January 9, 2006

Mr. Mark H. Williams, Director
Office of License Application and Strategy
Office of Repository Development
U. S. Department of Energy
1551 Hillshire Drive
Las Vegas, NV 89134-6321

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION OBSERVATION AUDIT REPORT NO. OAR-05-05, OBSERVATION AUDIT OF BECHTEL SAIC COMPANY, LLC INTERNAL AUDIT BQAP-BSC-05-07

Dear Mr. Williams:

Enclosed is the U.S. Nuclear Regulatory Commission (NRC) Observation Audit Report (OAR-05-05) of the Bechtel SAIC Company, LLC (BSC), internal performance-based audit BQAP-BSC-05-07, conducted on August 15 - 31, 2005, at the U.S. Department of Energy (DOE) facilities in Las Vegas, Nevada, and at Lawrence Livermore National Laboratories (LLNL) in Livermore, California.

The BSC audit team assessed the effectiveness and implementation of the quality assurance program requirements applicable to scientific investigations supporting the waste package and drip shield degradation models. At the conclusion of the audit, the BSC audit team presented its findings at an exit briefing with DOE and BSC management and issued an audit report, dated October 7, 2005. Based on the results of its evaluations, the BSC audit team identified several condition adverse to quality, including problems with the documentation, traceability and reproducibility of the Thermal-Hydrological-Chemical (THC) Seepage Model. With the exception of the THC Seepage Model, the BSC audit team's conclusion was that the overall performance of audited activities was satisfactory. In addition, the BSC audit team found that LLNL satisfactorily and effectively implemented the examined sections of the DOE Quality Assurance Requirements and Description (QARD) document, Revision 16.

NRC conducted an audit observation of BSC's audit in accordance with NRC Manual Chapter 2410, "Conduct of Observation Audits." The NRC team observed the BSC audit team members performing the audit, reviewed the same documentation as the BSC audit team, and attended various interviews conducted by the BSC audit team. Regarding the acceptability of the models, NRC found a number of issues that are identified as either audit observation inquiries or weaknesses, in this report, that we believe the BSC audit team should have considered, as part of deciding that the models were adequate. In addition, contrary to the findings of the BSC audit team, the NRC observers concluded that LLNL did not effectively implement the control of maintenance and test equipment and corrective action requirements of DOE's QARD, related to the experiments conducted to study the effects of deliquescence on the corrosion rates of the waste package. Specifically, LLNL corrosion experiments were conducted at temperature ranges where the vendor had not certified the relative humidity probes nor calibrated them before use. Although these deficiencies were identified in Condition

Reports, LLNL continued to use the subject relative humidity probes in corrosion experiments, a condition which apparently rendered the data obtained from the experiments unusable. NRC brought this matter to the attention of the BSC audit team; however, it did not document the condition of its audit reports or effectively reflect it in its assessment of LLNL's compliance with the QARD requirements. As a result of these issues, NRC has concluded that the BSC audit was not effective in identifying, documenting, and alerting BSC and DOE management to the significance of the issues, at LLNL, which were in non-compliance with the QARD requirements. Items the NRC observers identified as involving non-compliance with the QARD are documented as deficiencies in this report.

A written response to this letter and the enclosed report is not required; however, a response is requested to the open Audit Observer Inquiries identified in Section 5.2 of the enclosed report. The staff will continue to interface with DOE and follow the action that you take to address the issues identified during this audit. If you have any questions, please contact Thomas Matula at 301-415-6700.

Sincerely,

/RA/

Elmo E. Collins, Deputy Director
Licensing and Inspection Directorate
Division of High-Level Waste Repository Safety
Office of Nuclear Material Safety
and Safeguards

Enclosure: U.S. Nuclear Regulatory Commission Observation Audit Report OAR-05-05, "Observation Audit of Bechtel SAID Company, LLC, Audit of Scientific Investigation, Waste Package, and Drip Shield Degradation," BAD.-BSC-05-07

cc: See Attached List

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cc:

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C. Marden, BNFL Inc.

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T. Kingham, GAO

D. Feehan, GAO

E. Hiruo, Platts Nuclear Publications

G. Hernandez, Las Vegas Paiute Tribe

K. Finfrock, NV Congressional Delegation

P. Johnson, Citizen Alert

M. Williams, DOE/ORD

J. Williams, DOE/Washington, DC

J. Bacoch, Big Pine Paiute Tribe of the Owens Valley

M. Plaster, City of Las Vegas

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D. Vega, Bishop Paiute Indian Tribe

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C. Bradley, Kaibab Band of Southern Paiutes

R. Joseph, Lone Pine Paiute-Shoshone Tribe

L. Tom, Paiute Indian Tribes of Utah

E. Smith, Chemehuevi Indian Tribe

D. Buckner, Ely Shoshone Tribe

V. Guzman, Walker River Paiute

D. Eddy, Jr., Colorado River Indian Tribes

H. Jackson, Public Citizen

J. Wells, Western Shoshone National Council

D. Crawford, Inter-Tribal Council of NV

I. Zabarte, Western Shoshone National Council

S. Devlin

G. Hudlow

D. Irwin, Hunton & Williams

P. Golan, DOE

M. Rice, Lincoln County, NV

G. Hellstrom, DOE

Reports, LLNL continued to use the subject relative humidity probes in corrosion experiments, a condition which apparently rendered the data obtained from the experiments unusable. NRC brought this matter to the attention of the BSC audit team; however, it did not document the condition of its audit reports or effectively reflect it in its assessment of LLNL's compliance with the QARD requirements. As a result of these issues, NRC has concluded that the BSC audit was not effective in identifying, documenting, and alerting BSC and DOE management to the significance of the issues, at LLNL, which were in non-compliance with the QARD requirements. Items the NRC observers identified as involving non-compliance with the QARD are documented as deficiencies in this report.

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Sincerely,

/RA/

Elmo E. Collins, Deputy Director
Licensing and Inspection Directorate
Division of High-Level Waste Repository Safety
Office of Nuclear Material Safety
and Safeguards

Enclosure: U.S. Nuclear Regulatory Commission Observation Audit Report OAR-05-05, "Observation Audit of Bechtel SAID Company, LLC, Audit of Scientific Investigation, Waste Package, and Drip Shield Degradation," BAP.-BSC-05-07

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U.S. NUCLEAR REGULATORY COMMISSION OBSERVATION AUDIT REPORT NO. OAR-05-05,
"OBSERVATION AUDIT OF BECHTEL SAIC COMPANY, LLC,
AUDIT OF SCIENTIFIC INVESTIGATION,
WASTE PACKAGE, AND DRIP SHIELD DEGRADATION," BQAP-BSC-05-7

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Elmo Collins, Chief
Licensing and Inspection Directorate
Division of High-Level Waste Repository Safety
Office of Nuclear Material Safety and Safeguards

1.0 INTRODUCTION

On August 15 – 31, 2005, staff from the U.S. Nuclear Regulatory Commission (NRC) Division of High-Level Waste Repository Safety, NRC Region IV, and the Center for Nuclear Waste Regulatory Analyses (CNWRA) observed the Bechtel SAIC Company, LLC (BSC) audit BQAP–BSC–05–07 of "BSC Waste Package Degradation Investigations and Analyses." The BSC audit team, comprised of quality assurance (QA) personnel and technical specialists, conducted the audit at the U.S. Department of Energy (DOE) facilities in Las Vegas, Nevada, and at the Lawrence Livermore National Laboratory (LLNL) facilities in Livermore, California. The purpose of this audit was to evaluate whether scientific investigations provided input, into the analysis and models for the waste package and drip shield degradation studies, that resulted in technically sound and defensible results. The audit included evaluations of the implementation of the Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description (QARD), DOE/RW–0333P, Revision 16, and technical evaluation of work against NUREG-1804, "Yucca Mountain Review Plan, Acceptance Criterion 2," Section 2.2.1.3.1.3. The NRC observers conducted their activities in accordance with NRC Manual Chapter 2410, "Conduct of Observation Audits," while observing the audit. In accordance with the guidance in Manual Chapter 2410, the NRC observers were to: (i) evaluate the effectiveness of the BSC audit team to identify deficiencies in the QA program of the organizations being audited; and (ii) to evaluate the implementation of the QA program by the organization being audited.

2.0 MANAGEMENT SUMMARY

NRC observers conducted an audit observation of the BSC audit team activities to assess the effectiveness of the audit and to evaluate the implementation of the QA program by the organizations being audited. The BSC audit team included the NRC observers in all activities related to the audit and allowed full access to the documents being reviewed and the interviews conducted. NRC observers were allowed the necessary freedom to make an independent evaluation of the effectiveness of the audit and the implementation of the QA program regarding the corrosion studies reviewed during this audit. The observers reviewed the qualifications of the Audit Team Leader, auditors, and Technical Specialists and determined that they were qualified by education, experience, and training and were independent of the areas reviewed.

The NRC observers provided periodic feedback to the BSC audit team related to issues identified during the audit and conducted a post-audit review, with the BSC audit team, of the more significant concerns identified by the NRC observers. These concerns are described in this report and focus on several key issues that are summarized in Section 5.1, "NRC Observation Summary." The areas of concern included the inadequate implementation of the QARD related to the work at LLNL for the deliquescence experiments that used uncalibrated humidity probes, the referencing of cancelled documents in the analysis model reports, and the inadequate surface cleaning of several samples used to determine corrosion rates. The issues related to the adequacy of the audit include concerns with the last-minute reductions in the audit scope and the lack of technical representation on the audit team that went to LLNL.

As a result of these issues, NRC does not agree with the conclusion reached by BSC, in its audit report issued October 7, 2005, that LLNL was satisfactorily and effectively implementing the QARD for the areas reviewed in this audit. NRC agreed with the BSC audit conclusions regarding the problems with documentation, traceability, and reproducibility with the Thermal-

Hydrological-Chemical (THC) Seepage Model.

3.0 AUDIT PARTICIPANTS

BSC Auditors/Technical Specialists

Judith Shipman, Audit Team Leader
Carl Wright, Auditor
Ajulena Barnes, Auditor
Sandra Castro, Auditor
Thomas Esper, Auditor
Bob Habbe, Auditor
Stanley Levine, Auditor
Stephen Schuermann, Auditor
Stanley Howard, Ph.D., Technical Specialist, Metallurgy/Corrosion
Kathryn Johnson, Ph.D., Technical Specialist, Geochemistry

NRC Observers/Technical Specialists

Robert Latta, NRC, Team Leader
Vincent Everett, NRC, Senior Inspector
Aladar Csontos, NRC, Ph.D., Technical Specialist
Rodney Weber, CNWRA, QA Specialist
Lietai Yang, CNWRA, Ph.D., Technical Specialist

Third-Party Observers

Susan Lynch, State of Nevada
Don Shettel, State of Nevada
Engelbrecht von Tiesenhausen, Clark County, Nevada
Ram Murthy, DOE, Office of Quality Assurance

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

The BSC auditors conducted the audit in accordance with Line Procedure (LP)-18.6Q-BSC, "QA Internal Audit Program," and Administrative Procedure (AP)-16.1Q, "Condition Reporting and Resolution." The audit team used elements of the QARD, applicable BSC procedures, LLNL procedures, and the two analysis model reports, to generate the audit checklist. The NRC observers followed NRC Manual Chapter 2410 "Conduct of Observation Audits," while observing the audit.

4.1 Scope of the Audit

The objective of the audit was to evaluate whether scientific investigations related to waste package and drip shield degradation provided input into selected models that resulted in technically sound and defensible model results. The models selected for review were ANL–MD–EBS–000003, "General and Localized Corrosion of the Waste Package Outer Barrier," and ANL–MD–EBS–000033, "Engineered Barrier System: Physical and Chemical Environment." The audit included a review of inputs to these models back to the original data collected and an evaluation of scientific approaches and methods. The audit scope also examined the use and control of measuring and test equipment, implementation of QA requirements, and the collection, documentation, control, and use of data. QA requirements examined during this audit were contained in DOE's QARD and applicable DOE and BSC quality-affecting procedures.

4.2 Conduct and Timing of the Audit

BSC provided its original audit plan to NRC on July 25, 2005. However, on August 3, 2005, less than two weeks before initiation of the audit, BSC issued a revised audit scope that reduced the areas to be reviewed during the audit. This reduction in audit scope brought into question whether the audit objectives, stated as a broad assessment of data input and technical products, could be fulfilled. As a minimum, the change in scope weakened the audit and reduced the number of products that would be reviewed. Overall, NRC finds that the reduced audit scope also limited the opportunities to identify issues with the data input and technical products.

NRC also observed that preparations for the audit were delayed, in that audit checklists were not complete and available until the start of the audit. This was inconsistent with past experiences related to audits, conducted by DOE and BSC, in which the audit scope and audit checklists were generally completed well in advance of the audit activity, allowing project personnel and NRC staff to adequately prepare for the audit.

NRC finds that reducing the scope of the audit at the last minute and not having the audit checklists available until the beginning of the audit represented an audit weakness.

4.3 Audit Team Qualifications and Independence

The NRC observers reviewed the qualifications for the audit team members, including the technical specialists assigned to the team, and determined they were qualified and independent of the areas reviewed. Several senior-level QA personnel were included on the BSC audit team. These individuals were cognizant of the DOE and BSC QA requirements and the various procedural requirements related to the type of work being reviewed during this audit. The technical specialists assigned to the audit were knowledgeable in the areas reviewed and asked in-depth questions during interviews. However, BSC did not include either of the two technical specialists in the LLNL portion of the audit, thereby reducing the effectiveness of the audit to identify technical issues with the experiments being conducted at LLNL. This concern was expressed to the BSC audit team during the audit by NRC. Not including the technical specialists in the LLNL portion of the audit is identified as an audit weakness.

4.4 Examination of QA Elements

The following activities were audited by the BSC QA specialists on the audit team.

4.4.1 QA Program

The BSC auditors reviewed planning-related documents to verify that sufficient detail was included to support testing and validation and to allow a technically competent independent individual to replicate the work. Technical work plans were reviewed to determine that qualified personnel were assigned to perform the scientific investigation work. Software, measuring, and test equipment and sample selection were reviewed for appropriateness. Qualification records, for selected personnel responsible for performing, verifying, and managing scientific activities associated with the audited models, were reviewed, to verify that these aforementioned individuals' education and experience were commensurate with the requirements established in the job descriptions for the assigned positions. It was also confirmed that these individuals had completed training as specified in the assigned training program descriptions. No NRC issues were identified related to this audit topic.

4.4.2 Procurement Document Control

The BSC audit team reviewed a representative sample of scientific notebooks and associated procurement documents to determine if the purchases made in support of scientific activities were in compliance with quality-related procedures. Procurement document records for these purchases were reviewed to verify that appropriate item or service descriptions were included and quality, technical, and acceptance requirements were specified for items and services. No NRC issues were identified related to this audit topic.

4.4.3 Implementing Documents

The BSC auditors verified that management was responsible for assuring work was conducted in accordance with appropriate technical implementing procedures. Implementing documents were reviewed and verified to address work modifications or changes, data collection, and analysis, and verifications and traceability. No NRC issues were identified related to this audit topic.

4.4.4 Document Control

The BSC auditors reviewed and verified that controlled documents were distributed through electronic notification with links to the controlled document in the Control Document Information System. Paper copies being maintained were verified to have the appropriate required red stamp on the first page.

The NRC observers noted that some of the analysis model reports reviewed during the audit contained references to documents that were "canceled." Specifically, the "Drip Shield and Waste Package Outer Barrier," analysis model report (ANL–EBS–MD–000001, Revision 1), which had been cancelled, was referenced numerous times in the two analysis model reports evaluated during the audit. This cancelled analysis model report was not in the current report database. Subsequent to the identification of this issue, the NRC observers were advised that referencing cancelled documents is considered an acceptable BSC practice. However, the referencing of canceled documents could be problematic during the potential license application review, and NRC has requested clarification from DOE regarding its plans to use cancelled documents. This request has been submitted as Audit Observation Inquiry AOI-OAR-05-05-04.

4.4.5 Control of Purchased Items and Services

The BSC auditors reviewed scientific notebooks to evaluate items and services that had been purchased. The BSC auditors verified that acceptance reports were completed, that items and services met purchasing requirements, deficiencies were resolved with suppliers, and reports were transmitted to BSC procurement for inclusion with the project data package. No NRC issues were identified related to this audit topic.

4.4.6 Control of Measuring and Test Equipment

The BSC auditors reviewed the scientific notebooks associated with the LLNL corrosion study experiments, to identify the specific equipment used in these tests. This included a review of records associated with calibrated equipment for service procurement, receipt inspection, labeling, recall, calibration standards used, calibration method, and out-of-tolerance and nonconformance report documentation. The review included examination of two previously documented Condition Reports (CRs). Specifically, CRs 2247 and 5430 documented the use of the Vaisala Model HMP-243 Temperature/Humidity Probes at temperatures in excess of their calibrated range. The use of these probes was also in excess of the range for which the manufacturer certified the accuracy of the indicated relative humidity.

The information identified by the NRC observers during the review of the two CRs 2247 and 5430 brought into question the validity of the data collected, when the subject humidity probes were used, during the corrosion experiments conducted between the years 2002 and 2005 at LLNL. Based on the result of the review of the CRs and observation of BSC interviews with the LLNL researchers and managers, the NRC observers questioned whether the corrosion data could be considered technically sound and defensible. The NRC observers concluded that LLNL had started at least two experiments in non-compliance with the QARD calibration requirements and had conducted several years of data collection with the humidity probes not calibrated and used outside the manufacturer's documented range of acceptable use.

At the end of the audit, BSC concluded that LLNL had effectively implement the QARD. The NRC observers are concerned about this conclusion, based on the following issues related to QARD Section 12.0, "Control of Measuring and Test Equipment," and BSC Procedure LP–12.1Q–BSC, "Control of Measuring and Test Equipment":

- Experiments Were Started Without Calibrated Instruments: Two experiments were identified, during this audit, that had been started without the Vaisala humidity probes calibrated for the high range of temperatures used in the experiments. Specifically, QARD Section 12.2.1 states, in part, that ... "instruments shall be calibrated prior to use against reference calibration standards traceable to nationally recognized standards." Despite this QARD requirement, experiments related to Scientific Notebook SN–LLNL–SCI–474–V2, "Mixed Salts," and Scientific Notebook SN–LLNL–SCI–484–V1, "Deliquescence of Mixed Salts, Measurements of Deliquescence Relative Humidity and Determination of Boiling Point from Deliquescence Relative Humidity," were started without the Vaisala humidity probes being calibrated for the expected temperature ranges of the experiments.

- Calibration Basis Was Not Documented: LLNL did not comply with QARD Section 12.2.1, concerning establishing a basis for calibration when nationally recognized standards are not available. Specifically, QARD Section 12.2.1 states, in part, that "If no nationally recognized standard exists, the basis for calibration shall be documented." Despite this QARD requirement, no basis for calibration was established by LLNL before

using the Vaisala humidity probes in two of the experiments reviewed during this audit.

- LLNL Planned to Conduct an In-House Experiment to Calibrate Probes and Qualify Data after the Experiments Were Completed: In response to the problem documented in CRs 2247 and 5430, LLNL devised an in-house experiment to "calibrate" the Vaisala humidity probes at the higher temperatures. This was required because the manufacturer declined to certify that the probes were appropriate for use at the higher temperatures or to provide calibration documentation, and it was determined that a National Institute of Standards and Technology traceable standard did not exist. Once the probes were "calibrated," LLNL planned to declare the data collected during the SCI-474 and SCI-484 experiments "qualified," despite the fact that the probes had not been calibrated before starting the experiments. No industry standard protocol, such as that identified in ANSI/ISO/IEC 17025:2005(E), had been adopted as the basis for performing the independent "calibration" of the probes. Additionally, no process for an independent validation of the LLNL calibration results had been identified to ensure the calibration experiments could withstand a rigorous scientific examination. NRC also noted that no provisions are included in the QARD for starting an experiment with an instrument not calibrated at the temperatures in which it will be used, and then calibrating it after completion of the experiment and considering the experimental data as qualified.

- Scientific Notebook SCI–484 States Probes Were Calibrated: Scientific Notebook SCI–484 documented that the Vaisala humidity probes were calibrated and provided the calibration date for the probes in the scientific notebook. Scientific Notebook SCI-484 was initiated 6 months after the calibration problem was identified and documented in CR 2247. However, no explanation nor notation was included in the scientific notebook identifying the humidity probes as not being calibrated at the high range of temperatures being used in the experiments. Although this information was provided to the BSC audit team, it did not elevate this misrepresentation of the calibration status of the probes in the scientific notebook to DOE and BSC managements for further investigation.

NRC determined that LLNL had not complied with the requirements of Section 12.0 of the QARD related to the performance of corrosion rate experiments. Specifically, it was concluded that LLNL had initiated these experiments: (i) without properly calibrated instruments; (ii) had not established an adequate basis for calibration when nationally recognized standards were unavailable; and (iii) misrepresented the correct status of the calibration of the humidity probes in the associated scientific notebook. Based on the issues identified above, NRC concluded that LLNL had not satisfactorily and effectively implemented the QARD requirements related to the control of measuring and test equipment. This conclusion disagreed with the conclusions reached by the BSC audit team. Therefore, NRC is requesting an explanation as to why these issues did not constitute an unsatisfactory implementation of the QARD at LLNL. This request has been submitted as Audit Observation Inquiry AOI-OAR-05-05-05.

4.4.7 Handling, Storage, and Shipping

While at LLNL, the BSC auditors verified that samples were handled, stored, and shipped adequately to prevent damage, deterioration, and loss. Controls, inspections, and tests for special handling tools and equipment were conducted in accordance with documented procedures. Specified time intervals were in place to ensure that tools and equipment were adequately maintained. No NRC issues were identified related to this audit topic.

4.4.8 Corrective Action

The BSC auditors reviewed a number of CRs related to the LLNL experiments. Of the 14 CRs issued, 12 were identified by the LLNL QA organization and only 2 were identified by the researchers. Based on the NRC observer's discussions with the LLNL researchers, the threshold at which a CR was required was based on the significance of the issue and whether the problem could be easily resolved. Specifically, if the problem were significant or could not be resolved quickly, a CR was initiated. However, low-significance issues that were easily fixed were typically not documented in the corrective action system. As noted by the NRC observers, this approach to problem identification for quality-affecting activities does not comply with the requirements of Procedure AP-16.1Q, "Condition Reporting and Resolution." Specifically, Procedure AP-16.1Q states that, "Conditions shall be entered into the Corrective Action Program (CAP) system as soon as practical after identification." Furthermore, Procedure AP-16.1Q does not establish a threshold that provides for easily fixed and low-significance issues to be excluded from the requirement to issue a CR. Allowing staff to make a determination as to when an issue is entered into the corrective action program, as opposed to requiring all issues to be entered into the system, is identified as a deficiency.

Within the scope of the audit, two CRs were reviewed in detail by the NRC observers. These were: (i) CR 2247, "Measuring and Test Equipment Used Outside the Range of Calibration," initiated February 19, 2004, and closed December 1, 2004; and (ii) CR 5430, "Data Acquired by Vaisala Temperature/Humidity Probes Above 90 Degrees Celsius [194 °F] Is Indeterminate," initiated April 8, 2005. CR 5430 was still open at the time of this audit. Both CRs concerned the use of the Vaisala probes to make relative humidity measurements outside their calibrated temperature range. Specifically, the probes were calibrated at temperatures of 20 °C, 40 °C, and 60 °C, for use in collecting relative humidity readings. The NRC observers noted that a May 12, 2004, entry in the "Investigation Findings" section of CR 2247 documented that the industry current standards do not support traceable calibrations above 70 °C, and that there is no current standard that can be used to properly calibrate humidity probes at temperatures above 70 °C. CR 2247 also identified that the probes had been used at temperatures up to 90 °C, and CR 5430 references test temperatures above 120 °C. Additionally, CR 5430 identified an action to construct a system for calibrating the probes up to 180 °C. The 180 °C value was the upper temperature limit being used in the SCI-484 experiments, which was not mentioned in either of the CRs. The NRC observers further noted that CR 2247 was issued as a Significance Level B. However, the subsequent problems, documented in CR 5430, that were repetitive to the deficiencies identified in CR 2247, were characterized as a Level C. No explanation for the disparity in CR significance levels was provided during the audit, and the BSC audit team did not identify this issue as an item requiring follow-up.

The specific concerns, identified by the NRC observers related to the corrective action program aspects of these CRs are discussed below.

- Corrective Actions for CR 2247 Not Implemented as Described: CR 2247 identified a deficiency regarding the use of relative humidity probes outside their calibrated range. The remedial actions associated with this CR stated that ... "investigators will document (make reference to) CR 2247 in open scientific notebooks identified as having used the Vaisala temperature/humidity probes outside their range of calibration." This entry in CR 2247 was made three months before Scientific Notebook SCI–484 being opened. However, Scientific Notebook SCI–484 does not include a reference to CR 2247, even though CR 2247 was still open when the experiments for Scientific Notebook SCI-484

were started. Therefore, once the initial review of the open scientific notebooks had been completed as a remedial action for CR 2247, no provisions were established to ensure that future scientific notebooks that used the Vaisala probes would reference CR 2247.

- Out-of-Calibration Measuring and Test Equipment Were Not Controlled: The Vaisala humidity probes identified in CR 2247 were not tagged, segregated nor otherwise controlled to prevent use until they had been calibrated. This is a requirement of Section 12.2.3.B of the QARD. No objective evidence was presented, during the audit at LLNL, that the Vaisala probes had been tagged with a Measuring and Test Equipment (M&TE) Limited Calibration sticker in accordance with the requirements of Procedure LP–12.1Q–BSC, "Control of Measuring and Test Equipment." The M&TE Limited Calibration sticker identifies the calibration limitations of an instrument and could have been a valuable part of the corrective action program to prevent use of the probes in future high-temperature experiments.

- CR 5430 was Opened Without Recognizing That Additional Experiments Were Underway with the Uncalibrated Probes: CR 5430 was opened April 8, 2005, concerning the 2002 mixed-salt experimental results that were entered into the Data Tracking Number (DTN) System as "qualified." CR 5430 was a follow-up of issues related to CR 2247. A review of the DTN information related to the mixed-salt data found that the data were entered between November 2002 and February 2003 and remained in the system as qualified until July 2005, a period of approximately 2 ½ years.

  CR 5430 discussed the problem with the calibration of the Vaisala probes and referenced CR 2247. However, CR 5430 did not identify that experiments related to Scientific Notebook SCI–484 were currently underway and had been underway for 8 months, also using the Vaisala probes outside their calibrated range.

- LLNL Had Not Issued a CR for the Second Set of Experiments Using the Uncalibrated Probes: The experiments related to Scientific Notebook SCI-484 had been initiated in August 2004. As of the date of this audit in August 2005, no CR had been issued related to the use of the uncalibrated humidity probes in the Scientific Notebook SCI-484 experiments. LLNL failure to recognize this repetitive non-conformance with the QARD requirements related to instrument calibration and issue a CR is an example of the ineffectiveness of the implementation of the QARD at LLNL, related to the corrective action program.

The NRC observers determined that LLNL had not complied with the requirements of Procedure AP-16.1Q related to documenting deficiencies, preventing recurrence of the problems, and capturing the second set of experiments using uncalibrated probes in the corrective action program. Based on the issues identified above, NRC concluded that LLNL had not satisfactorily and effectively implemented the QARD requirements related to corrective actions. This conclusion disagreed with the conclusions reached by the BSC audit team. NRC is requesting an explanation as to why these issues did not constitute an unsatisfactory implementation of the QARD. This request has been submitted as Audit Observation Inquiry AOI-OAR-05-05-05.

4.4.9 QA Records

After task completion by project personnel, document packages are submitted to the records processing center. The BSC audit team reviewed the availability of selected records that had been submitted to the records process center through both the computerized system and, for records not yet available in the computerized system, the ability to access the paper copies of the records. The BSC auditors identified several minor deficiencies specifically related to the records management process. These included instances of late record submittals, incorrect sensor identification in an acceptance report, and a signature missing from the document review record.

During the review of various records related to ANL–MD–EBS–000003, "General and Localized Corrosion of the Waste Package Outer Barrier," Revision 2, the NRC observers noted that scanning electron microscope images related to the corrosion-rate experiments were not available in the technical data management system. Further review found that the documents had not been submitted as part of the project records. These documents, identified as Binder #11, were eventually located at LLNL. In the experiments discussed in these documents, corrosion rates were determined by cleaning the samples of all corrosion, then examining the sample under the scanning electron microscope, to verify all corrosion had been removed. If corrosion were still present on the sample, the cleaning process was repeated. Once all corrosion was removed, the sample was weighed and compared to the weight before cleaning, to determine the weight loss. From these data, the corrosion rate could be determined. However, NRC observers examined the images in the documentation package and determined that all of the scale had not been completely removed from the samples. This finding was inconsistent with the information in ANL–MD–EBS–000003, which stated that all of the scale had been removed from the samples. The NRC observers noted that the incomplete cleaning of all the surface corrosion from the samples would impact the determination of the corrosion rate values.

In summary, the failure to submit Binder #11 as part of the project records, the incorrect statement in the associated analysis model report related to the final condition of the corrosion samples, and the concern related to the impact of inadequate cleaning of the samples on the conclusions reached on the corrosion rate values is identified as a deficiency. The NRC observers identified these issues to the BSC audit team; however, no CR was issued. The failure to issue a CR to document these conditions is identified as a deficiency.

4.4.10 Software, QARD Supplement I

The BSC auditors reviewed software used during data collection and determined that all the software was off-the-shelf software that did not require independent verification and validation. No NRC issues were identified related to this audit topic.

4.4.11 Sample Control, QARD Supplement II

The BSC auditors examined the pertinent scientific notebooks and identified samples for review. Inspection records were accessed though the technical data management system. Implementation of controls was reviewed during the onsite audit at LLNL. The BSC auditors verified that samples were being controlled in accordance with the applicable procedures. Sample identification, location, transfer, storage life, segregation, traceability to the appropriate logs, and other records were verified. No NRC issues were identified related to this audit topic.

4.4.12 Scientific Investigation, QARD Supplement III

During this audit, selected scientific notebooks were reviewed by the BSC audit team. The notebooks were reviewed to determine completeness, level of detail, traceability, and the documentation of compliance reviews. Four of the 14 scientific notebooks were found to have problems. These problems included inadequate entries, traceability of information, incomplete information, and lack of detail that would allow confirming the results without additional information from the original investigator. The BSC audit team issued two Level B CRs related to incomplete information in the scientific notebooks. No NRC issues were identified related to this audit topic.

4.4.13 Control of the Electronic Management of Data, QARD Supplement V

The BSC audit team technical specialists evaluated the transparency of technical products through document and data reviews and interviews conducted with the appropriate model development staff. The BSC audit team also examined the inputs that were documented in the technical products themselves and verified that all data were compiled in accordance with the appropriate technical data management system database requirements. The BSC auditors identified a discrepancy regarding the absence of a To-Be-Verified (TBV) number for data used in an approved document. No NRC issues were identified related to this audit topic.

4.4.14 Monitored Geologic Repository, QARD Appendix C

The BSC auditors reviewed documentation associated with purchased items and services where alternatives to QARD Section 7.0 were identified. Specifically, these included the procurement of quality-affecting services from non-quality supplier laboratories. In these cases, the BSC auditors verified the existence of the quality control sample plan and that the principal investigator confirmed that the analytical results received have been evaluated to the acceptance criteria established by the applicable quality control sample plan. No NRC issues were identified related to this audit topic.

4.5 Examination of Technical Activities

The BSC audit team technical specialists reviewed several documents supporting the engineered barrier system model, and conducted interviews with the technical report authors, checkers and reviewers. During the review of the associated technical data, the NRC observers identified several issues that were documented as audit observation inquiries. Based on the significance of these issues, NRC requests that BSC provide additional information, that can be used to evaluate the effectiveness of the BSC audit team, and to evaluate the implementation of the QA program by the organization being audited.

4.5.1 ANL–EBS–MD–000033, "Engineered Barrier System: Physical and Chemical Environmental Model," Revision 4

The BSC technical specialist reviewed the engineered barrier system physical and chemical environment model and the other documents that support this analysis model report, in conjunction with the audit team QA specialists, who interviewed the documents' originators, reviewers, and team lead.

4.5.1.1 MDL–NBS–HS–000001, "Drift-Scale Thermal-Hydrological-Chemical (THC) Seepage Model," Revision 4, dated February 2005

The BSC technical specialist reviewed various scientific notebooks and documents and conducted numerous interviews with individuals involved with collecting and analyzing the data for the Drift Scale THC Seepage Model. As a result of these review activities and interviews, the BSC audit team identified the following technical discrepancies:

- The notebook that described the minerals used in the report (Section 6.2.2.2) did not provide transparent and traceable information to support the selection of the minerals.
- The determination of the mineral reactive surface areas described in Appendix B, that was used as input to the rate equations in Section 6.4.2, was not properly documented and referenced.
- The documents that provided the basis for the selection of some thermodynamic data in the model report (Section 4.1.4) were not referenced in the report, nor were they listed in the references.
- The basis for the selection of the uncertainty used in the analysis for the mineral dissolution and precipitation rate was not properly documented, nor was it referenced.

- The description for the selection of the waters (PERM–2 and PERM–3) was not transparent.

As a result of the technical discrepancies found in this report, the BSC technical specialist determined that this model was unsatisfactory. BSC issued a Level B CR.

The NRC observers agree with the conclusions of the BSC technical specialist . In addition, the NRC observer questioned the technical basis for the assumption that no dripping will take place when the temperature of the drift wall is above 100 °C (212 °F). The Engineered Barrier System Physical and Chemical Environment Model Report assumes a 100 °C (212 °F) threshold for the onset of seepage. The statement, "Seepage waters do not enter the drifts until the host rock temperatures fall below 100 °C (212 °F)," is not supported by sufficient justification. BSC is being asked to provide the basis for why it did not consider the salt effect on the boiling point. This request will be tracked as audit observation inquiry AOI-OAR-05-05-01.

4.5.1.2 ANL–EBS–MD–000074, "Analysis of Dust Deliquescence for Features, Events, and Processes (FEP) Screening," Revision 0, dated June 2005

The technical basis for the selection of the salt assemblage and the adequacy of the database in ANL-EBS-MD-000074 were reviewed. Based on this review, the BSC team identified a technical discrepancy related to adequate justification for the selection of the log K value for sepiolite in the validation of the model.

The NRC observers also questioned the validated relative humidity range for the model and why the deliquescence relative-humidity data were presented in the report below the model-validated range of 40 percent. The EQ3/6 model for deliquescence relative humidity (RH_d) was validated for a relative humidity range from 100 to 40 percent. This is documented in the notes for Table 7-8 of ANL–EBS–MD–000045, "In-Drift Precipitates/Salts Model," Revision 2. However, ANL–EBS–MD–000074 presented results, in Figure 6.2-5, that have deliquescence relative humidity values much lower than 40 percent. Similarly, the equilibrium relative humidity data calculated by the EQ3/6 model for solutions containing mixed salts were well below 40 percent, as presented in Figures 6.13-2 and 6.13-13 of ANL–EBS–MD–000033, "Physical and Chemical Environment Model," Revision 4. BSC is requested to provide the basis for using model results that are outside of the model validation range. This request will be tracked as audit observation inquiry AOI-OAR-05-05-02.

4.5.1.3 ANL–DSD–MD– 00001, "Aqueous Corrosion Rates for Waste Package Materials," Revision 1, dated October 2004

Based on discussion between the BSC technical specialist and the researchers, BSC identified a technical discrepancy concerning the adequacy and transparency of documentation in this report. The discrepancy related to the criteria the investigator followed to select or exclude the corrosion rate data compiled in the report.

4.5.1.4 ANL–EBS–MD–000045, "In-Drift Precipitates/Salts Model," Revision 2, dated October 2004

The BSC technical specialist conducted interviews regarding the accuracy in uncertainty

represented in the technical basis for this model. The uncertainty range of the output pH from the model had been developed by comparing the model results with four experimental data points. The BSC technical specialist determined that this was not adequate. This determination was documented on Condition Report CR6487.

4.5.1.5 ANL–EBS–MD–000033, "Engineered Barrier System: Physical and Chemical Environment," Revision 4, dated July 2005

The BSC technical specialist conducted interviews regarding the accuracy, and appropriateness of the Pitzer database, and the completeness and accuracy of the calculations for the seepage evaporation in the model. As previously noted, the NRC observer questioned why the relative humidity data was below 40 percent, which is the lower limit that the Pitzer model was validated, were presented in the report. (Reference AOI OAR-05-05-02)

4.5.2 ANL–EBS–MD–000003, "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," Revision 2

The BSC technical specialists reviewed the sections of this model that included the dry oxidation model parameters; general corrosion temperature dependence modeling; localized corrosion model logic and data interpretation; experimental methods for corrosion tests; microbiological-induced corrosion modeling; statistical methodologies for corrosion-rate distributions; and associated model data from supplementary technical documents ANL–EBS–MD–000003, and ANL–WIS–MD–000023D, "Analysis of Waste Package Outer Barrier Localized Corrosion." As a result of the NRC observers' evaluation of the technical information related to this model, the following observations have been made.

4.5.2.1 Corrosion of Titanium Grade 24 Based on Grade 7 Data

The BSC technical specialist conducted interviews regarding the selection of corrosion-rate measurements in ANL–DSD–MD–000001, "Aqueous Corrosion Rates for Waste Package Materials," Revision 1. The NRC observers reviewed this document as well and identified the lack of adequate justification for using the general corrosion rates for the single phase (α) Titanium Grade 7 alloy in the modeling of the dual phase (α/β) Titanium Grade 24 alloy in representative repository environments (see Section 6.5, page 6-39 of ANL–DSD–MD–000001). No technical justification was provided for the basis that the measured corrosion rates of Titanium Grade 7 can be extrapolated to the Titanium Grade 7/24 weldments in the as-welded and stress-relieved conditions. This issue will be followed by NRC and will be discussed at future DOE and NRC technical meetings.

Specifically, the following information is needed to make a determination of the adequacy of the information related to the corrosion rates.

- A technical basis for modeling the general corrosion rates of the dual-phase (α/β) Titanium Grade 24 alloy in a representative repository environment using the general corrosion rates from the single-phase (α) Titanium Grade 7.

- A technical basis for the general corrosion rates for Titanium Grade 24 base material and Titanium Grade 7/24 weldments in the as-welded and stress-relieved conditions, as would be expected on an as-fabricated drip shield in a representative repository environment.

The lack of an adequate justification for the Titanium Grade 7/24 weldments and Titanium Grade 24 general corrosion rates under representative repository conditions is identified as a significant weakness related to this analysis model report and an area of technical concern for the potential license application.

4.5.2.2 Corrosion Scaling Factor for the Microbiologically Induced Corrosion Model

The BSC technical specialist conducted interviews regarding the adequacy of the models in ANL–EBS–MD–000003, "General Corrosion and Localized Corrosion of Waste Package Outer Barrier." Based on the review of this information, the NRC observers identified the need for additional justification for modeling microbiologically influenced corrosion, using a scaling factor to the generalized corrosion model. The scanning electron micrographs of the corrosion under biotic conditions in Figure 6-67, of ANL–EBS–MD–000003, appear significantly different from typical general corrosion. Specifically, the NRC observer noted that micropores were found, on the specimens, that were tested under the biotic condition. This may be an indication of localized corrosion, as opposed to general corrosion. Although the general corrosion scaling factor was intended to represent a conservative approach, the exclusion of localized microbiologically influenced corrosion effects without a documented justification is identified as a weakness in the modeling used for this analysis model report.

4.5.2.3 Inconsistencies for Overall Localized Corrosion Modeling

The BSC technical specialist conducted interviews regarding the technical adequacy of the models in ANL–EBS–MD–000003, "General Corrosion and Localized Corrosion of Waste Package Outer Barrier." The NRC observers identified inconsistencies between the localized corrosion model criteria found on page 8-6 of ANL–EBS–MD–000003, "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," Revision 2 as compared to the model criteria found in ANL–EBS–MD–000074, "Analysis of Dust Deliquescence for Features, Events, and Processes Screening," Revision 0. For example, ANL–EBS–MD–000003, states on pages 1-3, 6-97, and 8-6, "If the exposure temperature exceeds 160 °C [320 °F] and a water film is present on the waste package surface, then localized corrosion initiates"; however, ANL–EBS–MD–000074 considers that localized corrosion will not initiate when a water film is formed by deliquescence at elevated temperatures (page 7-1), even though it has been shown experimentally that some salt assemblage may deliquesce at temperatures over 190 °C [374 °F] (page 7-2). BSC is requested to provide an explanation for these inconsistencies. This request will be tracked as audit observation inquiry AOI-OAR-05-05-03.

4.6 Potential Audit Findings

The BSC audit team identified the following potential CRs:

Three conditions adverse to quality were identified as Level B CRs:

1. Inadequate entries in Scientific Notebooks SN–LLNL–SCI–484–V1 (LP–SIII.11Q–BSC);

2. Inadequate documentation and traceability of work on MDL–NBS–HS–000001 “Drift-Scale THC Seepage Model,” Revision 4 (LP–SIII.10Q–BSC); and

3. Inadequate scientific notebooks supporting scientific investigations for MDL–NBS–HS–000001.

Eleven minor conditions adverse to quality were identified as Level C CRs:

1. Licensing Support Network-relevant records not submitted to the records processing center within 2 weeks (LP–IM–026–BSC);

2. Errors in calibration documentation (AP 17.1Q and LP–12.1Q–BSC);

3. Incorrect identification of a sensor in an acceptance report (AP–17.1Q);

4. Out-of-calibration report not changed to document out-of-calibration condition (LP–12.1Q-BSC);

5. QA records not submitted to the records process center within 60 days (AP–17.1Q);

6. Signature missing from document review record (LP–2.14Q–BSC);

7. Documentation errors in ANL–EBS–MD–000005 (LP–SIII.10Q);

8. No to-be-verified (TBV) number for data used in approved document (LP–3.15Q–BSC);

9. Need for additional confidence in development of uncertainty range for pH output from ANL–EBS–MD–000045, “In-Drift Precipitates/Salt Model,” Revision 2, (LP–SIII.10Q–BSC);

10. Need to document the process for selecting aqueous corrosion-rate data in ANL–DSD–MD–000001, “Aqueous Corrosion Rates for Waste Package Materials,” Revision 2, (LP–SIII.10Q–BSC); and

11. Need to examine the effects of uncertainties in the sepiolite log K on the output concentrations of magnesium in ANL–EBS–MD–000074, “Analysis of Dust Deliquescence for FEP Screening,” Revision 0 (LP–SIII.10Q–BSC).

Two Recommendations were identified (Level D CRs):

1. Improve the description of critical potential measurement in ANL–EBS–MD–000005, “General Corrosion and Localized Corrosion of the Waste Package Outer Barrier,”

Revision 2; and

2. Clarify the decision tree for localized corrosion in ANL–EBS–MD–000005.

5.0 NRC STAFF FINDINGS

5.1 NRC OBSERVATION SUMMARY

Although most of the audit observation results were found to be acceptable, several areas were identified as deficiencies or weaknesses. Deficiencies are a departure from a specific requirement such as an applicable code, standard, guide, the QARD, or acceptable industry or scientific practice. Weaknesses are activities which, though not a requirement, are less than optimum for the audit or for the organization being audited.

The following weaknesses and deficiencies are identified in the body of the report and are summarized below:

- Less than 2 weeks before initiation of the audit, BSC issued a revised audit scope, which reduced the areas to be reviewed during the audit. The change in scope reduced the number of products to be reviewed and reduced the opportunity to identify issues with the data input and technical products. NRC also observed that preparations for the audit were delayed in that audit checklists were not complete and available until just before the audit. Reducing the scope of the audit at the last minute and not having the audit checklists available until the beginning of the audit are identified as an audit weakness. (Section 4.2)

- The technical specialists were not included in the audit activities at LLNL, thereby reducing the effectiveness of the review of the experiments conducted at LLNL. This was identified as an audit weakness. (Section 4.3)

- LLNL initiated experiments to study the deliquescence effect on the corrosion of the outer surface of the waste package, using Vaisala humidity probes that were not vendor-qualified nor calibrated for the upper temperature limits of the experiment. This is in non-compliance with the QARD, which requires that test instruments be calibrated before use. This deficiency is an example of ineffective implementation of the QARD, at LLNL, related to the control of measuring and test equipment. (Section 4.4.6)

- LLNL planned to conduct experiments to calibrate the Vaisala humidity probes at the high temperatures used during the corrosion experiments. However, no nationally recognized standard existed, nor was the manufacturer able to provide a standard process for performing a calibration at high temperatures. Also LLNL had not adopted a nationally recognized protocol for conducting the calibrations. Not

  identifying these concerns to BSC and DOE management as potentially significant issues related to the defensibility of the LLNL experiments was identified as a deficiency. (Section 4.4.6)

- Scientific Notebook SCI-484 identified the Vaisala humidity probes as calibrated and documented the calibration date for the probes. However, appropriate documentation

was not included, in the scientific notebook, identifying the limitation on the use of the humidity probes at high temperatures. Failure to identify this potential misrepresentation of the information in the scientific notebook to management for further investigation is identified as a deficiency. (Section 4.4.6)

- Based on discussions with LLNL researchers, there was an understanding that problems that could be easily rectified or that were minor in nature did not require entry into the corrective action program. This practice is inconsistent with DOE's procedures concerning corrective action reporting, in that a threshold is not established for determining whether a problem should be captured in the corrective action system. This was identified as a deficiency. (Section 4.4.8)

- LLNL had issued two CRs identifying problems with the use of the Vaisala humidity probes. However, the corrective actions associated with these CRs were ineffective in establishing adequate controls on the humidity probes to prevent their use in a second set of experiments. This deficiency was identified as an example of ineffective implementation of the QARD, at LLNL, related to the corrective action program. (Section 4.4.8)

- The second set of experiments using the Vaisala probes was started at LLNL, 1 year before this audit as documented in Scientific Notebook SCI-484; yet, no CR had been issued capturing this repetitive non-conformance with the QARD requirements related to instrument calibration. LLNL has not established adequate provisions to prevent recurrence of the problem. This deficiency was identified as an example of ineffective implementation of the QARD, at LLNL, related to the corrective action program. (Section 4.4.8)

- A review of the list of documents submitted to the records processing center for the "General and Localized Corrosion of the Waste Outer Barrier Analysis Model Report," determined that not all documents had been submitted. The missing documents related to the corrosion-rate experiments. The documents were later located at LLNL. The documents included images of the samples, used in the experiments that were suppose to be cleaned of all corrosion; yet, the images appeared to still have corrosion present: (i) the incomplete submittal of all documents to the records-processing center; (ii) the lack of an accurate statement in the associated analysis model report concerning the cleanliness of the samples; and (iii) the potential impact of the samples not being clean, on the conclusions reached on the corrosion rate values are identified as deficiencies. NRC identified these issues to the BSC audit team. However, no CR was issued. Not issuing a CR on these problems is also identified as a deficiency. (Section 4.4.9)

- A review of ANL–DSD–MD–000001, "Aqueous Corrosion Rates for Waste Package Materials," Revision 1, identified a lack of adequate justification for using the general corrosion rates for the single-phase (α) Titanium Grade 7 alloy in the modeling of the dual-phase (α/β) Titanium Grade 24 alloy in representative repository environments. No technical justification was provided for the basis that the measured corrosion rates of Titanium Grade 7 can be extrapolated to the Titanium Grade 7/24 weldments in the as-welded and stress-relieved conditions. The lack of an adequate justification for the Titanium Grade 7/24 weldments and Titanium Grade 24 general corrosion rates under representative repository conditions is identified as a significant weakness related to this analysis model report and an area of technical concern for the potential license application issue. (Section 4.5.2)

- A review of ANL–EBS–MD–000003, "General Corrosion and Localized Corrosion of Waste Package Outer Barrier," identified the need for additional justification for modeling microbiologically influenced corrosion, using a scaling factor to the generalized corrosion model. The scanning electron micrographs of the corrosion under biotic conditions in Figure 6-67, on page 6-106 of ANL–EBS–MD–000003, appear significantly different from typical general corrosion. Specifically, the NRC observer noted that micropores were found on the specimens that were tested under the biotic condition. This may be an indication of localized corrosion, as opposed to general corrosion. Although the general corrosion scaling factor was intended to represent a conservative approach, the exclusion of localized microbiologically influenced corrosion effects without a documented justification is identified as a weakness in the modeling used for this analysis model report. (Section 4.5.2)

5.2 NRC AUDIT OBSERVER INQUIRY

In addition to the findings noted in Section 5.1 above, additional areas of technical product weaknesses were noted. Seven audit observation inquiries (AOI) were initiated and submitted to BSC for response.

1. AOI-OAR-05-05-01: "Drift-Scale THC Seepage Analysis Model Report," (Sections 4.5.1.1)

2. AOI-OAR-05-05-02: "Analysis of Dust Deliquescence for Features, Events and Processes (FEP) Screening," (Section 4.5.1.2)

3. AOI-OAR-05-05-03: "Inconsistencies for Overall Localized Corrosion Modeling," (Section 4.5.2.3)

4. AOI-OAR-05-05-04: "Referencing of Cancelled Documents," (Section 4.4.4)

5. AOI-OAR-05-05-05: "Use of the Vaisala Humidity Probes at Temperatures Outside their Calibrated Range," (Sections 4.4.6 and 4.4.8)

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