U.S. NUCLEAR REGULATORY COMMISSION

OBSERVATION AUDIT REPORT OA-96-05

OF THE YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION

AUDIT YM-ARC-96-16

OF THE LOS ALAMOS NATIONAL LABORATORY

08/14/96
John W. Bradbury
Geosciences and Hydrology
Review Section
Engineering and Geosciences Branch
Division of Waste Management

08/14/96
John G. Spraul
High-Level Waste Projects &
Quality Assurance Section
Performance Assessment and High-
Level Waste Integration Branch
Division of Waste Management

Reviewed and approved by:

08/14/96
David J. Brooks, Section Leader
Geosciences and Hydrology
Review Section
Engineering and Geosciences Branch
Division of Waste Management

08/16/96
John O. Thoma, Section Leader
High-Level Waste Projects &
Quality Assurance Section
Performance Assessment and High-
Level Waste Integration Branch
Division of Waste Management

ENCLOSURE

9608220034 960816
PDR WASTE
WM-11 PDR

1.0 INTRODUCTION

Members of the Nuclear Regulatory Commission Division of Waste Management quality assurance (QA) and geotechnical engineering staff observed the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM), Office of Quality Assurance, Yucca Mountain Quality Assurance Division (YMQAD) audit of the implementation of the Los Alamos National Laboratory (LANL) QA program and technical evaluation of Study Plan 8.3.1.2.2.2, "Water Movement Tracer Tests Using Chloride and Chloride-36 Measurements of Percolation at Yucca Mountain." The audit, YM-ARC-96-16, was conducted on June 24 through 28, 1966, at LANL offices and laboratories in Los Alamos, New Mexico. The State of Nevada was also represented at this audit.

The objectives of this compliance-based audit by YMQAD were to determine whether the LANL QA program and its implementation meet the applicable requirements of the OCRWM Quality Assurance Requirements and Description document (QARD-DOE/RW-0333P) and associated LANL implementing procedures. The objective of the technical portion of this audit was to evaluate the quality of the $^{36}Cl/Cl$ work for Yucca Mountain to determine the degree to which it meets program requirements and commitments.

The principle objective of the NRC staff was to evaluate the quality of the $^{36}Cl/Cl$ work for Yucca Mountain. A second objective was to gain confidence that YMQAD and LANL are properly implementing the requirements of their QA programs in accordance with the OCRWM QARD and Title 10 of the Code of Federal Regulations (10 CFR), Part 60, Subpart G (which references 10 CFR Part 50, Appendix B).

This report addresses the effectiveness of the YMQAD audit and the adequacy of implementation of QA controls in the audited areas of the LANL QA program.

2.0 MANAGEMENT SUMMARY

This compliance-based audit evaluated the implementation of the LANL QA program and included a performance-based technical evaluation of Study Plan 8.3.1.2.2.2, "Water Movement Tracer Tests Using Chloride and Chloride-36 Measurements of Percolation at Yucca Mountain." This study plan uses the ratio of $^{36}Cl/Cl$ measurements to estimate groundwater residence time. Bomb-pulse water is defined as precipitation that entered the ground as recharge during or since the peak period of atmospheric nuclear testing (post 1950). Evidence of bomb-pulse water in feature-based samples (samples from faults, fractures, and lithophysal cavities) from the Exploratory Studies Facility (ESF) suggests the existence of preferred pathways for water movement. Bomb-pulse ratios of $^{36}Cl/Cl$ were not observed in the systematic samples (samples of bulk rock material taken every 200 meters through the Topapah Spring welded and Paintbrush Tuff nonwelded units of the ESF). The most surprising aspect of the systematic samples, however, is that they did not exhibit depleted ratios, i.e., $<500 \times 10^{-15}$, suggestive of "old" water, as found in surface-based drillhole cuttings. Interpretation of the groundwater residence time of the systematic samples using the ratio of $^{36}Cl/Cl$ measurements alone is ambiguous. LANL personnel recognize that alternative lines of evidence are required to reduce the ambiguity, and efforts to reduce the ambiguity are continuing.

The audit team's overall finding was that the audit showed satisfactory LANL QA and technical performance. However, LANL's compliance with DOE procurement and software controls was rated unsatisfactory. Nonconformances were reported by the audit team at the post-audit conference as one preliminary Corrective Action Request (CAR), six preliminary Deficiency Reports (DRs), and one preliminary Performance Report (PR). These are listed in Section 4.9. The NRC staff agrees with the audit team findings noted above.

The NRC staff has determined that YMQAD Audit YM-ARC-96-16 was useful and effective. The audit was organized and conducted in a thorough and professional manner. Audit team members were independent of the activities they audited, they were well qualified in their disciplines, and their assignments and checklist items were adequately described in the audit plan.

3.0 AUDIT PARTICIPANTS

3.1 NRC

John G. Spraul	Observer
John W. Bradbury	Observer

3.2 DOE

Richard L. Maudlin	Audit Team Leader (ATL)	YMQAD/QA Technical Support Services (QATSS)
John R. Doyle	ATL in Training	YMQAD/QATSS
James Blaylock	Auditor	YMQAD
Henry T. Greene	Auditor	YMQAD/QATSS
Stephen T. Nelson	Technical Specialist (Geochemistry)	Civilian Radioactive Waste Management and Operating Contractor (M&O)/Woodward Clyde Federal Services

3.3 Other

Susan Zimmerman	Observer	State of Nevada

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

4.1 Auditing Procedures

This YMQAD audit of LANL was conducted in accordance with OCRWM Quality Assurance Administrative Procedure (QAAP) 18.2, "Audit Program" and QAAP 16.1, "Corrective Action." The NRC staff observation of this audit was based on the NRC procedure, "Conduct of Observation Audits," issued October 6, 1989.

4.2 Scope of the Audit

The audit plan identified this as a full-scope compliance-based audit to evaluate implementation of the M&O's QA program at LANL, Los Alamos, New Mexico, to determine whether the program meets the requirements and commitments imposed by OCRWM. This was done by determining the adequacy of

LANL's QA program, its implementation, and its effectiveness as well as verifying compliance with requirements. This audit concentrated on evaluating the compliance of LANL activities to applicable requirements. It was also intended to determine whether the LANL QA program is being implemented satisfactorily.

In addition to being an audit of LANL's compliance to QA requirements, this audit was also a performance-based technical audit of LANL's activities on the study, "Water Movement Tracer Tests Using Chloride and Chloride-36 Measurements of Percolation at Yucca Mountain."

The NRC's primary interest in observing this audit was to gain information regarding the Key Technical Issue of "Unsaturated and Saturated Flow under Isothermal Conditions," and the technical portion of the audit received most of the NRC staff's attention. Some NRC staff time was spent, however, observing each of the audit team members.

4.2.1 QA Programmatic Elements

The audit scope included the applicable QA programmatic elements and QARD supplements. They are listed below:

1.0	Organization
2.0	Quality Assurance Program
4.0	Procurement Document Control
5.0	Implementing Documents
6.0	Document Control
7.0	Control of Purchased Items and Services
12.0	Control of Measuring and Test Equipment
15.0	Nonconformances
16.0	Corrective Action
17.0	QA Records
Supplement I	Software
Supplement II	Sample Control
Supplement III	Scientific Investigation

Prior to the audit, the audit team had determined that the other QARD supplement and programmatic elements were not applicable to the current scope of LANL activities.

4.2.2 Technical Area

The Key Technical Issue associated with the audit is "Unsaturated and Saturated Flow under Isothermal Conditions."

The following technical documents were identified in the Audit Plan and were audited by the YMQAD audit team:

- Study Plan 8.3.1.2.2.2 R1, "Water Movement Tracer Tests Using Chloride and Chloride-36 Measurements of Percolation at Yucca Mountain"

- Detailed Procedure (LANL-CST-DP-93, R1) "Step-Leaching Procedure for Extracting Soluble Chloride and Bromide"
- Detailed Procedure (LANL-CST-DP-103, R0) "Identification, Storage, and Handling Samples for the Water Movement Tests"
- Detailed Procedure (LANL-CST-DP-105, R0) "Extraction of Chloride from Rat-Urine Samples for Chlorine-36 Analysis"
- LANL Level 4 Milestone Report 3783AD, "Summary Report of Chlorine-36 Studies: Systematic Sampling for Chlorine-36 in the Exploratory Studies Facility," March 1996

4.3 Conduct Of Audit

QA Programmatic Checklist YM-ARC-96-16-01 was used for the QA programmatic portion of the audit. QA evaluations were made by the audit team's auditors.

The performance-based technical portion of the audit focused on all points in the process at which technical judgements were made, and the important technical and performance-related audit criteria were assessed with the use of Technical Checklist YM-ARC-96-16-02. Technical evaluations were made by the audit team's technical specialist.

The YMQAD audit team and the observers caucused at the end of each day's audit. Also, The ATL met daily with LANL management (with observers present) to discuss the audit status and preliminary findings of the audit team.

The audit was performed in a professional manner and previously recognized good audit practices were followed. The members of the audit team were well prepared and demonstrated a sound knowledge of their assigned audit areas.

4.4 Timing of the Audit

The NRC staff believes the timing of the QA programmatic portion of this audit was appropriate for YMQAD to evaluate the pertinent QA activities of LANL and for the NRC staff to evaluate the YMQAD audit process and implementation of the LANL QA program. The last full scope QA audit was conducted in May 1995.

The technical portion of this audit was also timely because it was conducted after the preliminary report was issued but before the scheduled issue in September, 1996, of a "synthesis" report of the subject matter.

4.5 Examination of Audited Areas

The interview method of auditing, combined with periodic checking of objective evidence, allowed for thorough responses to the questions and permitted additional questions to be answered. The auditors and technical specialist were persistent in their interviews, challenged responses when necessary, and performed an acceptable audit.

The technical specialist on the audit team had prepared Checklist YM-ARC-96-16-02 prior to the audit. The checklist was divided into subsections dealing with the documents and detailed procedures listed in Section 4.2.2.
At the observer-audit team meeting preceding the audit, the State of Nevada observer submitted 14 additional questions (Audit Observer Inquiry forms) to the ATL. During the course of the audit, an NRC observer submitted an Audit Observer Inquiry form to the ATL. The audit team reviewed the questions before giving them to LANL for response. The audit team also reviewed the LANL responses before they were given to the observers. There was little open discussion of the specific questions from the State of Nevada and the LANL responses during the audit. The attachment to this report lists the additional questions and gives an assessment of LANL's responses.

Section 4.5.1 of this report addresses the audit of the QA programmatic elements and supplements listed in Section 4.2.1. Section 4.5.2 addresses the audit of the technical documents listed in Section 4.2.2.

4.5.1 QA Programmatic Elements

The QA portion of the audit checklist (YM-ARC-96-16-01) contained questions regarding the QA programmatic elements listed in Section 4.2.1. Several nonconformances regarding the QA programmatic elements were found by the auditors during this portion of the audit. The nonconformances were classified as to their importance to safety, they were discussed with involved LANL personnel, and they form the bases of the audit team findings. They are discussed in Section 4.9 of this report. No other discrepancies regarding the QA programmatic elements were found.

This portion of the audit dealing with the QA programmatic elements was performed in an acceptable manner using the questions in checklist YM-ARC-96-16-01 prepared prior to the audit. The audit team's overall finding was that the audit showed satisfactory LANL QA and technical performance. However, LANL's compliance with DOE procurement and software controls was rated unsatisfactory. The NRC staff agrees with the audit team's findings.

4.5.2 Examination of Technical Activities

Prior to the audit, the Technical Specialist developed the checklist (YM-ARC-96-16-02) of questions to be asked of the Principle Investigator and colleagues who work in the study area. The questions dealt with all levels of the technical investigations - from details of specific applicable detailed procedures to interpretations of the results of the analyses as they might affect repository performance.

The audit team's Technical Specialist utilized the checklist questions during the interviews systematically and completely. Additional questions were asked as a result of some of the answers to the checklist questions. He performed "vertical slice" reviews, where he tracked randomly selected samples from the scientific notebooks. He started with the current location of the samples; where they were collected in the ESF; methods of collection, handling, shipping, receiving, sample preparation, analysis, and storage; and, finally, use in performance assessment modeling.

In addition to interviewing the Principle Investigator and other involved LANL technical staff, the Technical Specialist toured the laboratories, where sample preparation was being conducted, and inspected the sample storage facilities. The sample preparation involves extracting small quantities of chloride (10 mg) from large masses (tens of kg) of tuff. Contamination of the samples is of prime concern, and procedures have been written and are implemented to minimize it.

The work done to Study Plan 8.3.1.2.2.2 is continually evolving, and the study plan was recognized as being out of date. However, LANL personnel indicated they do not intend to revise the plan but, rather, they will concentrate their efforts at producing Synthesis Reports. The laboratory notebooks contain all the information needed for tracking the $^{36}Cl/Cl$ work, and the NRC staff agrees with the decision made by the LANL staff concerning study plan revisions.

As more samples are collected from various locations in the vicinity of Yucca Mountain and analyzed, the interpretations with regard to the significance of the $^{36}Cl/Cl$ ratios has changed. A major effort of this work has been to eliminate alternative interpretations of the $^{36}Cl/Cl$ information. Recent questions were raised concerning the possible source of ^{36}Cl from cosmogenic spallation of calcium in caliches (that is, "desert pavement") producing ratios similar to those generally assumed to be associated with nuclear testing. In order to support the interpretation that the elevated $^{36}Cl/Cl$ ratios were bomb-pulse, the investigators looked for technetium-99, another bomb-pulse radionuclide in the ESF. They found it in the Bow Ridge fault portion of the tunnel. This state-of-the-art technique involves femtogram (one quadrillionth, 10^{-15}, gram) samples of technetium.

Initial interpretations of $^{36}Cl/Cl$ in surface-based boreholes suggested water with residence times of hundreds of thousands of years. Ratios of 500×10^{-15} atoms of ^{36}Cl to total atoms of chloride were thought to represent present day meteoric water. New information suggests that the $^{36}Cl/Cl$ ratio has varied throughout time. Consequently, ratios of 500×10^{-15} could result from "old" water with initially elevated $^{36}Cl/Cl$ ratio. Multiple interpretations have yet to be eliminated.

The technical portion of the audit was thorough and covered all aspects of the $^{36}Cl/Cl$ work.

4.6 Audit Team Qualifications and Independence

The qualifications of the ATL and audit team members were found to be acceptable in that each team member met the requirements of QAAP 18.1, "Qualification of Audit Personnel."

Although this was the first YMQAD audit in which the Technical Specialist participated, he was well prepared for conducting the audit with a reasonable checklist and questions. The audit checklist was adequately formulated and covered the subject matter well. The Technical Specialist posed several questions during the audit indicating that he was familiar with the subject matter and was well prepared for the audit. He made several suggestions that should be reflected in documents that supersede the documents audited.

The audit team members did not have prior responsibility for performing the activities they audited. Although the Technical Specialist is an M&O employee who is familiar with the technical activities audited, he had no prior direct or oversight responsibility for these activities. The audit team members had sufficient independence to carry out their assigned functions without adverse pressure or influence. The audit team was well qualified in the QA and technical disciplines, and the assignments and checklist items were adequately described in the audit plan.

4.7 Review of Previous Audit Findings

Several audits of LANL were conducted by DOE in 1995 during which deficiencies were identified. The corrective action for these deficiencies were either verified previously by DOE or had not been completed at the time of this audit. Therefore, this audit did not address the open deficiencies.

4.8 NRC Staff Findings

The QA programmatic and technical portions of the audit were conducted in a professional manner, and the audit team adequately evaluated activities and objective evidence. The audit was effective in determining the adequacy and degree of implementation of the LANL QA program, particularly as applied to the ^{36}Cl studies for Yucca Mountain.

The initial checklist questions provided an adequate technical basis to conduct a thorough audit of the ^{36}Cl studies for Yucca Mountain. The technical specialist went into sufficient detail during the audit to examine the planning assumptions, the bases for technical analyses, and the adequacy of numerical modeling performed at LANL. Based on the discussions, it appeared that the technical personnel audited were knowledgeable in their respective fields. The method used by the technical specialist to perform the audit was an appropriate combination of technical discussions with the LANL staff and reviews of project files and other reference material requested by the audit team and provided by LANL.

Previously recognized good auditing practices were followed by the ATL and the audit team, and the NRC staff did not observe any deficiencies in the audit process. The auditor and the technical specialist worked well as a team in that they audited items of mutual interest together but separated to audit items that were only within one's area of interest.

The NRC staff agrees with the YMQAD audit team overall finding that the audit showed satisfactory LANL QA and technical performance even though the audit team rated LANL's compliance with DOE procurement and software controls as unsatisfactory.

4.9 YMQAD Audit Team Findings

The audit team's overall finding was that the audit showed satisfactory LANL QA and technical performance. However, LANL's compliance with DOE software and procurement controls was rated unsatisfactory. Nonconformances reported by the audit team at the post-audit conference are shown below:

4.9.1 CAR

One preliminary CAR was initiated by the audit team. CARs are used to report significant deficiencies. The preliminary CAR stated that LANL procedures do not require procurement documents that a supplier have a documented QA program that meets the requirements of the QARD. Two examples of purchase requisitions and their resultant purchase orders for analytical services were noted that did not include QA requirements. The preliminary CAR also stated that there was no objective evidence that 1) a technical reviewer had signed and dated the two purchase requisitions as required by procedure and 2) a purchase requisition had been generated to procure the services of Sandia National Laboratories' Primary Standards Laboratory that were being used by LANL augmented staff to perform calibrations of primary standards.

4.9.2 DRs

Six preliminary DRs were initiated by the audit team. DRs are used to report nonsignificant deficiencies. The preliminary DRs were as follows:

- Five of eleven controlled document manuals included procedures that had been superseded or deleted.

- There was no documented evidence that LANL had conducted the required annual performance evaluation of a supplier. This preliminary PR indicated that the last performance evaluation of the supplier had been in January 1995.

- LANL procedures do not require documented justification when software that has not been verified and validated is released for use nor do they describe a mechanism for continuing its use prior to verification and validation. This preliminary PR also noted that FEHM software, not verified and validated, was used in a milestone report with no documentation to justify its use nor to show its release for use under LANL's configuration management program.

- The review of two scientific notebooks showed that, contrary to procedure, there was no objective evidence that mandatory comments had been documented or resolved from technical or QA reviews that were performed.

- A nonconformance report (DR or PR) was not issued as required by procedure when a balance was found to be not within tolerance before calibration.

- This DR provided several examples where conditions adverse to quality had not been promptly documented on a DR or PR form as required by procedure.

4.9.3 PR

One preliminary PR was initiated by the audit team. PRs are used to report isolated conditions that require only remedial actions or minor improvements to meet requirements. The preliminary DR noted that calibration traceability for an item of measuring an test equipment stopped at Sandia National Laboratories' Primary Standards Laboratory and did not extend to the National Institute of Standards Technology as required by procedure. It also noted that the calibration expiration date had been extended 18 months with no apparent approval under the LANL QA program.

ADDITIONAL TECHNICAL QUESTIONS

(1) Can elevated $^{36}Cl/Cl$ ratios be used to determine flux volumes? (Nevada)

(2) Are there differences in $^{36}Cl/Cl$ ratios between geologically defined cooling joints and faults? (Nevada)

(3) Do $^{36}Cl/Cl$ ratios derived from drillhole samples corroborate the $^{36}Cl/Cl$ ratios derived from tunnel samples? (Nevada)

(4) Can elevated $^{36}Cl/Cl$ ratios and bomb-pulse ^{36}Cl findings be used to determine water infiltration travel times, i.e., did infiltrating water containing bomb-pulse ^{36}Cl reach a certain subsurface level in one day or 50 years? (Nevada)

(5) Are there analyses where the ESF samples with bomb-pulse ^{36}Cl cannot be explained by LiBr construction water tracers? Do the bomb-pulse ^{36}Cl analyses associated with boreholes and other places where ^{36}Cl analyses indicate deep penetration of bomb-pulse ^{36}Cl have potential water tracer contamination as well? (Nevada)

(6) How do the findings of Flint and others (1996, in review) of 11 mm/yr distributed net infiltration over the repository footprint compare to the ^{36}Cl findings? (Nevada)

(7) Is there a way to evaluate the importance of fracture flow with ^{36}Cl studies at the bedded tuff horizons above and below the repository host rock? Is this planned? (Nevada)

(8) Is there any possibility of estimating quantitatively what volume percent of fractures (or fracture features) have been sampled and analyze, so that the total volume of rock in the repository horizon may be estimated that may experience fracture flow? (Nevada)

(9) Can the ^{36}Cl databases be used quantitatively to determine annual recharge? Can the bedded tuffs be sampled above and below the repository to establish bounding quantitative estimates? What is the site-specific database that argues for <1% of mean annual precipitation? (Nevada)

(10) How can the conceptual models for flow in the vadose zone be constrained by hydrochemistry including isotope hydrology? (Nevada)

(11) Is it possible that all flux in Paintbrush welded zones is via fracture flow? (Nevada)

(12) What is the most ideal (hypothetically) sampling procedure(s), including drilling, to establish the strongest database for ^{36}Cl studies? (Nevada)

(13) How do studies of ^{36}Cl concentrations compare when sampling for rock matrix ^{36}Cl and fracture ^{36}Cl in varied rock type? (Nevada)

ATTACHMENT

(14) Research at laboratory scales with parallel plates and natural fractures and some field evidence indicates fracture flow may be locally channelized along much more extensive planar fractures. Are there sampling density opportunities for ^{36}Cl to evaluate this phenomenon? (Nevada)

(15) How will drill and blast excavation of the alcoves affect the $^{36}Cl/Cl$ sampling and analysis? What changes in the detailed procedures might be required to compensate for the effects, if any? How far into the rock might explosive effects be observed given the variations in fracture properties (aperture, length, density, intersections, etc.) in TSw? (NRC)

RESPONSE ASSESSMENT

The NRC technical observer and the technical specialist on the audit team were satisfied with LANL responses to these questions. LANL personnel were able to explain verbally (and, when appropriate, provide objective evidence to substantiate) the LANL views and positions.

TO BE OPENED BY ADDRESSEE ONLY

LSS

NRC FILE CENTER COPY

96-86