | LANL | Software Validation Test prior to Control Point 1 Baselined | Not Applicable | 8/28/02 |
| LBNL(B)-02-O-031 | LBNL | Inconsistent identification of Responsible Manager throughout process | Not Applicable | 6/28/02 |
| BSC-02-D-092 | OQA | Inappropriate code bundling and errors | Not Applicable | 5/10/02 |
| BSC-02-D-070 | OQA | Use of software within range | BSC(O)-03-D-179 | 6/13/02 |
| BSC-02-D-037 | OQA | Timely submittal of records to Records Processing Center | Not Applicable | 3/27/02 |
| BSC-02-D-022 | OQA | Failure to submit Software Activity Plan for interim use | Not Applicable | 2/14/02 |
| BSC-01-D-131 | OQA | Unqualified software use in technical product | Not Applicable | 1/09/02 |
| USGS-01-D-118 | USGS | Use of unqualified software | Not Applicable | 11/13/01 |
| LANL-01-D-117 | LANL | Work prior to training completion | Not Applicable | 9/25/01 |
| BSC-01-D-110 | OQA | Use of unqualified software | Not Applicable | 7/09/01 |

Attachment 7 - Cont.
Software Deficiency Documents Issued Since CAR BSC-01-C-002
Was Initiated (June 2001)

The following software Deficiency Reports (DRs) and Quality Observations (QOs) represent repetitive conditions identified during the audit.

BSC(O)-03-O-099 cites AP-SI.1Q, Revision 3, ICN 0, Sections 5.6.1b and 5.6.3b, which require Software Configuration Control Requests (SCCR) for retired software to be signed off by the Software User from a list generated from Software Configuration Management (SCM). The DR documents that SCCRs were signed by the Responsible Manager (RM) to retire software codes without obtaining a list of users from SCM with the users' concurrence. Similar conditions were identified during the audit as Audit Item 15 where the RM improperly signed SCCRs prior to the preparer's signature. This condition has been documented on DR BSC(O)-03-D-174.

BSC(B)-03-D-098 cites the AP-S.I.1Q, Revision 3, ICN 4, and Section. 5.7.2.2, requirement that software be installed with the applicable baseline documentation. The DR documents the use of TCODMU V 1.0 software on Windows 2000, outside its parameters of Windows 95, 98 or NT. Similar adverse conditions were discovered as Audit Items 34, 53, and 55 during the audit. Audit item 34 concerns the operational range for the STRELTSOVA_ADAMS software, which is not clearly defined. Items 53 and 55 identify that the operating system used to run DICTRA V 2.0 and THERMA_CALC, V. M. was not the same as that called out on the qualified software baseline. These conditions have been identified as DR BSC(O)-03-D-179 (Audit Item 34) and QO BSC(O)-03-O-104 (Audit Items 53 and 55).

BSC(B)-03-D-114 cites AP-SI.1Q, Revision 4, ICN 0, Sections 5.2.1.1 and 5.2.1.2, which require that SCCRs are initiated by the software user and are signed by the RM. This DR identified incomplete SCCR documentation and noncompliance with AP-S.I.1Q, Sections 5.2.1.1 and 5.2.1.2, where there are two SCCRs completed for the same MFCP_LA Version 1.0 Level B software. During the audit, similar conditions were identified as Audit Item 38. Audit Item 38 identifies the condition that the FLOWCON V 1.0 SCCR submitted to Verification and Validation (V&V) is not the same as that submitted to records by SCM. This condition is documented as DR BSC(O)-03-D-176.

BSC(B)-03-O-067 cites AP-SI.1Q, Revision 3, ICN 4, Section 5.7.3.2, which states that software used outside its operating environment is unqualified. The QO documents the condition that spreadsheet application GetEQData V 1.0.1 was used for which quality-affecting activities in an operating environment other than that for which it was qualified. Similar adverse conditions were discovered as Audit Items 34, 53, and 55 during the audit. Audit Item 34 concerns the operational range for the STRELTSOVA_ADAMS software, which is not clearly defined. Audit Items 53 and 55 identify that the operating system used to run DICTRA V 2.0 and THERMA_CALC, V. M. was not the same as that called out on the qualified software baseline. These conditions have been identified as DR BSC(O)-03-D-179 (Audit Item 34) and QO BSC(O)-03-O-104 (Audit Items 53 and 55).

Attachment 7 - Cont.
Software Deficiency Documents Issued Since CAR BSC-01-C-002
Was Initiated (June 2001)

BSC(B)-03-D-083 cites AP-SI.1Q, Revision 3, ICN 4, Section 5.7.3.2, which states that software used outside its operating environment is unqualified. The DR documents that TOUGH2 V1.6 was recompiled with different input parameters. Similar adverse conditions were discovered as Audit Item 34. Audit Item 34 concerns the operational range for the STRELTSOVA_ADAMS software, which is not clearly defined. This condition has been identified as DR BSC(O)-03-D-179.

BSC(O)-02-D-099 cites QARD, Revision 10, Sections 6 and 2, which require implementing documents that specify that technical and quality requirements be reviewed and that mandatory comments are resolved. The DR documents that there is no evidence of technical reviews and resolution of mandatory comments performed for Requirements Documents and Design Documents during software development. The audit identified the same condition as Audit Items 25 and 27. Audit Item 25 concerns no objective evidence of technical reviews performed for the RD and DD for SZ_CONVOLUTE V 3.0. Audit Item 27 identifies that when the review was performed, it was not to a level that ensured consistency between the design and system requirements document. This condition is documented as DR BSC(O)-03-D-177.

LANL(B)-02-D-062 documents that the STO_UNSAT v1.0LV Test Code Version that was submitted to SCM is incorrect. Audit Item 45 identifies a similar condition that Validation Test Plans and Test reports do not consistently document the test environment for STRELTSOVA-ADAMS and TOUGH2 V 1.6. This condition is documented as DR BSC(O)-03-D-179.

BSC-02-D-070 cites AP-SI.1Q, Revision 2, ICN 4, Section 5.8.3.2, which requires that the use of software be controlled so that comparable results can be obtained and replicated within the defined boundaries to which the software was originally qualified. The DR documents that NUFT V3.0s was baselined for Solaris 5.5.1 yet used Sun OS 5.6 for AMR-ANL-EBS-MD-000026. Similar conditions were identified as Audit Item 34. Audit Item 34 concerns the operational range for the STRELTSOVA_ADAMS software, which is not clearly defined. These conditions have been documented as DR BSC(O)-03-D-179.