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Civilian Radioactive Waste Management System Management & Operating Contractor

Data Qualification Report: Pore Water Data for Use on the Yucca Mountain Project

TDR-NBS-GS-000014 REV 00

May 2000

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:

TRW Environmental Safety Systems Inc.
1211 Town Center Drive
Las Vegas, Nevada 89144

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DISCLAIMER

Civilian Radioactive Waste Management System
Management & Operating Contractor

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May 2000

Prepared by:

Holly Miller, Chairperson — 5-31-00 Date

Royce Monks, Qualification Team Member — 5-31-00 Date

Charles Warren
Charles Warren, Qualification Team Member — 5-31-00 Date

for William Wowak
William Wowak, Qualification Team Member — 6/5/00 Date

~~Rob Howard~~, Responsible Manager — 06/09/00 Date
RFW 06/09/00 ROBERT WEMHEUER

EXECUTIVE SUMMARY

In accordance with procedure AP-3.15Q Rev. 1, ICN 1, *Managing Technical Product Inputs*, Attachment 6, it has been determined that data referenced by DTN# LL990702804244.100 are used in Analysis and Model Reports that provide a direct calculation of "Principal Factors" for the Post-closure Safety Case or Potentially Disruptive Processes or Events. Therefore, in accordance with the requirements of procedure AP-SIII.2Q, Rev 0, ICN 2, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*, Section 5.3.1.a, a Data Qualification Report has been prepared for submittal to the Assistant Manager, Office of Project Execution for concurrence.

A Data Qualification Team comprised of Subject Matter Experts, Quality Assurance Professionals, and a member of the Office of Quality Assurance has reviewed the practices, data, and documentation associated with the analyses of the mineral composition of Yucca Mountain Site pore water samples by Lawrence Livermore National Laboratory's (LLNL) Analytical Sciences/Analytical and Nuclear Chemistry Division (ASD). Based on this review it was determined that a subset of the pore water data identified by DTN# LL990702804244.100, i.e., that ASD pore water data that correlates to the three specific samples identified in AMRs currently referencing DTN# LL990702804244.100, is traceable. In addition, the Data Qualification Team has determined that ASD activities associated with these specific samples were conducted in accordance with sound technical and administrative practices. These practices, which specifically involved performance of Ion Chromatography and Inductively Coupled Plasma/Atomic Emission Spectroscopy analyses generating the subset of data referenced by DTN# LL990702804244.100, were demonstrated to meet the applicable requirements of the Office of Civilian Radioactive Waste Management Quality Assurance Requirements and Description and AP-SIII.2Q, Attachment 2 for qualifying data by the Equivalent Quality Assurance Program Method for the purpose of this qualification, this subset of data has been extracted and given a new DTN number: DTN# MO0005PORWATER.000.

Pore water sample data currently identified by AMRs and used as input to models and analyses, is that subset of data for samples ESF-HD-PERM-1, -2, and -3. The data for these three samples comprise the data subset extracted from DTN# LL990702804244.100 and identified by DTN# MO0005PORWATER.000 that the Data Qualification Team recommend to be qualified. The Data Qualification Team determined that DTN# LL990702804244.100 data associated with porewater samples other than the three "PERM" samples were inconsistent with the original ASD documentation of analytical results and concluded that this data could not be recommended for qualification at this time.

Measurement of pore water hydrogen ion concentration (pH) is a parameter also identified by the subject DTN. The pore water extraction from Yucca Mountain Site rock core samples and pH measurement was conducted by UFA Ventures Inc. prior to the shipment and receipt of these samples at LLNL. UFA Ventures Inc. is a company approved for placement on the Qualified Suppliers List as of 1/9/98 to perform analytical testing of pore water in rock samples. The Data Qualification Team did not review the practices and procedures of UFA Ventures Inc, however it was verified that UFA Ventures Inc. conducted the extraction and pH measurement activities between 3/20/98 and 8/11/98.

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TABLES

ACRONYMS AND ABBREVIATIONS

AE	Activity Evaluation
AES	Atomic Emission Spectroscopy
AMOPE	Assistant Manager, Office of Project Execution
AMR(s)	Analysis and Model Report(s)
ASD	Analytical Sciences Division/Analytical and Nuclear Chemistry Division
BS	Bachelor of Science
CAR	Corrective Action Report
CRWMS	Civilian Radioactive Waste Management System
DIRS	Document Input Reference System
DOE	Department of Energy
DST	Drift Scale Test
DTN	Data Tracking Number
EBS	Engineered Barrier System
EPA	U.S. Environmental Protection Agency
IC	Ion Chromatography
ICP	Inductively Coupled Plasma
LLNL	Lawrence Livermore National Laboratory
MS	Master of Science
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology
OCRWM	Office of Civilian Radioactive Waste Management
OQA	Office of Quality Assurance
QA	Quality Assurance
QARD	Quality Assurance Requirements and Description
SN	Scientific Notebook
SRM	Standard Reference Material
Supp.	Supplement

TDMS	Technical Data Management System
THC	thermal-hydrological-chemical
TIPs	Technical Implementation Procedures
UZ	Unsaturated Zone
YMP	Yucca Mountain Project

1. INTRODUCTION

1.1 PURPOSE

Pore water data associated with Data Tracking Number (DTN) #LL990702804244.100 are referenced in the Analysis and Model Reports (AMRs) prepared to support the Site Recommendation in determining the suitability of the Yucca Mountain, Nevada as a repository for high-level nuclear waste. It has been determined, in accordance with procedure AP-3.15Q Rev. 1, ICN 1, *Managing Technical Product Inputs*, Attachment 6, that the DTN-referenced data are used in AMRs that provide a direct calculation of "Principal Factors" for the Post-closure Safety Case or Potentially Disruptive Processes or Events. Therefore, in accordance with the requirements of procedure AP-SIII.2Q, Rev 0, ICN 2, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*, Section 5.3.1.a, a Data Qualification Report has been prepared for submittal to the Assistant Manager, Office of Project Execution for concurrence.

1.2 SCOPE

This report summarizes the findings of the Data Qualification Team assembled to evaluate unqualified "pore water data" represented by DTN# LL990702804244.100. This DTN is currently used in the following AMRs: *Drift-Scale Coupled Processes (DST and THC Seepage) Models* (CRWMS M&O 2000a), *Environment of the Surfaces of the Drip Shield and Waste Package Outer Barrier* (CRWMS M&O 2000b), and *Engineered Barrier System: Physical and Chemical Environment Model* (CRWMS M&O 2000c). Mineral composition of pore water submitted to the Technical Data Management System (TDMS) using the subject DTN were acquired data from the analysis pore water samples sent to Lawrence Livermore National Laboratory's (LLNL) by UFA Ventures, Inc. and analyzed by LLNL's Analytical Sciences/Analytical and Nuclear Chemistry Division (ASD).

The purpose and scope of the AMRs that reference the subject DTN and the potential application of pore water data is described below. These AMRs use only that data associated with the specific samples: ESF-HD-PERM-1, ESF-HD-PERM-2, and ESF-HD-PERM-3. The data for these samples represents a subset of the data identified as DTN# LL990702804244.100.

The purpose of the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* (CRWMS M&O 2000a, pp. 13, 19–20), is to document the near field environment and unsaturated zone (UZ) and to provide the framework to evaluate THC (thermal-hydrological-chemical) coupled processes at the drift-scale, predict flow and transport behavior for specified thermal loading conditions, and predict the chemistry of waters and gases entering the emplacement drifts. This AMR provides input for the following: *Performance Assessment* (CRWMS M&O 2000d); *Unsaturated Zone Flow and Transport Process Model Report* (CRWMS M&O 2000e); the *Near-Field Environment Process Model Report* (CRWMS M&O 2000f). The pore water analyses from the Exploratory Studies Facility (ESF) and chemistry of water from Drift Scale Test (DST) hydrology boreholes is used as water and gas chemistry sources of data input to the DST THC Model and THC Seepage Model and contain mineralogical data that are representative of the Topopah Spring Middle Nonlithophysal repository host unit. From these models thermodynamic data for minerals, aqueous, and gaseous species, and kinetic data for mineral-water reactions were developed.

The *Environment of the Surfaces of the Drip Shield and Waste Package Outer Barrier* (CRWMS M&O 2000b, pp. 37) AMR specifies environments on the surfaces of the Drip Shield and Waste Package Outer Barrier relevant to conditions of the potential repository site at Yucca Mountain, Nevada. Aqueous solution compositions are specified for the purposes of corrosion testing of the Engineered Barrier System (EBS) component candidate materials. Pore water analytical data were used to define the composition of pore waters from Topopah Springs welded unit. This AMR provides input to the *Waste Package Degradation Process Model Report* (CRWMS M&O 2000i)

The *Engineered Barrier System: Physical and Chemical Environment Model* AMR (CRWMS M&O 2000c, pp. 15, 38), provides conceptual models intended to estimate the evolution of the physical and chemical conditions within the EBS emplacement drifts. The models' output is data intended for use in modeling the performance of the EBS, the waste package, and the waste form. Pore water analytical data provides the composition (i.e., bicarbonate concentration) of pore water samples used in models to analyze CO_2 transport at Borehole SD-12. This AMR provides input to the *EBS Physical and Chemical Environment Performance Assessment Abstraction Model* (CRWMS M&O 2000g).

The principal focus of this report is qualification of pore water data submitted to the TDMS associated with DTN# LL990702804244.100. Where possible, the data are qualified for general use; however, any limitations imposed by the data qualification team on the appropriate use of the qualified data have been noted in this report. Qualification is extended, where possible, to data that may not have been used in the identified AMRs but is of a similar quality to the data that was used. Any subset of DTN# LL990702804244.100 data identified as a result of this qualification effort as meeting the OCRWM QARD and APSIII.2Q, Attachment 2 requirements for qualifying data by the Equivalent QA Program method, will be assigned a new DTN#. Approval of this report by AMOPE will constitute approval and qualification of this data.

1.3 DATA QUALIFICATION TEAM

The Responsible Manager for this data qualification task is Rob Howard.

The Chairperson and Subject Matter Expert for this data qualification team was Ms. Holly Miller. Ms. Miller has a BS degree in Chemistry and an MS degree in Environmental Management. H. Miller has 24 years of experience at LLNL that includes Environmental Safety and Health management, research and development in nuclear and nonuclear technologies, and Quality Assurance (QA) management for nuclear facilities and repository research programs. She was QA Manager for the LLNL Nevada Nuclear Waste Site Isolation/Office of Nuclear Waste Isolation research program from 1981 to 1984 and Compliance Officer for the LLNL Plutonium Facility 1989 to 1990 during which time she was certified as a lead nuclear auditor. Ms. Miller supports LLNL's Yucca Mountain Project as a QA Specialist. Ms. Miller had no involvement with the collection or processing of this data.

Qualification team members are:

Royce Monks. Mr. Monks has a BS degree in Chemistry from the University of the Pacific and an MS degree in Public Administration from the University of Southern California. He has over 17 years of experience in Quality Assurance programs for the Department of Energy, Department of Defense, and LLNL. In addition, he has 20 years experience with Systems Development and Testing. Mr. Monks is currently the Engineering Assurances Manager for the LLNL Yucca Mountain Project. He had no involvement with the collection or processing of this data.

Charles Warren. Mr. Warren has 25 years experience in Quality Assurance at licensed nuclear facilities. Mr. Warren has developed and verified implementation of quality programs for an Architect-Engineer, Constructor, and several nuclear generating facilities. Mr. Warren has spent the past 11 years in various management positions with the Office of Quality Assurance on the Yucca Mountain Project and currently serves as its representative at LLNL. Mr. Warren had no involvement with the collection or processing of this data.

William Wowak. Mr. Wowak has an MS degree in Structural Engineering from the University of Illinois. He has over 24 years experience on nuclear waste repository programs including responsibility for managing a variety of site characterization support activities. Mr. Wowak had no involvement with the collection or processing of this data.

1.4 BACKGROUND

The subject pore water data documents the results of Yucca Mountain Site water sample analyses conducted by LLNL ASD. These analyses were performed by ASD when ASD was neither an integral part of the Yucca Mountain Project (i.e., functioning under the Office of Civilian Radioactive Waste Management (OCRWM QA) Program) nor an approved supplier of analytical services to the project. The subject data is part of the data currently identified as nonconforming in Yucca Mountain Site Characterization Project Nonconformance Report (NCR) YMSCO-00-0055. The recommended disposition for the data as identified in the NCR is "Use As Is" contingent upon the qualification of the data per AP-SIII.2Q. This Data Qualification Report addresses a subset of the data addressed by the NCR, specifically only that data referenced by DTN# LL990702804244.100.

The term "pore water data" as used in this report refers to ASD analytical data identifying the chemical constituents/parameters/species and their concentrations in pore water samples provided to LLNL by UFA Ventures Inc. Pore water samples were extracted from rock cores and measurements of pH were taken in the field by UFA Ventures Inc. in accordance with UFA Ventures Inc. applicable procedures. The measurement of pH is included in DTN# LL990702804244.100. UFA Ventures Inc. was approved for placement on the Qualified Supplies List for "analytical testing of pore water in rock samples and testing to determine diffusion coefficients" as of 1/9/98. A Supplier Evaluation Report shown in Appendix K signed by the Director of DOE's Office of Quality Assurance (OQA) provides the record of this approval (MOL.19980406.0179). Pore water samples ESF-HD-PERM-1, -2, and -3 from cores taken at various depths were requested to be shipped from the Thermal Testing Facility to James Conca, UFA Ventures, Inc. on 3/20/98 (see email from Mark Peters, 3/20/98 shown in Appendix K. UFA Ventures Inc. completed pore water extraction and pH measurements of the PERM samples as of 8/9/98. See letter report (J. Conca, UFA Ventures, Inc. to R. Datta, 8/11/98 provided in Appendix K.

2. QUALIFICATION METHODS

Consistent with AP-SIII.2Q Rev.0, ICN 2, data that were not acquired or developed in accordance with an approved QA program that meets 10CFR60 Subpart G, and do not meet the definition of Accepted Data, must be qualified if it is used for Principal Factors or Potentially Disruptive Processes and Events, as determined using AP-3.15Q, *Managing Technical Product Inputs*. Pore water data included in DTN# LL990702804244.100 were determined to require qualification on this basis in accordance with AP-3.15Q, Attachment 6. The principal qualification method for the subject data will be demonstration of *equivalent QA program*. This method is used to demonstrate that the controls in effect at the time ASD performed the analyses were equivalent to the necessary Quality Assurance Requirements and Description (QARD) controls that would be imposed if the analyses were performed today.

The objectives, scope, and methodology for qualification of the unqualified DTN# LL990702804244.100 documented in this report and the determination of Principal Factor applicability is based on an OCRWM Development Plan (CRWMS M&O 2000h). This DTN is referenced by the three AMRs identified in this report and their associated Document Input Reference System (DIRS) files. However, AMRs in revision at the time of this report may produce changes in their associated DIRS files and later cite or delete the subject DTN. Because this report addresses the data set submitted to the TDMS using DTN# LL990702804244.100, the impact of the recommendations of this report will be the same on any document citing the DTN. The qualification of any additional unqualified DTNs that may be identified in these or other AMRs will be addressed separately.

2.1 EVALUATION CRITERIA

The following criteria are identified as the basis for evaluating DTN# LL990702804244.100 data. The source of this data was identified as LLNL ASD analyses of pore water taken from Yucca Mountain borehole core samples. The criteria were used in demonstrating that activities associated with performing analyses of Yucca Mountain pore water samples generally meet the applicable requirements of the OCRWM QA Program. In addition, the selected criteria incorporate the considerations in procedure AP-SIII.2Q, Attachment 2 and the applicable qualification process attributes listed in procedure AP-SIII.2Q, Attachment 3.

1. Sample identification and traceability is maintained from the time samples were received by LLNL until analysis was performed.

2. LLNL Technical Implementing Procedures (TIPs) for the types of analysis performed on Pore Water Samples were developed, reviewed, approved and issued under the OCRWM QA Program.

3. Instruments used to perform analyses were calibrated prior to use with National Institute of Standards and Technology (NIST)-traceable calibration standards.

4. Procurement of calibration standards was accomplished in accordance with methods that comply with OCRWM QA Program requirements.

5. Practices used in the performance of analysis are those required by current LLNL TIPs that were reviewed, approved and issued under the OCRWM QA Program.

6. Personnel involved in control of samples and performance of analyses were indoctrinated on the OCRWM QA Program and were trained/indoctrinated in practices utilized in performance of activities.

7. Pore water data identified by DTN# LL990702804244.100 cited in AMRs is traceable to and consistent with ASD documentation and the analyses conducted.

2.2 RECOMMENDATION CRITERIA

Recommendation criteria used in determining whether the status of DTN# LL990702804244.100 pore water data should be changed to *qualified* are identified below. However, the final recommendations of the data qualification team subject matter experts will be based on a preponderance of evidence, and not all of the recommendation criteria may be applied.

1. A unique identifier for each pore water sample is documented and is traceable from the point of sample receipt by LLNL/ASD through performance of ASD sample analysis.

2. TIPs describing the methods used in the analysis of pore water samples were developed by the organization personnel performing the analyses and reviewed, approved and issued in accordance with appropriate LLNL procedures which implement applicable requirements of the OCRWM QA Program.

3. Calibration of instruments prior to performance of each analysis is documented and the calibration standards used indicate evidence of NIST traceability.

4. Calibration standards were procured in accordance with the methods described in the current approved Activity Evaluation for procurement and confirmation of chemicals used for calibration standards.

5. Documentation of results of analyses and discussion with personnel performing analysis indicate that practices used were those described in current LLNL TIPs.

6. OCRWM QA Program Indoctrination for personnel involved in the control of pore water samples and the performance of analyses is documented. Evidence of training/ indoctrination to the practices used in performance of the analyses is available.

7. Pore water data identified by DTN# LL990702804244.100 in the AMRs was traceable to and consistent with ASD's documentation in scientific notebooks and analysis records.

3. EVALUATION RESULTS

3.1 INDUCTIVELY COUPLED PLASMA/ATOMIC EMISSION SPECTROSCOPY ANALYSIS AND ION CHROMATOGRAPHY ANALYSIS DATA

Two analytical methods were used by ASD in analysis of Yucca Mountain Site pore water samples denoted by DTN# LL990702804244.100: Inductively Coupled Plasma/ Atomic Emission Spectroscopy (ICP/AES) and Ion Chromatography (IC). These analytical methods are currently documented in LLNL TIPs. Sample and experimental data for the samples identified by DTN# LL990702804244.100 were documented in LLNL-YMP Scientific Notebooks (SN) 00342 and 00349 and LLNL-YMP Supplement Binders 342.3 and 349.1 respectively. However, problems exist with traceability of sample data and documentation from receipt to records of analysis for several samples identified by DTN# LL990702804244.100. Traceability was however verified for a specific subset of samples and data identified by DTN# LL990702804244.100. Specifically, these samples are ESF-HD-PERM-1, -2, and -3. It is this specific subset of sample data from DTN# LL990702804244.100 that is actually used and referenced in the AMRs identified in this report.

Unique sample identifiers were documented in LLNL-YMP SN# 00342 and LLNL-YMP SN# 00349 at the time samples were received by LLNL ASD. Sample numbers, location of sample information in scientific notebooks/supplements and pages that document sample receipt are listed in Tables 1 and 2. However this information is not fully traceable to the data in the DTN for all samples identified by the DTN. This information is fully traceable to the DTN data for samples ESF-HD-PERM-1, -2, and -3. Sample identification and the receipt records for these "PERM" samples can be found in SN# 00349, page 30. Performance of each analysis, i.e., the analytical record and data for ICP/AES and IC analyses, is documented and traceable for these "PERM" samples and can be found in Supplement 349.1 to SN 00349. This information is shown in Table 1 for ICP/AES analyses and Table 2 for IC analyses. Sample numbers from SN entries were found to be traceable to and consistent with documentation of performance of each analysis by ASD for all samples shown. However, the analytical data in the DTN is not traceable for all the samples shown. The analytical data in the DTN is traceable for samples ESF-HD-PERM-1, -2, and -3 (identified as PERM-1, PERM-2, and PERM-3 in Table 1 and 2). The analytical data record for ICP/AES analysis of the "PERM" samples is denoted by Case 579; the analytical data record IC analysis of "PERM" samples is denoted by Case 609.

Table 1. ICP /AES Analysis Performed by ASD

Sample Number	Analysis Case #	Analysis Date	SN#, Pages(s) and Supp. #
Perm-1, Perm-2, Perm-3	579	12/8/98	#00349, Page 30 and Supp. 349.1
54-1 1/20/99 filtered, 56-2D 12/8/98 filtered, 59-4: 1/99 filtered, 60-3: 1/99 filtered, 186-3: 1/99 filtered, 54-1 1/20/99 unfiltered, 59-4 1/99 unfiltered, 60-3: 1/99 unfiltered, 186-3 1/99 unfiltered	826	1/22/99	#00342, Pages 105, 106,112 and Supp. 342.3
186-3 1/26, 60-3 1/26/99, 59-4 1/26/99, D56-3 1/22/99, D56-1 1/22/99, D54-3 1/22/99	1034	3/18/99	#00342, Pages 113, 114,118 and Supp. 342.3
DST 60-2, DST 60-3, DST 77-3	422	9/21/98	#00349, Page 30 and Supp. 349.1
59-4 11/98, 60-2 6/98, 60-3 #1, 60-3 #2, 60-3 #3, 60-3 6/98, 60-3 8/98, 60-3 11/98, 60-3 1/26, 77-3 3/99, 186-3 11/98,	1101	4/21/99	#00342, Pages 81, 111,112, 118,125 and Supp. 342.3
D54-1, 60-3 #1, 60-3 #2 0955, 60-3 #310:10 3/31, 77-3 3/99	1102	4/22/99	#00342, Pages 123,125 and Supp. 342.3

Table 2. IC Analysis Performed by ASD

Sample Number	Analysis Case #	Analysis Date	SN#, Page(s) and Supp. #
Perm-1, Perm-2, Perm-3	609	12/7/98	#00349, Page 30 and Supp. 349.1
54-1 filtered, 56-2 filtered, 56-3 filtered, 59-4 filtered, 60-3 filtered, 60-3 unfiltered, 186-3 filtered, 186-3 unfiltered	813	1/25/99	#00342, Pages 105,106, 112 and Supp. 342.3
D54-3 1/22/99, D56-1 1/22/99, D56-3 1/22/99, 59-4 1/26/99, 60-3 1/26/99, 186-3 1/26/99	1020	3/18/99	#00342, Pages 113,114, 118 and Supp. 342.3
60-3F	N/A	8/13/98	#00342, Page 81 and Supp. 342.3
DST 60-2 8/12/98, DST 60-3 8/12/98, DST 77-3 8/12/98	399	10/8/98	#00349, Page 30 and Supp. 349.11
D54-1 3/30, D54-4 3/31/99, 59-4 11/98, 60-3 #1 0950 3/30, 60-3 #2 0955 3/30, 60-3 #3 1010 3/30, D71-3 3/31/99, 77-3 3/99	1029	4/14/99	#00342, Pages 112,123, 124,125 and Supp. 342.3

The following LLNL TIPs currently in effect document methods that were used in the ASD analysis of pore water samples:

- TIP-AC-02, *Solutions Analysis: Cations by Inductively Coupled Plasma Atomic Emission Spectroscopy.*
- TIP-AC-03, *Determination of Inorganic Anions by Ion Chromatography.*

These TIPs were developed by ASD personnel after pore water samples were analyzed. Development was in accordance with LLNL Yucca Mountain Project (YMP) Procedure 033-YMP-QP-5.0, *Technical Implementing Procedures*, and were reviewed, approved and issued in accordance with LLNL YMP Procedure 033-YMP-QP-2.1, *Preparation, Approval and Revision of Procedures and Plans.* LLNL YMP Procedures and TIPs implement the applicable requirements of DOE/RW-0333P, *Quality Assurance Requirements and Description.*

Per discussions with ASD personnel, the TIPs identified above document the standard protocols used when ASD performs IC and ICP/AES analyses. These protocols were derived from equipment Manufacturer's Operating Instructions and/or U.S. Environmental Protection Agency (EPA) Standard Methods and were in use at the time data identified in this report were being generated by ASD. As stated, TIPs reflecting these protocols have since been developed, reviewed, approved and issued in accordance with OCRWM QA Program requirements.

Memorandums issued by the analysts that performed IC and ICPLAES analysis of pore water samples are included in Appendix A. These memorandums document the specific protocols and EPA methods used during performance of analysis.

Documentation in SN Supplements indicate the following evidence of calibration of instruments prior to performance of the IC and ICP/AES analyses identified in Tables 1 and 2:

- For ICP/AES Analysis – Spectrochemical Analysis Reports and attached "run", i.e., data print-out sheets (analytical records), are included for each ASD analysis Case Number reviewed. Table 1 identifies this for the samples that are included in DTN# LL990702804244.100. These reports indicate that calibration of instruments prior to running ICP/AES analysis was performed. Each test standard used for calibration was prepared from stock standard materials identified and traceable to a "Certificate of Analysis." This documentation of analysis and the certificates are traceable and are included in SN Supplements. Standards used for a secondary check of instruments prior to performance of ICP/AES analysis were also prepared from materials identified and traceable to its "Certificate of Analysis."

- For IC Analysis – Calibration Update Reports are included and traceable for each ASD analysis Case Number identified in Table 2. These reports indicate that six calibration standards were used for instrument calibration prior to performance of each IC analysis. Each calibration standard was prepared from an identified IC stock solution standard having a "Certificate of Analysis." Calibration documentation and the certificates are traceable to analytical Case Numbers and are included in SN Supplements.

The QAP-2-0 Activity Evaluation (AE), *Procurement and Confirmation of Chemicals Used for the Calibration of Standards*, was issued by the Waste Package Operations/Waste Package Materials Department on 12/6/99. The AE states that it is applicable to procurement of chemicals utilized for the calibration of pH, conductivity, and analytical standards whose purity is traceable to NIST. The AE further states that procurements of chemicals are not subject to QARD requirements however, confirmation that chemicals are suitable for their intended use is an activity that is subject to requirements of the QARD. The AE requires that when standards are purchased directly from a commercial supplier, lot number traceability to NIST standards be verified by review of chemical certificates. The AE also requires independent standards be used to verify calibration of equipment for IC and ICP/AES analysis.

It was determined by review of Supplement 349.1 to SN 00349 that the following has been achieved and documented:

- For IC Analysis – Ion chromatography stock solution standards were purchased from a commercial supplier (Alltech) with Certificates of Analysis documenting NIST traceability by Standard Reference Material (SRM) number. Material lot numbers are also documented on the certificates. Documentation indicates that independent standards were used to verify IC calibration prior to performance of each analysis.

- For ICP/AES Analysis – Stock standard materials were purchased from a commercial supplier (Spex CertiPrep) with a Certificate of Analysis documenting NIST traceability by SRM number. Starting material lot numbers are also documented on certificates. Documentation in the SN supplements indicates that two independent standards are used to verify ICP/AES calibration prior to performance of analysis.

All ASD personnel who made entries in LLNL-YMP SN# 00342 and LLNL-YMP SN# 00349 for the purpose of sample control or documenting the results of pore water sample IC and ICP/AES analyses, received the basic indoctrination and training required for LLNL YMP participants implementing the OCRWM QA Program prior to performing the annotated work. Education and training requisites for performing the work were accomplished and verified.

Training matrices were completed for identified ASD personnel. These matrices identify specific LLNL quality procedures governing work they performed. This training was completed and verified prior to doing any quality affecting work. Additionally, documentation shows that those Analysts administratively assigned to ASD completed "on-the-job" instruction and participated in training provided by the vendors for the equipment used.

Appendix A identifies applicable training for ASD personnel who made entries in the SNs or who performed pore water analysis reported in the SNs. The dates shown in the Table in Appendix A represent initial training. This training was maintained current during the time that individuals were assigned to the project performing work.

3.2 TRACEABILITY OF ASD DATA TO DATA REPORTED AND REFERENCED IN AMRS BY DTN# LL990702804244.100

The DIRS files for the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (CRWMS M&O 2000a) indicate that the subject DTN is used in Tables 2, 3 and 9, and Sec. 6.2.7.3.1 of the AMR. Table 2 is a list of DTN#'s for sources of data input to the DST and THC Seepage Model. The description of the data referenced in Table 2 for DTN# LL990702804244.100 refers to "analyses of pore waters from the ESF (HD-PERM-1 and HD-PERM-2 samples); chemistry of water from DST hydrology boreholes (Nov. '98 & Jan. '99)." Table 3 entitled "Initial Water Composition and CO_2 Partial Pressure in Fractures, Matrix, and Recharge Waters" identifies the composition of pore water by parameter/species and corresponding concentration and identifies DTN# LL990702804244.100 as the source of this data. The samples from which these data are derived are identified in the AMR as "ESF-HD-PERM-1 (30.1' to 30.5') and ESF-HD-PERM-2 (34.8' – 35.1')." IC analyses (Case No. 609) and ICP/AES analyses (Case No. 579) data provided in Tables 1 and 2 of this report, correlate with the data in Table 3 of the AMR, however the data reported in the AMR has mislabeled sample identifiers. Data reported in the AMR at depth 30.1' – 30.5' as ESF-HD-PERM-1 correlates to the sample receipt documentation and analysis print-out records in ASD SN00349 and Supplement 349.1 respectively, for ESF-HD-PERM-2 (depth 30.1' to 30.5'). Similarly, the data (in Table 3 of the AMR) identified as ESF-HD-PERM-2 (depth 34.8' – 35.1') correlates to the sample receipt documentation and analysis print-out records in ASD SN00342 and Supplement 349.1 respectively, for sample ESF-HD-PERM-3 (depth 34.8' – 35.1'). Refer to the following Appendices:

- Appendix B shows Table 3 of the AMR, Footnote (1) indicating the depths for ESF-HD-PERM-1 and ESF-HD-PERM-2 samples data in the AMR. Table 9 and a memo from the author of the AMR on the use of the data is also provided.
- Appendix C shows sample traceability/receipt documentation from page 30 of LLNL-YMP SN# 00349 indicating the depths for ESF-HD-PERM-1, -2, and-3 samples.
- Appendix D shows the analytical data for ICP/AES (Case No. 579) analyses of corresponding PERM-1, -2, and -3 samples.
- Appendix E shows the analytical data for IC (Case 609) analyses of corresponding PERM-1, -2, and -3 samples.
- Appendix F shows a table prepared by the Data Qualification Team supporting the determination that the sample labels in the AMR are incorrect.

Note that the data corresponding to the depths identified in the AMR are correct. However, the sample ID labels for the data at that depth are not correct in the AMR, i.e., the data in the AMR identified as ESF-HD-PERM-1 should be labeled ESF-HD-PERM-2 data (depth of 30.1' – 30.5') and data in the AMR identified as ESF-HD-PERM-2 should be labeled ESF-HD-PERM-3 data (depth of 34.8' – 35.1') in order to be fully traceable to the original receipt record and corresponding ASD analytical data.

Checks were performed on all parameters/species to verify this conclusion, except where the concentration value for the ion in the AMR was derived using SOLVEQ 1.0 software (as noted in Footnotes 2-5 of Table 3 of the AMR (Appendix B of this report)). SOLVEQ 1.0 is identified as verified and "approved for use on YMP" in accordance with Corrective Action Report (CAR)-006 re-validation effort approvals documented in Carlisle (1999) shown in Appendix I of this report. The Corrective Action Report accurately identifies the software as SOLVEQ/CHILLER V.1.0. The author of this AMR has agreed to revise this reference to reflect the correct name of the validated software used, i.e., SOLVEQ/CHILLER V.1.0.

Appendix F provides a check of the data by comparing the data shown in Table 3 of the AMR (identified as the "average of Tptpmn porewater analyses ESF-HD-PERM-1 (30.1' – 30.5') and ESF-HD-PERM-2 (34.8' – 35.1')" concentrations) to the calculated average of ASD data (concentrations shown in Appendices D and E) for PERM-1 + PERM-2 and PERM-2 + PERM-3 (multiplied by their respective dilution factors). This check of the data shows that the data for PERM-2 + PERM-3 was used in the AMR's tables.

Table 9 of AMR: *Drift Scale Coupled Processes (DST and THC Seepage) Models*, displays the "Measured Concentrations in TSW Pore Water from Alcove 5 and Chemistry of Water Taken from Hydrology Boreholes." Although all the data in Table 9 is part of DTN# LL990702804244.100, only that data identified as "pore water" data and associated PERM samples was used as input to the model of this AMR. Water chemistry from boreholes 60-3 and 186-3 were used solely for comparison to modeled results. A communication from the author of the AMR shown in Appendix B testifies to the use of this data.

The only referenced use of DTN# LL990702804244.100 in *Environment of the Surfaces of the Drip Shield and Waste Package Outer Barrier* (CRWMS M&O 2000b) is in Table 15, Sec. 4.1.1 of the AMR. Table 15, entitled "Major ion concentrations reported for TSw pore water at ambient temperature," is presented in Appendix G to this report. Although depths corresponding to the reported data associated with samples ESF-HD-PERM-1 and ESF-HD-PERM-2 are not indicated in the AMR, checks of the data were made to determine the traceability of ASD analytical data to the sample identifier used in the AMR. This evaluation showed that the data in the AMR reported in Table 15 of the AMR (shown in Appendix G of this report) for sample ESF-HD-PERM-1 is actually the data for ESF-HD-PERM-3, i.e., the I.D. label in Table 15 for the data shown as ESF-HD-PERM-1 should be identified as ESF-HD-PERM-3. Data in Table 15 identified for sample I.D. ESF-HD-PERM-2 is labeled correctly, i.e., corresponds to the analytical records for PERM-2 ICP/AES (Case 579) and IC (Case 609) data. Appendices C, D, E, G and H provide the basis for determining and verifying this discrepancy by comparing the ion-concentration values reported in Table 15 of the AMR with ASD analytical data for samples ESF-HD-PERM-1, -2, and -3.

The source of the error is in the table of pore water data submitted to the TDMS as DTN# LL990702804244.100. The DTN is shown as Appendix L of this report. The PERM-sample data identified by the DTN are presented in three columns labeled ESF-HD-PERM-1, ESF-HD-PERM-2, and ESF-HD-PERM-1 (presented in that order). The data presented in the first column of the DTN table identified as ESF-HD-PERM-1 corresponds with ASD data for ESF-HD-PERM-1 ("PERM-1") data, the data presented in the DTN table as ESF-HD-PERM-2 data corresponds with ASD data for ESF-HD-PERM-2 ("PERM-2") data. However, the data in the third column of the DTN table identified also as ESF-HD-PERM-1 is actually ASD ESF-HD-PERM-3 ("PERM-3") data. Thus the data in the AMR reflects the data in the table of the DTN but neither are labeled correctly. The data is traceable to the original ASD sample receipt and analysis data if the label on the third column of the DTN table is corrected to show ESF-HD-PERM-3. Correspondingly, the AMR's reference to ESF-HD-PERM-1 data is traceable to ASD receipt and analysis if the label in the AMR is changed to identify sample ESF-HD-PERM-3.

Reference to the subject DTN in *the Engineered Barrier System Physical and Chemical Environment Model* AMR (CRWMS M&O 2000c) is made only in Sec. 4.1.2.2, "Additional Input Data Used to Analyze CO_2 Transport at Borehole SD-12." No tabular data is presented for this DTN, only the general statement, "...additional input data consist of the following: Composition (i.e., bicarbonate concentration) of pore water samples extracted from samples of SD-12 drill core: DTNs GS970908312271.003, GS961108312271.002, and LL990702804244.100."

In the three AMRs that reference DTN# LL990702804244.100, bicarbonate concentration is not a directly measured component of pore water. Instead, the concentration of total aqueous bicarbonate (HCO_3^-) is a calculated value based on pH in conjunction with the analytical data defining the concentrations of the other cations and anions present. This is stated in Footnote (4) of Table 3 of the *Drift-Scale Coupled Processes (DST and THC Seepage) Models* AMR (CRWMS M&O 2000a) (Appendix B). This method of deriving the concentration of total aqueous bicarbonate was verified through conversations with ASD personnel. DTN LL990702804244.100 does not include a concentration value for aqueous bicarbonate for the "PERM" samples.

An additional check can be performed that verifies the correlation of ASD analytical data for PERM-1, -2, and -3 samples with the data in the DTN corresponding to ESF-HD-PERM-1, PERM-2, and the third column shown again as ESF-HD-PERM-1. The ASD ion concentrations shown in Appendices D and E can be multiplied by their dilution factors (shown on the Appendix). These numbers are traceable to the data in the DTN.

Sample traceability was based on the following, sample descriptors: sample name-number, depth, and Sample Management Facility (SMF) identification number:

ESF-HD-PERM-1. 23.1'–23.3'; SMF ID 01002488.

ESF-HD-PERM-2. 30.1'–30.5'; SMF ID 01002586.

ESF-HD-PERM-3. 34.8'–35.1'; SMF ID 01002525.

Records shown in Appendices B, C, D, E, F, G, H, J, K, and L provide evidence of traceability and support the conclusions of this report.

4. EVALUATION CONCLUSIONS

Based on the criteria used to evaluate the data represented by DTN# LL990702804244.100, the Data Qualification Team concludes that the subject DTN identifies pore water data for several samples, a subset of which is the ESF-HD-PERM-1, -2, and -3 sample data used by the AMRs identified in this report. Data for these "PERM" samples were fully traceable from the sample name, sample ID, specimen ID, and sample depth to ASD documentation. In addition, the activities associated with the analysis and collection of mineral composition data from that subset of Yucca Mountain site pore water samples, identified as ESF-HD-PERM-1, -2, and -3 samples, were conducted in accordance with sound technical and administrative practices. These practices, which involved performance of IC and ICP/AES analyses, can be demonstrated to meet the applicable requirements of the QARD and AP-SIII.2Q, Attachment 2 for qualifying data by the Equivalent QA Program Method, as they apply to this subset of data. Supporting information including objective evidence of equipment calibrations, personnel indoctrination and training, and practices used in sample handling, performance of analysis and data collection is documented for this subset of data in applicable SNs and supplements.

5. RECOMMENDATIONS

The Data Qualification Team conducted a thorough review of the controls that were in place during the collection and analysis of Yucca Mountain pore water data identified by DTN# LL990702804244.100, including the development of documentation for records, the use of analytical procedures, and practices reviewed and approved by OCRWM, as well as the qualifications and training of personnel conducting analyses for LLNL ASD. Because several samples included in the subject DTN could not be traced to the original sample identification numbers in a manner that allowed correlation between both ASD analytical data and the concentration values in the DTN, the Data Qualification Team recommends that DTN# LL990702804244.100 remain unqualified.

However, the Data Qualification Team recommends that the data corresponding to ESF-HD-PERM-1, ESF-HD-PERM-2, and ESF-HD-PERM-3 samples identified in the subject DTN be separated to form a new DTN as these data can be demonstrated to meet the applicable requirements of the QARD and AP-SIII.2Q, Attachment 2 for qualifying data by the Equivalent QA Program Method.

As a result of this recommendation, personnel supporting the Responsible Manager of the Management and Operating Contractor of CRWMS's Data/Software Qualification Department, Applied Research and Testing Programs of CRWMS has submitted a Technical Data Information Form (TDIF# 310555) and a new DTN# has been assigned to the subset of data recommended by this report to be qualified, i.e., "PERM" sample data. The new DTN# for these data is MO0005PORWATER.000.

6. REFERENCES

Carlisle, G.P. 1999. "Configuration Management Notice, Quarterly Software Configuration Status Accounting Report." Interoffice correspondence from G.P. Carlisle (CRWMS M&O) to Distribution (CRWMS M&O), December 10, 1999, LV.SQA.GPC.12199-1299. ACC: MOL.20000530.0274

CRWMS M&O 2000a. *Drift-Scale Coupled Processes (DST and THC Seepage) Models.* MDL-NBS-HS-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. Submit to RPC, URN-0042.

CRWMS M&O 2000b. *Environment of the Surfaces of the Drip Shield and Waste Package Outer Barrier.* ANL-EBS-MD-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000328.0590.

CRWMS M&O 2000c. *Engineered Barrier System: Physical and Chemical Environment Model.* ANL-EBS-MD-000033. Las Vegas, Nevada: CRWMS M&O. Submit to RPC, URN-0279.

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10 CFR 60. Energy: Disposal of High-Level Radioactive Wastes in Geologic Repositories, Subpart G, Quality Assurance. Readily available.

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AP-SIII.2Q, Rev. 0, ICN 2. *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data.* Washington, D.C.: Office of Civilian Radioactive Waste Management. ACC: MOL.19991214.0625.

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QAP-2-0. *Activity Evaluation Procurement and Confirmation of Chemicals Used for the Calibration of Standards.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991213.0234.

SOURCE DATA

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LLNL YMP Scientific Notebook Supplement 342.3 (Supplement 3). Porewater Analytical Data. 399 pages. MOL.2000316.0801.

LLNL YMP Scientific Notebook SN00349. Drift Scale Test Activity. pp. 1–36. MOL.20000316.0690.

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7. APPENDICES

APPENDIX A: Initial Training to LLNL Procedures in effect at time work was performed

(4 pages)

APPENDIX B: Tables 2, 3 and 9 of AMR *Drift-Scale Coupled Processes (DST and THC Seepage) Models*, and memo from AMR author on use of data in AMR

(5 pages)

APPENDIX C: Page 30 of LLNL Scientific Notebook: LLNL-SN00349

(2 pages)

APPENDIX D: Spectrochemical Analysis Report (LLNL/ASD), ICP/AES, Case# 579

(27 pages)

APPENDIX E: Ion Chromatography Report (LLNL/ASD); Case# 609

(32 pages)

APPENDIX F: Correlation of AMR *Drift-Scale Coupled Processes (DST and THC Seepage) Models* Data (Table 3, MDL-NBS-HS-000001, REV00) with ASD Sample Data

(2 pages)

APPENDIX G: Table 15, "Major Ion Concentration Reported for TSw Pore Water at Ambient Temperature," from AMR: *Environment on the Surfaces of the Drip Shield and Waste Package Outer Barrier,*" ANL-EBS-MD-000001 REV00

(2 pages)

APPENDIX H: Correlation of AMR Data (Table 15, ANL-EBS-MD-000001, REV00) with ASD Sample Data

(2 pages)

APPENDIX I: CAR-006 revalidation effort approvals continued:

(2 pages)

APPENDIX J: Re: Distribution of Pore Water Samples and Results/pH of pore water samples

(3 pages)

APPENDIX K: Recommendation of UFA Ventures, Inc. as a Qualified Supplier and Sample Traceability Documentation

(10 pages)

APPENDIX L: Original Pore Water Data Tables from DTN LL990702804244.100

(5 pages)

APPENDIX M: YMSCO-00-0055 Yucca Mountain Site Characterization Project Nonconformance Report

(12 pages)

APPENDIX N: DTN# MO0005PORWATER.000

(2 pages)

APPENDIX A: INITIAL TRAINING TO LLNL PROCEDURES IN EFFECT AT TIME WORK WAS PERFORMED

NAME	TIPs										Initial Training to LLNL Procedures in effect at time work was performed							
	TIP-AC-01	TIP-AC-02	TIP-AC-03	TIP-AC-04	TIP-AC-05	TIP-AC-06	TIP-AC-07	TIP-AC-08	TIP-AC-09	TIP-YM-03	PVAR TRAINING	EDU VERIFICATION	INDOCTRINATION	QP 3.0	QP 3.4	QP 8.0	QP 12.0	QP 13.0	QP 17.0
Laura DeLoach	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99				12/22/97	7/13/99	1/6/97	8/798	10/31/96	11/4/96	4/4/96	4/4/96		11/4/96
Dave Ruddle										3/15/95	7/13/99	5/28/89	5/7/98	5/6/94	12/20/93	12/13/95	12/22/94	6/8/93	10/20/94
Roger Martinelli												11/24/97	5/7/98	12/8/97	12/8/97	12/8/97	12/8/97		12/8/97
Nora Briant	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99					1/19/00	2/11/98	*2/11/98	2/11/98		3/9/98	3/9/98	2/11/98	3/9/98
Terry Duewer	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99	8/26/99				7/1/91		4/25/91	5/7/98	4/13/94	11/30/93	11/30/93	11/30/93	5/25/93	9/16/94
Marina Chiarappa												11/24/97	5/7/98	12/15/97	12/3/97	12/3/97	12/15/97		12/15/97

* QA Policy Statement Training 033-LLNL-QP-B

TIPs

TIP-AC-01, Gas Chemical Analysis by Mass Spectrometer
TIP-AC-02, Solutions Analysis: Cations by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP/AES)
TIP-AC-03, Determination of Inorganic Anions by Ion Chromatography (EPA Method 300.0)
TIP-AC-04, Determination of Hexavalent Chromium
TIP-AC-05, Phenanthroline Spectrophotometric Method
TIP-AC-06, Total Organic Carbon/Total Inorganic Carbon Analysis
TIP-AC-07, Elemental Analysis by Inductively Coupled Plasma and Mass Spectrometry
TIP-AC-08, pH Buffer Standardization of Fisher Scientific Accumet Model 950 pH Meter
TIP-AC-09, Calibration of Hamilton Microlab Series 500 Autodilutor
TIP-YM-03, Labeling, Tracking and Shipping of Samples

QP's

QP 3.0, Scientific Investigation Control
QP 3.4, Scientific Notebooks
QP 8.0, Identification & Control of Items, Samples & Data
QP 12.0, Control of Measuring & Test Equipment
QP 13.0, Handling, Storage, & Shipping
QP 17.0, Quality Assurance Records

Roger Martinelli - Scientific Notebook Custodian LLL-SCI-349 VI
Laura DeLoach - Scientific Notebook Custodian LLNL-SCI0-341 VI
Author of TIPs
Nora Briant - Analyst
Terry Duewer - Analyst
Dave Ruddal - Made entries in Scientific Notebook LLL-SCI-342 VI

Interdepartmental Letterhead
Mail Station: L-091
Ext: 2-6414

Chemistry & Materials Science Directorate
Analytical & Nuclear Chemistry Division

Date: May 10, 2000

MEMORANDUM

TO: Yucca Mountain Project File

FROM: Nora Briant NLB

SUBJECT: Protocol for IC Analysis

Analysts within ASD at Lawrence Livermore National Laboratory (LLNL) currently perform IC analysis for anions utilizing the Technical Implementing Procedure (TIP) AC-03. The same protocols and procedures outlined in the TIP previous to its creation were followed by me for the years 1998 and 1999. The TIP is based on Environmental Protection Agency (EPA) Method 300: Ion Chromatography Analysis. This EPA method is routinely applied throughout the world and is accepted as a standard analytical reference.

Instrument Calibration

EPA Method 300 requires an Initial Calibration Verification, which is "prepared from a standard source different from that of the calibration standard and at concentrations within the linear working range of the instrument". Thus, two independent standards are used, one in calibration of the instrument, and the other in verifying the calibration. This concurrent checking and use of two independent NIST-traceable standards provides reasonable assurance of quality.

To furnish a supporting, corroborative line of evidence for accurate standards, NIST traceability is required. The manufacturer supplies a Certified Value for anion standards comparing them to NIST standards. There may be a deviation between the label concentration and the Certified Value, but only the Certified Value is important; it is only necessary to know what the concentration of the standard is. The purpose of NIST certification is only to provide additional corroborative evidence of the multiple standard comparison described above.

University of California
Lawrence Livermore
National Laboratory

Interdepartmental Letterhead
Mail Station: L-091
Ext: 3-1897

Chemistry & Materials Science Directorate
Analytical & Nuclear Chemistry Division

Date: May 10, 2000

MEMORANDUM

TO: Yucca Mountain Project File

FROM: Terry Duewer T. Duewer

SUBJECT: Protocol for ICP/AES Analysis

Analysts within ASD at Lawrence Livermore National Laboratory (LLNL) currently perform ICP/AES analysis utilizing the Technical Implementing Procedure (TIP) AC-02. The same protocols and procedures outlined in the TIP previous to its creation were followed by me for the years 1998 and 1999. The TIP is based on Environmental Protection Agency (EPA) Method 6010: ICP/AES analysis. This EPA method is routinely applied throughout the world and is accepted as a standard analytical reference.

Analytical Method Accuracy

Typical laboratory accuracy for TIP-AC-02 may be assessed from the EPA Method 6010 description. EPA submitted aqueous samples to seven laboratories for comparison. Accuracies of 95 to 104% with relative standard deviations ranging from 3.1 to 9.1% were determined.

Instrument Calibration

EPA Method 6010 requires an Initial Calibration Verification, which is "prepared from a standard source different from that of the calibration standard and at concentrations within the linear working range of the instrument". Thus, two independent standards are used, one in calibration of the instrument, and the other in verifying the calibration. This concurrent checking and use of two independent NIST-traceable standards provides reasonable assurance of quality.

To furnish a supporting, corroborative line of evidence for accurate standards, NIST traceability is required. The manufacturer supplies a Certified Value for ICP standards comparing them to NIST standards. There may be a deviation between the label concentration and the Certified Value, but only the Certified Value is important; it is only necessary to know what the concentration of the standard is. The purpose of NIST certification is only to provide additional corroborative evidence of the multiple standard comparison described above.

University of California
Lawrence Livermore
National Laboratory

APPENDIX B: TABLES 2, 3 AND 9 OF AMR *DRIFT-SCALE COUPLED PROCESSES (DST AND THC SEEPAGE) MODELS*, AND MEMO FROM AMR AUTHOR ON USE OF DATA IN AMR

Table 2. Data Tracking Numbers for Sources of Data Input to the DST THC Model and THC Seepage Model

DTNs	Description
Hydrological and Thermal Rock Properties:	
LB990861233129.001	Calibrated property set† – Basecase
LB990861233129.002	Calibrated property set† – Upper bound
LB990861233129.003	Calibrated property set† – Lower bound
LB997141233129.001	Fracture porosity
LB991091233129.001	Infiltration rate – Basecase
LL000114004242.090	Infiltration rates - Average Infiltration Rate (mean, lower bound, and upper bound for present day, monsoon, and glacial transition climates) from the TH drift-scale models.
Mineralogic Data	
LASL831151AQ98.001	Mineralogic characterization of the ESF SHT Block
LA9912SL831151.001 LA9912SL831151.002	DST and SHT fracture mineralogy data
LA9908JC831321.001	Model input and output files for Mineralogic Model "MM3.0" Version 3.0.
Water and Gas Chemistry Data	
LB991215123142.001	CO_2 gas analyses (1st, 2nd, 3rd and 7th Qtr.)
LB990630123142.003	4th, 5th, and 6th Qtr. DST CO_2 data
LB000121123142.003	DST CO_2 data (Aug. '99 - Nov. '99)
LL990702804244.100	Analyses of porewaters from the ESF (HD-PERM-1 and HD-PERM-2 samples) Chemistry of water from DST hydrology boreholes (Nov. '98 & Jan. '99)
Repository Drift Data	
SN9907T0872799.001	Heat load data and repository footprint
SN9908T0872799.004	Hydrologic and thermal properties of drift design elements
SN9907T0872799.002	Effective thermal conductivity
PA-SSR-99218.Ta (Design Criterion)	Drift spacing
THC Seepage Model Grid Data	
LB990501233129.004	Borehole SD-9 geology in UZ model grid UZ99_2_3D.mesh
LB990701233129.002	Top and bottom boundary temperatures, pressure, and boundary elevations

NOTES: Thermodynamic data for minerals, aqueous, and gaseous species are found in Attachment IV. Kinetic data for mineral-water reactions are found in Table 4.

† Data taken from the calibrated property sets include calibrated and uncalibrated hydrological and thermal properties.

4.1.3 Water and Gas Chemistry

The pore water composition chosen for the input to the simulations is summarized in Table 3. These data are the average of two samples obtained from the Topopah Spring Tuff middle nonlithophysal geologic unit (Tptpmn) in Alcove 5 near the DST (Table 3). These are the only relatively complete pore water analyses for samples collected from a potential repository unit near the potential repository footprint. For model simulations, the initial water composition was set to be the same in fractures and matrix, and the same throughout the model domain, This water composition was also used for infiltrating water, as discussed in Section 6.1.2.

The initial CO_2 partial pressure in fractures and matrix (Table 3) was calculated as the partial pressure of CO_2 in chemical equilibrium with the initial water at 25°C, assuming ideal gas behavior (i.e. partial pressure is equal to fugacity). The 25°C temperature is close to the initial temperature at the location of the drift.

Table 3. Initial Water Composition and CO_2 Partial Pressure in Fractures, Matrix, and Recharge Waters.(1)

Parameter/Species	Units	Concentration
pH (at 25°C)	pH Units	8.32
Na^+	mg/l	61.3
$SiO_2(aq)$	mg/l	70.5
Ca^{2+}	mg/l	101
K^+	mg/l	8.0
Mg^{2+}	mg/l	17
Al^{3+}	mg/l	9.92×10^{-7} (2)
Fe^{3+}	mg/l	6.46×10^{-8} (3)
HCO_3^- (4)	mg/l	200
Cl^-	mg/l	117
SO_4^{2-}	mg/l	116
F^-	mg/l	0.86
CO_2 (gas) (5)	Pa	85.2

— pH is for PERM-2 30.1'-30.5'

DTN: LB991200DSTTHC.001 (this Table), LL990702804244.100 for water composition (CRWMS M&O 1999e)

NOTES:
(1) Average of Tptpmn Porewater Analyses ESF-HD-PERM-1 (30.1'-30.5') and ESF-HD-PERM-2 (34.8'-35.1').
(2) Calculated by equilibrating with Ca-smectite at 25°C (using SOLVEQ 1.0).
(3) Calculated by equilibrating with hematite at 25°C (using SOLVEQ 1.0).
(4) Total aqueous carbonate as HCO_3^-, calculated from charge balance computed by speciation at 25°C (using SOLVEQ 1.0).
(5) Calculated at equilibrium with the solution at 25°C (using SOLVEQ 1.0).

Perm 2 depth

perm 3 depth

5-2-00

Table 9. Measured Concentrations in TSw Pore Water from Alcove 5 and Chemistry of Water Taken from Hydrology Boreholes

Parameter	Units	Pore Water[1]	60-3[2] (11/12/98)	60-3[2] (1/26/99)	186-3[2] (11/12/98)	186-3[2] (1/26/99)
Temperature	C	25	26.5-40.6	51.7	34.3-34.8	Unknown
pH		8.32	6.92	7.4	6.83	7.2
Na^+	mg/l	61.3	20.3	19.1	17	26.9
SiO_2 (aq)	mg/l	70.5	115.5	139	68.2	106.5
Ca^{2+}	mg/l	101	13.9	5.9	20.2	2.92
K^+	mg/l	8.0	7.8	4.1	3.9	6.9
Mg^{2+}	mg/l	17	3	1.2	5.7	6.3
Al^{3+}	mg/l	9.02×10^{-7} [3]	n.d. (< 0.06)	n.d. (< 0.06)	n.d. (< 0.06)	n.d. (< 0.06)
HCO_3^- [4]	mg/l	200	n.a.	41	n.a.	118
Cl^-	mg/l	117	20	10	19	23.3
SO_4^{2-}	mg/l	116	30.8	13.5	26.2	21

NOTES: [1] Average of porewater analyses ESF-HD-PERM-1 (30.1'-30.5') and ESF-HD-PERM-2 (34.8'-35.1'). DTN: LL990702804244.100.

[2] DTN: LL990702804244.100.

[3] Calculated by equilibrating with Ca-smectite at 25°C.

[4] Total aqueous carbonate as HCO_3, calculated from charge balance.

n.a.=not analyzed, n.d.=not detected

6.2.7.3.2 Aqueous Species Simulation Results

The model simulates numerous aqueous species and only a limited discussion will be presented here. Data for all of the species are included in the output files (submitted under DTN: LB991200DSTTHC.002). The modeled variation in pH during the DST is shown in Figure 13 for the Case 2 simplified geochemical system. The most obvious effect on pH is a reduction to values predominantly around 6.5 in the condensate region, corresponding directly to the increases in CO_2 concentrations shown in Figure 6. As for the CO_2 concentrations, the low pH zone increases in size and moves outward with time. Within the dryout zone, the pH of the last residual water is also plotted, which reaches a maximum of nearly 9.5. However, the liquid saturation associated with these values is usually well below the residual liquid saturation. The modeled pH of condensate waters in fractures compares favorably with those collected from the hydrology boreholes (Table 9). As in the measured data collected at two times before the borehole intervals dried out, the model results show the effect of increasing pH with time and with increasing temperature in areas greater than 60°C. Therefore, in a given zone, the pH in the fractures first starts to drop because of steam condensation; then once the temperatures increase, so that the rate of evaporation and mineral-water reactions (and loss of CO_2) are greater than the rate of addition of water (and CO_2) via condensation, then the pH rises.

Eric Sonnenthal <elsonnenthal@lbl.gov> on 05/25/2000 02:12:42 PM

Please respond to elsonnenthal@lbl.gov

To: Holly Miller/YM/RWDOE
cc:

Subject: memo

Dear Holly,

This letter is in reference to the use of water chemistry from borehole intervals 60-3 and 186-3 listed in Table 9 and also referenced in Table 2 in AMR U0110/N0120. These waters were not used as input to the model. They are waters collected from the Drift Scale Test and were used solely for comparison to model results.

Sincerely,

Eric Sonnenthal

--

++++++
Eric Sonnenthal
Earth Sciences Division
Lawrence Berkeley National Lab
ph: (510)486-5866; fax: (510)486-5686
elsonnenthal@lbl.gov

APPENDIX C: PAGE 30 OF LLNL SCIENTIFIC NOTEBOOK: LLNL-SN00349

Page 30
LLNL-SN 00349 HW 6-1-00

9/28/98 RM I RECEIVED 3 WATER SAMPLES FROM
LBNL BOREHOLES AT YUCCA MOUNTAIN (YM).
60-2, ESF-HD-HYD-4, ZONE2, SPC00527915
60-3, ESF-HD-HYD-4, ZONE3, SPC00527916
77-3, ESF-HD-HYD-9, ZONE3, SPC00527917
IN GLASS
THE SAMPLES WERE SENT TO C&MS
FOR ANION & CATION ANALYSIS. SAMPLES
HAD HEAD SPACE 9/28/98 RM

11/20/98 RM I RECEIVED 3 WATER SAMPLES FROM
THE SAMPLE MANAGEMENT FACILITY
(SMF) AT YUCCA MOUNTAIN. THEY ARE
FROM ROCK OVERCORES.
ESF-HD-PERM-1 23.1'-23.3'; SMF ID
01002488.
ESF-HD-PERM-2 30.1'-30.5'; SMF ID
01002586.
ESF-HD-PERM-3 34.8'-35.1'; SMF ID
01002525.
THESE WERE 2 TO 2.5 mL SAMPLES
IN GLASS. THEY WERE SENT TO
C&MS FOR ANION & CATION ANALYSIS.
NO HEADSPACE. 11/20/98 RM

7/16/99 RM THE USE OF DATA (ANION & CATION) FROM
CHEMISTRY & MATERIAL SCIENCES ISSUES DESCRIBED
IN DR LLNL-98-D-092 NEED TO BE RESOLVED.

APPENDIX D: SPECTROCHEMICAL ANALYSIS REPORT (LLNL/ASD), ICP/AES, CASE# 579

1/10/00

I HAVE REVIEWED
AN ACCEPT THIS
DATA. Roger A. Martinelli

11/98 SAMPLES

SPECTROCHEMICAL ANALYSIS REPORT

Lawrence Livermore National Laboratory
Analytical Chemistry Section
Inductively-Coupled Plasma Atomic Emission Spectrometer

Ext. 3-1827

Sample Description: **YMP**
pH<2 0.45 u filtered
Pore water from Rocks
Case 579

Received:	Dec. 4, 1998	Reported:	Dec. 9, 1998
Requester:	R. Martinelli	Analyst:	T. Duewer
Signature:		Instrument:	ARL
Unit:	microgram/ml	Account:	8781-80

Note: The elements reported below were the only ones sought. For elements "not detected", the number cited is the concentration required to confirm the true value.

ANALYSIS

Your Sample I.D.	Al	B	Ca	Fe	K
Perm-blank	n.d.<0.06	n.d.<0.01	0.33	n.d.<0.02	n.d.<0.5
Perm-1	n.d.<0.06	0.61	19.7	n.d.<0.02	1.2
Perm-2	n.d.<0.06	0.55	21.3	n.d.<0.02	1.4
Perm-3	n.d<0.06	0.55	19.4	n.d.<0.02	1.8

	Li	Mg	Na	S	Si
Perm-blank	n.d.<0.01	n.d.<0.001	n.d.<0.1	n.d.<0.2	n.d.<0.06
Perm-1	0.02	5.13	12.1	8.45	7.4
Perm-2	0.09	3.31	12.2	7.72	6.2
Perm-3	0.01	3.47	12.3	7.73	7.0

PERMS 1 -3
WERE 1:5
DILUTIONS
12/10/98 RM.

	Sr
Perm-blank	n.d.<0.01
Perm-1	0.28
Perm-2	0.20
Perm-3	0.21

Jan.13.03

CERTIFICATE OF ANALYSIS

SPEX CertiPrep

I have reviewed + accept this certificate of Analysis

12/08/98

Catalog Number: QC-7

Description: Quality Control Standard 7

Lot Number: 13-83AS

ICP CHECK:

Element	Labeled[ug/ml]	Measured[ug/ml]	Element	Labeled[ug/ml]	Measured[ug/ml]
K	1,000	1,003.26			
Ag	100	100.49			
Al	100	100.79			
B	100	100.13			
Ba	100	100.37			
Na	100	99.62			
Si	50	50.17			

Instrumental Analysis by Inductively Coupled Plasma Spectroscopy:

The following SRM's were used in establishing the above results:

K : NIST 3141a, Ag : NIST 3151, Al : NIST 3101a, B: NIST 3107,
Ba: NIST 3104a, Na: NIST 3152a, Si : NIST 3150.

Spex Reference Multi: 2-265BDREF, 2-170BDREF, 11-36AS

Balances are calibrated regularly with weight sets traceable to NIST.

SPEX CertiPrep reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kocherlakota
Manufacturing Manager

DEC '98
Date

SPEX CertiPrep ISO 9001 CERTIFIED

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CERTIFICATE OF ANALYSIS

SPEX CertiPrep

Catalog Number: QC-21

Description: Quality Control Standard 21

Lot Number: 12-126AS

I have reviewed + accepted the certificate
[illegible]
12/08/98

ICP CHECK:

Element	Labeled[ug/ml]	Measured[ug/ml]	Element	Labeled[ug/ml]	Measured[ug/ml]
As	100	100.33	Mo	100	100.02
Be	100	99.90	Ni	100	100.30
Ca	100	99.52	Pb	100	99.90
Cd	100	99.53	Sb	100	100.05
Co	100	100.23	Se	100	100.11
Cr	100	100.65	Sr	100	100.20
Cu	100	100.54	Ti	100	99.80
Fe	100	99.80	Tl	100	99.62
Li	100	99.98	V	100	100.08
Mg	100	99.39	Zn	100	99.68
Mn	100	99.53			

Instrumental Analysis by Inductively Coupled Plasma Spectroscopy:

The following SRM's were used in establishing the above results:

As: NIST 3103a, Be: NIST 3105a, Ca: NIST 31-9a, Cd: NIST 3108, Co: NIST 3113, Cr: NIST 3112a, Cu: NIST 3114, Fe: NIST 3126a, Li: NIST 3129a, Mg: NIST 3131a, Mn: NIST 3132, Mo: NIST 3134, Ni: NIST 3136, Pb: NIST 3128, Sb: NIST 3102a, Se: NIST 3149, Sr: NIST 3153a, Ti: NIST 3162a, Tl: NIST 3158, V : NIST 3165, Zn: NIST 3168a.

Spex Reference Multi: Lot #2-89BDREF, 11-63AS, 9-138AS, 1-70CR

Balances are calibrated regularly with weight sets traceable to NIST.

SPEX CertiPrep reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kolhatkar

Manufacturing Manager

DEC '96

Date

SPEX CertiPrep ISO 9001 CERTIFIED

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National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material 3150

Silicon

Received & open
Jan. 8, 98
T.O.

This Standard Reference Material (SRM) is intended for use in atomic absorption spectrometry, optical emission (plasma) spectrometry, spectrophotometry, or any other analytical technique that requires aqueous standard solutions for calibrating instruments. SRM 3150 is a single element solution prepared gravimetrically to contain 10.00 mg/mL of silicon in water. The certified value is based on a gravimetric procedure, i.e., weight per volume composition of the high-purity salt dissolved in NIST high-purity reagents.

Metal	Concentration (mg/mL)	SourceAcid Purity, %	Conc. (V/V) Approximate
Si	10.00 ± 0.03	$Na_2SiO_3 \bullet 9H_2O$(99.99)*	Water

*This high-purity material was analyzed by optical emission spectrometry and atomic absorption spectrometry and found to contain less then 50 µg/g total impurities.

I have received & accept the certificate of Analysis
12/08/98

Procedures and Storage for Use

Stability

This certificate is valid for one year from the shipping date provided the SRM solution is kept tightly capped and stored under normal laboratory conditions. NIST will monitor the stability representative solutions from the SRM lot and if any changes occur that invalidate this certification, NIST will notify purchasers.

Preparation of Working Standard Solutions:

The SRM solution should be brought to 22 ± 1 °C before use. All glass or plastic surfaces coming into contact with the SRM must have been previously cleaned. A working standard solution can be prepared from the SRM solution by serial dilution. Dilutions should be made with certified volumetric class A flasks and 5 or 10 mL class A pipets. All volumetric transfers of solutions should be performed using a proven analytical technique. Each dilution should be acidified with an appropriate high-purity acid and diluted to calibrated volume using high-purity water. The stability of the working standard solution will depend on the final acid concentration; therefore, care should be exercised to insure that the final acid concentration of the dilution closely approximates that of the SRM. To achieve the highest accuracy, the analyst should prepare daily working solutions from 100 µg/mL dilutions of the original SRM solution.

Notice to Users:

The same acid mixture as listed on this SRM certificate should be used in making appropriate dilutions and working standards. For some instrumental techniques, small differences in acid type and concentration of the SRM and sample may lead to erroneous results.

Gaithersburg, MD 20899
August 11, 1989
(Revision of certificate dated 12-22-86)

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

(over)

ASSURANCE™

CERTIFICATE OF ANALYSIS

Catalog Number: PLSC2-2Y   Lot No. 5-123SC
Element and Matrix: Sc in HNO_3

Starting Material: Scandium Oxide Sc_2O_3
Starting Material Lot No.: 079411

Density: 1.0122 at 23.2°c

I have reviewed & accept the certificate of Analysis
T.
12/18/98

Trace Metallic Impurities in the Actual Solution via ICP Analysis:

Element	PPM	Element	PPM	Element	PPM
Ca	0.02	Lu	0.001	Tb	<0.001
Ce	<0.001	Mn	<0.001	Th	0.02
Dy	0.005	Mo	<0.001	Ti	<0.001
Er	0.003	Na	0.009	Tl	<0.001
Eu	<0.001	Nd	<0.001	Tm	<0.001
Fe	0.02	Ni	<0.001	V	<0.005
Gd	0.003	Pr	<0.001	W	<0.001
Hf	<0.001	Si	<0.02	Y	0.02
Ho	0.001	Sm	0.001	Yb	0.005
La	<0.001	Ta	<0.001	Zr	<0.001

Classical "Wet" Assay: 1,001 ppm.

Titrimetry: EDTA titration using Xylenol Orange as indicator. EDTA is standardized against $Pb(NO_3)_2$ NIST SRM 928.

Instrumentation Analysis By Inductively Coupled Plasma [ICP] Spectrometer: 1,000 ppm via NIST SRM 3148a.

Balances are calibrated with NIST weight sets NJ #92589 and #92550, according to NIST circular 547 3.4.3.

ASSURANCE reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kocherlakota
Manufacturing Manager

JAN 98
Date

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SPEX CERTIPREP, INC. 203 NORCROSS AVENUE METUCHEN, NJ 08840 908-549-7144 1-800-LAB-SPEX FAX: 908-603-9647

ASSURANCE™

CERTIFICATE OF ANALYSIS

Catalog Number: PLS9-2X/2Y Lot No. 5-161S
Element and Matrix: S in H_2O

Starting Material: Ammonium Sulfate $(NH_4)_2SO_4$
Starting Material Lot No.: 05891M

Density: 0.9985 at 22.6°c

I have reviewed + accept the certificate of the Analysis
T. O
12/18/98

Trace Metallic Impurities in the Actual Solution via ICP-MS Analysis:

Element	PPM	Element	PPM	Element	PPM
Ag	0.001	Cu	<0.001	Sb	<0.001
Al	<0.001	Fe	0.01	Si	<0.02
As	<0.001	K	<0.05	Sn	<0.001
B	<0.001	Li	<0.001	Sr	<0.001
Ba	<0.001	Mg	0.01	Ti	<0.002
Be	<0.001	Mn	<0.001	Tl	<0.001
Bi	<0.001	Mo	<0.001	V	<0.001
Ca	0.007	Na	0.03	Zn	0.003
Cd	<0.001	Ni	<0.001	Zr	<0.001
Co	<0.001	P	<0.05		
Cr	<0.001	Pb	<0.001		

Classical "Wet" Assay: 1,004 ppm.

Gravimetry: Precipitation using $BaCl_2$, filter, ignite and weigh as $BaSO_4$.

Instrumentation Analysis By Inductively Coupled Plasma Spectrometer[ICP]: 1,001 ppm via NIST SRM 3154.

Balances are calibrated regularly with weight sets traceable to NIST.

ASSURANCE reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

Manufacturing Manager

JAN 98
Date

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ASSURANCE™

CERTIFICATE OF ANALYSIS

Catalog Number: PLSR2-2X/2Y **Lot No. 6-67SR**
Element and Matrix: Sr in HNO_3

Starting Material: Strontium Carbonate $SrCO_3$
Starting Material Lot No.: 05941D

I have reviewed & accept the certificate of Analysis T. Du 12/08/98

Density: 1.0099 at 23.8°c

Trace Metallic Impurities in the Actual Solution via ICP Analysis:

Element	PPM	Element	PPM	Element	PPM
Ag	<0.001	Cr	<0.01	P	<1.0
Al	0.01	Cu	<0.001	Pb	<0.001
As	<0.001	Fe	<0.01	Sb	<0.001
B	<0.002	K	<0.05	Si	0.04
Ba	0.006	Li	1.0	Sn	<0.001
Be	<0.001	Mg	<0.005	Ti	<0.001
Bi	<0.001	Mn	0.003	Tl	<0.001
Ca	0.009	Mo	<0.001	V	<0.001
Cd	<0.001	Na	0.017	Zn	<0.003
Co	<0.001	Ni	0.001	Zr	<0.001

Classical "Wet" Assay: 1,001 ppm.

Titrimetry: EDTA titration using Methyl Thymol Blue as indicator. EDTA standardized against NIST $Pb(NO_3)_2$ SRM 928.

Instrumentation Analysis By Inductively Coupled Plasma [ICP] Spectrometer: 1,000 ppm via NIST SRM 3153a.

Balances are calibrated regularly with weight sets traceable to NIST.

ASSURANCE reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kocherlakota
Manufacturing Manager

JAN 98
Date

SPEX CertiPrep ISO 9001 CERTIFIED

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ASSURANCE™

CERTIFICATE OF ANALYSIS

Catalog Number: PLLI2-2Y **Lot #:** 4-260LI
Element and Matrix: Lithium / 1,000 / HNO_3
Starting Material: Lithium Carbonate Li_2CO_3
Starting Material Lot #: 12931C
Density: 1.0120 @ 22.22 C

I have reviewed
& accept the
Certificate
of Analysis
T. Ou
12/08/98

Trace Metallic Impurities in the Actual Solution via ICP Analysis:

Element	PPM	Element	PPM	Element	PPM
Ag	<0.001	Cr	<0.001	Pb	<0.001
Al	<0.010	Cu	<0.001	Sb	<0.001
As	<0.001	Fe	<0.001	Si	0.400
B	<0.001	K	0.005	Sn	<0.001
Ba	0.001	Mg	0.002	Sr	<0.001
Be	<0.001	Mn	<0.001	Ti	0.007
Bi	<0.001	Mo	<0.001	Tl	<0.001
Ca	0.019	Na	0.014	V	<0.001
Cd	<0.001	Ni	<0.001	Zn	0.003
Co	<0.001	P	<0.500	Zr	<0.001

Traceability Documentation for Solution Standard:

Classical Wet Assay: 1,001 ug/mL
Gravimetry: Evaporate to dryness, fume with Sulfuric Acid, Ignite and weigh as Li_2SO_4

Instrumentation Analysis By Inductively Coupled Plasma [ICP] Spectrometer: 995 ug/mL
via NIST SRM 3129a

Balances are calibrated with NIST weight sets NJ #92589 and #92550, according to NIST circular 547 3.4.3

ASSURANCE reference standards are guaranteed stable and accurate to ± 0.5% of labeled concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kocherlakota
Chemical Production Manager

JAN 96
Date

SPEX Chemical

SPEX CHEMICAL 203 NORCROSS AVENUE METUCHEN, NJ 08840 908-549-7144 1-800-LAB-SPEX FAX: 908-603-9647

Printed on Recycled Paper

ASSURANCE™

CERTIFICATE OF ANALYSIS

Catalog Number: PLB9-2Y **Lot No.** 6-27B
Element and Matrix: B in H_2O

Starting Material: Ammonium Tetraborate $(NH_4)_2B_4O_7.4H_2O$
Starting Material Lot No.: M0797B

Density: 1.0000 at 22.7°c

I have reviewed
& accept the
certificate &
analysis
12/08/98

Trace Metallic Impurities in the Actual Solution via ICP Analysis:

Element	PPM	Element	PPM	Element	PPM
Ag	<0.001	Cu	0.003	Pb	0.002
Al	0.1	Fe	0.03	Sb	<0.001
As	<0.001	K	<0.1	Si	<0.01
Ba	<0.001	Li	0.002	Sn	<0.001
Be	<0.001	Mg	0.008	Sr	<0.001
Bi	<0.001	Mn	<0.001	Ti	<0.001
Ca	0.004	Mo	<0.001	Ti	<0.001
Cd	<0.001	Na	0.005	W	<0.001
Co	<0.001	Ni	<0.001	Zn	<0.02
Cr	<0.001	P	<0.1	Zr	<0.001

Classical "Wet" Assay: 1,002 ppm.

Titrimetry: Titration with Sodium Hydroxide using Phenolphthalein as indicator.

Instrumentation Analysis By Inductively Coupled Plasma [ICP] Spectrometer: 1,003 ppm via NIST SRM 3107.

Balances are calibrated regularly with weight sets traceable to NIST.

ASSURANCE reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

N Kochekota
Manufacturing Manager

Date JAN 98

SPEX CertiPrep ISO 9001 CERTIFIED

SPEX CERTIPREP, INC. 203 NORCROSS AVENUE METUCHEN, NJ 08840 908-549-7144 1-800-LAB-SPEX FAX: 908-603-9647

CLÄRITAS PPT™

CERTIFICATE OF ANALYSIS

Catalog Number: CLAL2-2Y
Description: 1,000 ug/mL in 2% HNO3
Starting Material: Aluminum Nitrate $Al(NO_3)_3$
Lot Number: CL1-90AL
Density: 1.017 @ 23.7 °C

I have received
+ accept the
certificate of Analysis
T.
12/08/98

Classical Wet Assay: 1,001 ug/mL

Gravimetry: Precipitation using 8Hydroxy Quinoline, filter, dry and weigh as $Al(C_9H_6NO)_3$

Instrument Analysis by ICP Spectrometer: 998 ug/mL

NIST SRM 3101a

Trace Metallic Impurities in the Actual Solution, in PPB, via ICP-MS Analysis:

Ag	0.04	Ho	<0.01	Sb	10.00
As	<0.08	In	<0.01	Sc	<1.00
Au	<0.01	Ir	<0.01	Se	<0.80
B	<5.00	K	<30.00	Si	10.00
Ba	0.60	La	0.09	Sm	<0.01
Be	<0.08	Li	0.10	Sn	0.04
Bi	0.02	Lu	<0.01	Sr	0.05
Ca	15.00	Mg	2.00	Ta	<0.01
Cd	<0.02	Mn	<0.05	Tb	0.03
Ce	0.20	Mo	0.30	Te	<0.10
Co	0.20	Na	100.00	Th	<0.01
Cr	5.00	Nb	<0.01	Ti	8.00
Cs	<0.01	Nd	<0.02	Tl	0.03
Cu	1.00	Ni	<0.40	Tm	<0.01
Dy	<0.01	P	<100.00	U	<0.01
Er	<0.01	Pb	0.30	V	0.20
Eu	<0.01	Pd	<0.01	W	<0.50
Fe	30.00	Pr	<0.02	Y	0.07
Ga	30.00	Pt	<0.04	Yb	0.03
Gd	<0.02	Rb	0.05	Zn	<3.00
Ge	<0.20	Re	<0.01	Zr	1.00
Hf	0.02	Rh	<0.02		
Hg	<0.10	Ru	<0.01		

Balances are calibrated regularly with weight sets traceable to NIST.

CLARITAS PPT reference standards are guaranteed stable and ccurate to ± 0.5%, averaged certified analyte concentrations, for a period of one year from date of shipment. For these solutions we se the highest purity acids applicable, 18 megohm double-deionized water and acid-leached, triple-rinsed bottles. All glassware used is Class A.

Manufacturing Manager
DEC '98
Date

SPEX CertiPrep
203 NORCROSS AVENUE
METUCHEN, NJ 08840
908-549-7144
1-800-LAB-SPEX
FAX: 908-603-9647
E-mail: CRMSales@spexcsp.com

ISO 9001 CERTIFIED

CLÄRITAS PPT™

CERTIFICATE OF ANALYSIS

Catalog Number:	CLCA2-2Y
Description:	1,000 ug/mL Calcium in 2% HNO3
Starting Material:	Calcium Nitrate Ca(NO3)2 * 4H2O
Lot Number:	CL1-71CA
Density:	1.019 @ 22.8 C

I have reviewed
& accept the
certificate of
Analysis
12/08/98

Classical Wet Assay: 1,001 ug/mL

· Titrimetry: EDTA titration using Hydroxy Naphthol Blue as indicator. EDTA standardized against Pb(NO3)2 NIST SRM 928

Instrument Analysis by ICP Spectrometer: 1,004 ug/mL

NIST SRM 3109a

Trace Metallic Impurities in the Actual Solution, in PPB, via ICP-MS Analysis:

Ag	0.04	Ho	<0.01	Sb	<0.01
Al	15.00	In	<0.01	Sc	6.00
As	<0.20	Ir	<0.01	Se	<2.00
Au	<0.01	K	90.00	Si	<20.00
B	60.00	La	0.04	Sm	<0.01
Ba	0.20	Li	<0.03	Sn	0.30
Be	<0.05	Lu	<0.01	Sr	30.00
Bi	<0.01	Mg	40.00	Ta	<0.01
Cd	0.50	Mn	<1.00	Tb	<0.01
Ce	0.10	Mo	<0.01	Te	<0.20
Co	<3.00	Na	20.00	Th	<0.01
Cr	<4.00	Nb	<0.01	Ti	7.00
Cs	<0.01	Nd	0.01	Tl	0.02
Cu	0.80	Ni	2.00	Tm	0.01
Dy	<0.01	P	<100.00	U	0.01
Er	<0.01	Pb	0.10	V	1.00
Eu	<0.01	Pd	0.02	W	0.06
Fe	5.00	Pr	<0.01	Y	0.01
Ga	<0.01	Pt	<0.03	Yb	<0.01
Gd	<0.01	Rb	<0.01	Zn	4.00
Ge	<0.10	Re	<0.01	Zr	0.06
Hf	<0.01	Rh	<0.05		
Hg	0.15	Ru	<0.01		

Balances are calibrated regularly with weight sets traceable to NIST.

CLARITAS PPT reference standards are guaranteed stable and ccurate to ± 0.5%, averaged certified analyte concentrations, for a period of one year from date of shipment. For these solutions we se the highest purity acids applicable, 18 megohm double-eionized water and acid-leached, triple-rinsed bottles. All glassware used is Class A.

JL '98

Manufacturing Manager | Date

SPEX CertiPrep
203 NORCROSS AVENUE
METUCHEN, NJ 08840
908-549-7144
1-800-LAB-SPEX
FAX: 908-603-9647
E-mail: CRMSales@spexcsp.com

ISO 9001 CERTIFIED

CLÄRITAS PPT™

ISO 9001

CERTIFICATE OF ANALYSIS

Catalog Number:	CLK2-2Y
Description:	1,000 ug/mL Potassium in 2% HNO3
Starting Material:	Potassium Nitrate KNO3
Lot Number:	CL1-47K
Density:	1.0098 @ 22.3 C

Classical Wet Assay: 1,005 ug/mL

Gravimetry: Evaporate to dryness, fume with Sulfuric Acid, ignite and weigh as K_2SO_4

Instrument Analysis by ICP Spectrometer: 998 ug/mL

NIST SRM 3141a

Trace Metallic Impurities in the Actual Solution, in PPB, via ICP-MS Analysis:

Ag	0.01	Hg	<0.30	Sb	0.10
Al	6.00	Ho	0.01	Sc	3.00
As	<0.30	In	0.20	Se	1.00
Au	<0.01	Ir	0.02	Si	<10.00
B	<5.00	La	0.03	Sm	<0.02
Ba	2.00	Li	0.50	Sn	<0.20
Be	<0.20	Lu	<0.01	Sr	3.00
Bi	1.00	Mg	<2.00	Ta	<0.01
Ca	1.50	Mn	1.00	Tb	<0.01
Cd	0.20	Mo	<0.05	Te	<0.10
Ce	0.07	Na	40.00	Th	<0.01
Co	<0.04	Nb	0.05	Ti	1.00
Cr	<0.30	Nd	0.05	Tl	0.04
Cs	0.02	Ni	<0.80	Tm	<0.01
Cu	3.00	P	300.00	U	0.04
Dy	<0.01	Pb	4.00	V	2.00
Er	<0.01	Pd	<0.01	W	0.02
Eu	<0.01	Pr	<0.01	Y	0.06
Fe	<5.00	Pt	0.06	Yb	0.02
Ga	0.20	Rb	20.00	Zn	2.00
Gd	1.00	Re	<0.01	Zr	0.10
Ge	1.00	Rh	0.02		
Hf	<0.01	Ru	<0.01		

I have received & accepted
T. Quinn
Jan. 13. 00

Balances are calibrated with NIST weight sets NJ #92689 and #92550, according to NIST circular 547-8.4.3

CLARITAS PPT reference standards are guaranteed stable and accurate to ± 0.5%, averaged labeled analyte concentrations, for a period of one year from date of shipment. For these solutions we use the highest purity acids applicable, 18 megohm double-deionized water and acid-leached, triple-rinsed bottles. All glassware used is Class A.

N Kocherlakota
Manufacturing Manager

JAN 98
Date

SPEX CertiPrep

203 NORCROSS AVENUE
METUCHEN, NJ 08840

908-549-7144
1-800-LAB-SPEX
FAX: 908-603-9647
E-mail: CRMSales@spexcsp.com

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National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material 3152a

Spectrometric Standard Solution

Sodium

Batch Code 391412

This Standard Reference Material (SRM) is intended for use in atomic absorption spectrometry, optical emission (plasma) spectrometry, spectrophotometry, or any other analytical technique that requires aqueous standard solutions for calibrating instruments. SRM 3152a is a single element solution prepared gravimetrically to contain 10 mg/mL a nominal of sodium with a nitric acid concentration (V/V) of 1 percent. The certified values are based on gravimetric procedures, i.e., weight per volume composition of the high-purity salt dissolved in NIST high-purity reagents. The uncertainty listed is based on gravimetric and volumetric uncertainties of the preparation and the effect of solvent transpiration through the container walls for one year. The density of the solution at 22 °C is 1.024 g/mL.

Metal	Concentration (mg/mL)	Source Purity, %	Acid Conc. (V/V) Approximate
Na	10.00 ± 0.03	SRM 2201 (99.9)	HNO_3, 1%

Procedures for Use

Stability: This certification is valid for one year from the shipping date, provided the solution is kept tightly capped and stored under normal laboratory conditions. NIST will monitor the stability of representative solutions from the SRM lot; and if any changes occur that invalidate this certification, NIST will notify purchasers.

Preparation of Working Standard Solutions: All solutions should be brought to 22 ± 1 °C before use and all glass or plastic surfaces coming into contact with the standard must have been previously cleaned. A working standard solution can be prepared from the SRM solution by serial dilution. Dilutions should be made with certified volumetric class A flasks and 5 or 10 mL class A pipets. All volumetric transfers of solutions should be performed using a proven analytical technique. Each dilution should be acidified with an appropriate high-purity acid and diluted to calibrated volume using high-purity water. The stability of the working standard solution will depend on the final acid concentration; therefore, care should be exercised to ensure that the final acid concentration of the dilution closely approximates that of the SRM. To achieve the highest accuracy, the analyst should prepare daily working solutions from 100 µg/mL dilutions of the original SRM solution.

SRM 3152a was prepared, and atomic absorption and emission spectrometric analyses were made by, T.A. Butler of the NIST Inorganic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by J.S. Kane.

Gaithersburg, MD 20899
January 5, 1994

Thomas E. Gills, Acting Chief
Standard Reference Materials Program

I have accepted
+ reviewed it
T. Duan

Jar. 13, 00

CLARITAS PPT™

CERTIFICATE OF ANALYSIS

Catalog Number:	CLMG2-2Y
Description:	1,000 ug/mL Mg in 2% HNO3
Starting Material:	Magnesium Nitrate $Mg(NO_3)_2 \cdot 6H_2O$
Lot Number:	CL1-39MG
Density:	1.0128 @ 23.8 C

Classical Wet Assay: 1,001 ug/mL

Titrimetry: EDTA titration using Eriochrome Black T as indicator. EDTA standardized against $Pb(NO_3)_2$ NIST SRM 928

Instrument Analysis by ICP Spectrometer: 996 ug/mL

SRM 3131a

Trace Metallic Impurities in the Actual Solution, in PPB, via ICP-MS Analysis:

Ag	0.01	Hg	<0.50	Sb	0.50
Al	<5.00	Ho	<0.01	Sc	<0.50
As	<0.20	In	<0.01	Se	<5.00
Au	<0.01	Ir	<0.01	Si	<5.00
B	<2.00	K	<30.00	Sm	<0.01
Ba	0.10	La	0.25	Sn	0.20
Be	<0.10	Li	0.10	Sr	5.00
Bi	<0.05	Lu	<0.01	Ta	<0.01
Ca	37.00	Mn	10.00	Tb	<0.01
Cd	<0.10	Mo	<0.05	Te	<0.50
Ce	0.70	Na	11.00	Th	0.70
Co	<0.10	Nb	<0.01	Ti	<0.50
Cr	0.60	Nd	<1.00	Tl	<0.10
Cs	<0.01	Ni	0.80	Tm	<0.01
Cu	3.00	P	<100.00	U	<0.01
Dy	<0.10	Pb	3.00	V	<0.10
Er	<0.01	Pd	<0.05	W	<0.10
Eu	<0.01	Pr	0.11	Y	<0.10
Fe	<5.00	Pt	<0.01	Yb	<0.01
Ga	0.10	Rb	<0.01	Zn	25.00
Gd	<0.50	Re	<0.01	Zr	<0.10
Ge	<0.50	Rh	<0.01		
Hf	<0.01	Ru	<0.01		

I have reviewed
+ accepted.
T. Owen
Jan. 13. 00

Balances are calibrated with NIST weight sets NJ #92589 and #92550, according to NIST circular 547 3.4.3

CLARITAS PPT reference standards are guaranteed stable and rate to ± 0.5%, averaged certified analyte concentrations, for a d of one year from date of shipment. For these solutions we se the highest purity acids applicable, 18 megohm double-eionized water and acid-leached, triple-rinsed bottles. All glassware used is Class A.

N Kocherlakota
Manufacturing Manager

JAN 98
Date

SPEX CertiPrep

203 NORCROSS AVENUE
METUCHEN, NJ 08840

908-549-7144
1-800-LAB-SPEX
FAX: 908-603-9647
E-mail: CRMSales@spexcsp.com

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CLÄRITAS **PPT**™

ISO 9001

CERTIFICATE OF ANALYSIS

Catalog Number:	CLFE2-2Y
Description:	1,000 ug/mL Iron in 2% HNO3
Starting Material:	Ferric Nitrate Fe(NO3)3 * 9H2O
Lot Number:	CL1-52FE
Density:	1.0117@23.5°C

I have reviewed & accepted the certificate of Analysis
T. Duewer
Jan. 13, 00

Classical Wet Assay: 996 ug/mL

Gravimetry: Precipitation using Ammonium Hydroxide, filter, ignite and weigh as Fe2O3

Instrument Analysis by ICP Spectrometer: 998 ug/mL

NIST SRM 3126a

Trace Metallic Impurities in the Actual Solution, in PPB, via ICP-MS Analysis:

Ag	<0.02	Ho	<0.01	Sb	0.10
Al	2.00	In	<0.01	Sc	<5.00
As	0.50	Ir	<0.01	Se	<2.00
Au	0.07	K	<30.00	Si	<10.00
B	<4.00	La	0.09	Sm	<0.01
Ba	<0.01	Li	1.00	Sn	0.20
Be	<0.10	Lu	<0.01	Sr	0.09
Bi	<0.01	Mg	3.00	Ta	<0.01
Ca	34.00	Mn	2.00	Tb	<0.01
Cd	0.04	Mo	0.07	Te	0.05
Ce	0.02	Na	5.00	Th	<0.01
Co	2.00	Nb	0.02	Ti	<0.50
Cr	4.00	Nd	0.03	Tl	<0.01
Cs	<0.01	Ni	1.00	Tm	<0.01
Cu	0.50	P	<100.00	U	<0.01
Dy	<0.01	Pb	0.20	V	<0.50
Er	<0.01	Pd	0.01	W	0.05
Eu	<0.01	Pr	<0.01	Y	0.03
Ga	0.20	Pt	<0.01	Yb	<0.01
Gd	<0.01	Rb	<0.01	Zn	1.00
Ge	<50.00	Re	<0.01	Zr	0.07
Hf	<0.01	Rh	<0.40		
Hg	<0.05	Ru	<0.01		

I have reviewed & accepted
~~T. Due~~
T.D.
Jan. 13, 00
T. Duewer

Balances are calibrated with NIST weight sets NJ #92589 and #92550, according to NIST circular 547 3.4.3

CLARITAS PPT reference standards are guaranteed stable and curate to ± 0.5%, averaged labeled analyte concentrations, for a iod of one year from date of shipment. For these solutions we se the highest purity acids applicable, 18 megohm double-ionized water and acid-leached, triple-rinsed bottles. All glassware used is Class A.

N Kothakota — JAN 98
Manufacturing Manager — Date

SPEX CertiPrep
203 NORCROSS AVENUE
METUCHEN, NJ 08840
908-549-7144
1-800-LAB-SPEX
FAX: 908-603-9847
E-mail: CRMSales@spexcsp.com

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Calculation

Sample ID		Sxwt	Final wt	Dil factor	B	Ca	mg	Na	S	Si	Sr	Mg	Mg	Na	Na	S
Perm-blank		3.1291	10.1568	3.247		**0.33**							0.000			
Perm-1		3.3614	10.0883	3.001	0.609	**19.68**	**8.13**	**12.1**	**8.45**	**7.39**	**0.28**		0.000	2.006	6.01744556	
Perm-2		3.2818	10.0712	3.069	0.546	**21.30**	**3.31**	**12.2**	**7.72**	**6.19**	**0.20**		0.000	1.681	5.15865903	
Perm-3		3.4274	10.0826	2.942	0.547	**19.36**	**3.47**	**12.3**	**7.73**	**6.97**	**0.21**		0.000	1.661	4.88626907	
													0.000	6.642	0	
													0.000	0.241	0	
																4.062
																4.641
																4.608
																11.542
																1.280

Calculation

S	Sl	Sl	Sl	Sr	SR
				0.096	0.31166943
		5.104	15.3182255	0.218	0.6542659
		4.266	13.0915166	0.216	0.6628616
		4.302	12.6554663	0.026	0.07648585
		4.873	0	0.005	0
		0.146	0		
0					
0					
0					
0					
0					

```
Method : ROGER        Standardzn Report     02/11/00 10:39:37            page 1

El Name       Slope         Y-int         Correlation    Date Stdized
Al3082        0.0406        0.0034        0.9966617      09/28/99 11:11:30

Standard        Concentration          Difference            Signal
  Name        Stated     Found        Conc       %           (S)IR
a0000  5-25-00  0          0.0010023    0          0           0.0034612
b0002         0.199      0.12242      -0.0766    -38.5       0.0083895
b0004         0.396      0.33459      -0.0614    -15.5       0.017002
b0020         1.999      2.0053       0.00625    0.313       0.084815
b0040         3.977      4.1087       0.132      3.31        0.1702
       5-2500
Al      308.215   {109}

 (S)IR 0[       ]
             10
           Concentration

El Name       Slope         Y-int         Correlation    Date Stdized
Al3092        0.0655        0.0128        0.9997604      09/28/99 11:11:30

Standard        Concentration          Difference            Signal
  Name        Stated     Found        Conc       %           (S)IR
a0000         0          -0.000263550          0            0.012764
b0002         0.199      0.21916      0.0202     10.1        0.027129
b0004         0.396      0.41379      0.0178     4.49        0.03987
b0020         1.999      1.9818       -0.0172    -0.861      0.14252
b0040         3.977      3.9562       -0.0208    -0.522      0.27177
         5-25-00
Al       309.271   {109}

 (S)IR 0[       ]
             10
           Concentration
          5-25-00
El Name       Slope         Y-int         Correlation    Date Stdized
Al 3961       0.1911        -0.0011       0.9999265      09/28/99 11:11:30

Standard        Concentration          Difference            Signal
  Name        Stated     Found        Conc       %           (S)IR
a0000         0          -0.000143090          0            -0.0011274
b0002         0.199      0.21177      0.0128     6.42        0.039375
b0004         0.396      0.40093      0.00493    1.25        0.075528
b0020         1.999      1.9979       -0.00112   -0.056      0.38074
b0040         3.977      3.9604       -0.0166    -0.417      0.75583

Al    396.152   {85}

 (S)IR 0[       ]
             10
           Concentration

El Name       Slope         Y-int         Correlation    Date Stdized
B_2089        0.6005        0.0030        0.9999474      09/28/99 11:11:44

Standard        Concentration          Difference            Signal
  Name        Stated     Found        Conc       %           (S)IR
a0000         0          4.331e-05    0          0           0.0030118
a0002         0.2        0.1969       -0.0031    -1.55       0.12123
a0004         0.4        0.39472      -0.00528   -1.32       0.24002
a0008         0.798      0.80239      0.00439    0.55        0.48483
a0010         1          1.0067       0.00667    0.667       0.60749
a0001         0.0999     0.09722      -0.00268   -2.68       0.061367
        5-25-00
B       208.959   {161}

 (S) IR 0[       ]
             10
           Concentration
```

```
El Name        Slope          Y-int          Correlation       Date Stdized
B_2496         1.8305         0.0125         0.9999850         09/28/99 11:11:44

Standard Hw 5-25-00  Concentration        Difference             Signal
 Name            Stated      Found        Conc         %         (S)IR
a0000            0           1.9116e-050               0         0.012565
a0002            0.2         0.19735      -0.00265     -1.32     0.37378
a0004            0.4         0.39769      -0.00231     -0.577    0.74051
a0008            0.798       0.79903      0.00103      0.129     1.4752
a0010            1           1.0045       0.00452      0.452     1.8513
a0001            0.0999      0.099308     -0.000592    -0.593    0.19431
   Hw 5-25-00
B         249.678   (135)
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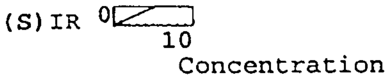

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El Name        Slope          Y-int          Correlation       Date Stdized
B_2497         3.8151         -0.0027        0.9999737         09/28/99 11:11:44

Standard             Concentration        Difference             Signal
 Name            Stated      Found        Conc         %         (S)IR
a0000            0           2.6302e-050               0         -0.0026139
a0002            0.2         0.19739      -0.00261     -1.31     0.75034
a0004            0.4         0.39653      -0.00347     -0.867    1.5101
a0008            0.798       0.79812      0.000121     0.0152    3.0422
a0010            1           1.0071       0.00715      0.715     3.8396
a0001            0.0999      0.098711     -0.00119     -1.19     0.37387
   Hw 5-25-00
B         249.773   (135)
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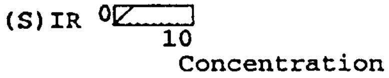

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El Name        Slope          Y-int          Correlation       Date Stdized
Ba4554         11.0534        0.0062         0.9999833         09/28/99 11:11:44

Standard             Concentration        Difference             Signal
 Name            Stated      Found        Conc         %         (S)IR
a0000            0           -9.9738e-060              0          0.0061162
a0002            0.201       0.20043      -0.000569    -0.283    2.2217
a0004            0.403       0.40734      0.00434      1.08      4.5087
a0008            0.804       0.79917      -0.00483     -0.6      8.8398
a0010            1.007       1.0073       0.000283     0.0281    11.14
a0001            0.1006      0.10137      0.000775     0.77      1.1268

Ba        455.403   (74)
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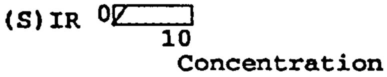

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El Name        Slope          Y-int          Correlation       Date Stdized
Ba4934         9.1168         0.1883         0.9999514         09/28/99 11:11:44

Standard             Concentration        Difference             Signal
 Name            Stated      Found        Conc         %         (S)IR
a0000            0           -3.5542e-050              0          0.18796
a0002            0.201       0.20426      0.00326      1.62      2.0505
a0004            0.403       0.40832      0.00532      1.32      3.9109
a0008            0.804       0.79609      -0.00791     -0.984    7.4461
a0010            1.007       1.0045       -0.00251     -0.249    9.346
a0001  Hw 5-25-00 0.1006     0.10243      0.00183      1.82      1.1222

Ba        493.409   (68)
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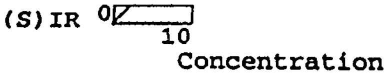

```
El Name       Slope         Y-int          Correlation       Date Stdized
Ca3179        0.3023        -0.0010        0.9996279         09/28/99 11:11:44

Standard AW       Concentration              Difference               Signal
  Name 6-25-00    Stated     Found           Conc        %            (S)IR
a0000             0          -0.00124870                 0            -0.0014106
a0002             1.996      2.0193          0.0233      1.17         0.60936
a0004             4.011      4.0741          0.0631      1.57         1.2305
a0008             7.996      7.8973          -0.0987     -1.23        2.3861
a0010             9.983      9.8747          -0.108      -1.09        2.9839
a0001             0.997      1.1177          0.121       12.1         0.33681
     AW 5-25-00
Ca    317.933   (106)
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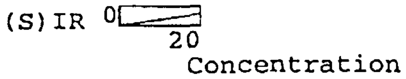
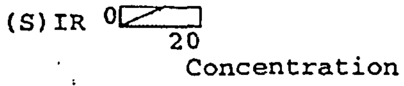
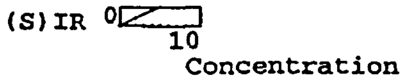


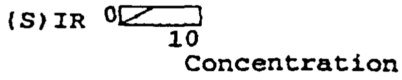
```
El Name       Slope         Y-int          Correlation       Date Stdized
Ca3968        18.8173       0.0646         0.9992657         09/28/99 11:11:44

Standard          Concentration              Difference               Signal
  Name            Stated     Found           Conc        %            (S)IR
a0000             0          -0.00181390                 0            0.030445
a0002             1.996      2.0759          0.0799      4.01         39.128
a0004             4.011      4.1265          0.115       2.88         77.714
a0008             7.996      7.8641          -0.132      -1.65        148.05
a0010             9.983      9.7689          -0.214      -2.14        183.89
a0001             0.997      1.1476          0.151       15.1         21.659

Ca    396.847   (85)
```



```
El Name       Slope         Y-int          Correlation       Date Stdized
Fe2382        1.9893        0.0055         0.9999418         09/28/99 11:11:30

Standard          Concentration              Difference               Signal
  Name            Stated     Found           Conc        %            (S)IR
a0000             0          8.1493e-050                 0            0.0056867
b0002             0.199      0.19507         -0.00393    -1.98        0.39357
b0004             0.394      0.38677         -0.00723    -1.83        0.77494
b0020             1.992      1.9694          -0.0226     -1.14        3.9233
b0040             3.963      3.9968          0.0338      0.853        7.9565
     AW 5-25-00
Fe    238.204   (142)
```



```
El Name       Slope         Y-int          Correlation       Date Stdized
Fe2395        2.2664        0.0037         0.9999684         09/28/99 11:11:30

Standard          Concentration              Difference               Signal
  Name            Stated     Found           Conc        %            (S)IR
a0000             0          6.0408e-050                 0            0.0038798
b0002             0.199      0.19571         -0.00329    -1.65        0.4473
b0004             0.394      0.38944         -0.00456    -1.16        0.88636
b0020             1.992      1.9749          -0.0171     -0.857       4.4797
b0040             3.963      3.9879          0.0249      0.628        9.0418
        5-25-00
Fe AW 239.562   (141)
```



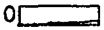
```
Method : ROGER        Standardzn Report     02/11/00 10:39:38           page 4

El Name      Slope        Y-int        Correlation     Date Stdized
Fe2599       4.8898       0.0065       0.9999862       09/28/99 11:11:30

Standard          Concentration           Difference             Signal
  Name         Stated        Found      Conc          %           (S)IR
a0000          0             6.147e-05  0             0           0.0067959
a0002          0.199         0.19534    -0.00366      -1.84       0.96169
a0004          0.394         0.38798    -0.00602      -1.53       1.9037
a0020          1.992         1.9933     0.00128       0.0643      9.7533
a0040          3.963         3.9714     0.00839       0.212       19.426

Fe     259.940   (130)
```

AM 5-25-00

AM 5-25-00

```
 (S)IR 0
```

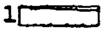
```
          10
       Concentration

El Name      Slope        Y-int        Correlation     Date Stdized
K_7664       0.1134       0.0349       0.9998304       09/28/99 11:11:44

Standard          Concentration           Difference             Signal
  Name         Stated        Found      Conc          %           (S)IR
a0000          0             -0.000792540             0            0.034819
a0002          1.99          2.0315     0.0415        2.09        0.26522
a0004          3.999         4.0864     0.0874        2.19        0.49819
a0008          7.971         7.8609     -0.11         -1.38       0.9261
a0010          9.953         9.876      -0.077        -0.774      1.1545
a0001          0.994         1.0522     0.0582        5.86        0.1542

K     766.490   (44)

 (S)IR 0
```



```
          20
       Concentration
```

AM 5-25-00

```
El Name      Slope        Y-int        Correlation     Date Stdized
Li6103       -0.0849      3.6790       -0.9999822      09/28/99 11:13:01

Standard          Concentration           Difference             Signal
  Name         Stated        Found      Conc          %           (S)IR
a0000          0             1.1234e-050              0           3.679
a0008          1.017         1.0224     0.00536       0.527       3.5922
a0010          0.811         0.80564    -0.00536      -0.661      3.6106

Li    610.362   (55)

 (S)IR 1
```

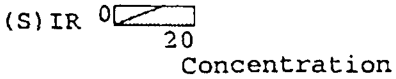


```
          5
       Concentration

El Name      Slope        Y-int        Correlation     Date Stdized
Mg2795       10.0837      0.0134       0.9995473       09/28/99 11:11:44

Standard          Concentration           Difference             Signal
  Name         Stated        Found      Conc          %           (S)IR
a0000          0             -0.00120860              0           0.0011791
a0002          1.995         2.0986     0.104         5.19        21.175
a0004          4.009         4.1672     0.158         3.95        42.034
a0008          7.992         7.8928     -0.0992       -1.24       79.602
a0010          9.979         9.7516     -0.227        -2.28       98.346
a0001          0.9966        1.0615     0.0649        6.51        10.717

Mg    279.553   (120)

 (S)IR 0
```

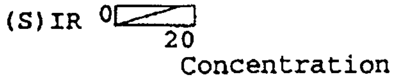
```
          20
       Concentration
```

AM 5-25-00

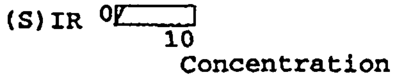
```
El Name     Slope       Y-int       Correlation     Date Stdized
Mg2802      5.5706      0.0020      0.9998183       09/28/99 11:11:44

Standard             Concentration            Difference           Signal
  Name  6-25-00   Stated      Found         Conc        %          (S)IR
a0000             0           -0.000709390               0          -0.0019498
a0002             1.995       2.0489        0.0539      2.7        11.416
a0004             4.009       4.1273        0.118       2.95       22.993
a0008             7.992       7.9261        -0.0659     -0.824     44.155
a0010             9.979       9.8355        -0.143      -1.44      54.791
a0001             0.9966      1.0337        0.0371      3.73       5.7605
       5-25-00
Mg     280.270    (120)
```



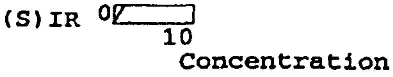
```
El Name     Slope       Y-int       Correlation     Date Stdized
Mg2852      0.5888      -0.0013     0.9999785       09/28/99 11:11:44

Standard          Concentration            Difference            Signal
  Name          Stated      Found         Conc        %          (S)IR
a0000           0           0.000138790               0          -0.0012565
a0002           1.995       1.9896        -0.00535    -0.268     1.1702
a0004           4.009       3.9534        -0.0556     -1.39      2.3265
a0008           7.992       8.0272        0.0352      0.441      4.7252
a0010           9.979       10.01         0.0306      0.306      5.8925
a0001           0.9966      0.99177       -0.00483    -0.484     0.58263
         5-25-00
Mg     285.213    (118)
```



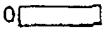
```
El Name     Slope       Y-int       Correlation     Date Stdized
Mn2576      26.0467     -0.0011     0.9999862       09/28/99 11:11:44

Standard          Concentration            Difference             Signal
  Name          Stated      Found         Conc         %          (S)IR
a0000           0           1.8859e-050                0          -0.00063882
a0002           0.203       0.19968       -0.00332     -1.64      5.1998
a0004           0.405       0.40552       0.000524     0.129      10.561
a0008           0.808       0.81011       0.00211      0.262      21.1
a0010           1.013       1.0145        0.00146      0.144      26.422
a0001           0.1012      0.10043       -0.00077     -0.761     2.6147
         5-25-00
Mn     257.610    (131)
```



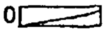
```
El Name     Slope       Y-int       Correlation     Date Stdized
Mn2605      7.1394      0.0041      0.9999714       09/28/99 11:11:44

Standard          Concentration            Difference             Signal
  Name          Stated      Found         Conc         %          (S)IR
a0000           0           7.8057e-060                0          0.0041492
a0002           0.203       0.20201       -0.000988    -0.487     1.4463
a0004           0.405       0.40127       -0.00373     -0.921     2.8689
a0008           0.808       0.80352       -0.00448     -0.554     5.7407
a0010           1.013       1.0219        0.00888      0.877      7.2997
a0001           0.1012      0.10152       0.000318     0.315      0.72887
         5-25-00
Mn     260.569    (130)
```



```
El Name      Slope       Y-int        Correlation     Date Stdized
Mn2933       0.1067      0.0010       0.9998805       09/28/99 11:11:44

Standard AM         Concentration              Difference             Signal
  Name  5-25-00    Stated       Found          Conc          %         (S)IR
a0000              0            -5.2648e-050                 0          0.00099993
a0002              0.203        0.19971        -0.00329      -1.62      0.022319
a0004              0.405        0.40768        0.00268       0.663      0.044515
a0008              0.808        0.80247        -0.00553      -0.685     0.086648
a0010              1.013        1.0121         -0.000876     -0.0865    0.10902
a0001              0.1012       0.10822        0.00702       6.93       0.012555
       AM 5-25-00
Mn        293.306    (115)
```

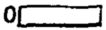


```
El Name      Slope       Y-int        Correlation     Date Stdized
Na5889       0.7552      -0.4908      0.9999757       09/28/99 11:11:44

Standard           Concentration              Difference             Signal
  Name             Stated       Found          Conc          %         (S)IR
a0000              0            -0.000112040                 0          -0.49089
a0002              3.275        3.3185         0.0435        1.33       2.0153
a0004              6.582        6.6499         0.0679        1.03       4.5311
a0008              13.121       13.037         -0.0837       -0.638     9.3547
a0010              16.383       16.371         -0.0119       -0.0727    11.872
a0001              1.636        1.6202         -0.0158       -0.964     0.73276

Na     588.995    (57)
```



```
El Name      Slope       Y-int        Correlation     Date Stdized
Na5895       0.4016      -0.0347      0.9999658       09/28/99 11:11:44

Standard           Concentration              Difference             Signal
  Name             Stated       Found          Conc          %         (S)IR
a0000              0            -0.00036470                  0          -0.03488
a0002              3.275        3.3008         0.0258        0.788      1.2907
a0004              6.582        6.682          0.1           1.52       2.6485
a0008              13.121       13.017         -0.104        -0.789     5.1926
a0010              16.383       16.345         -0.0376       -0.23      6.5289
a0001              1.636        1.6514         0.0154        0.942      0.62841

Na     589.592    (57)
```

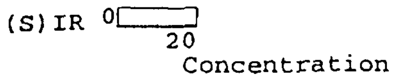
```
El Name      Slope       Y-int        Correlation     Date Stdized
S_1807       0.0416      0.0014       0.9998304       09/28/99 11:11:30

Standard           Concentration              Difference             Signal
  Name             Stated       Found          Conc          %         (S)IR
a0000              0            0.000924450                  0          0.0014469
b0002              1.995        1.9068         -0.0882       -4.42      0.08081
b0004              3.964        3.8736         -0.0904       -2.28      0.16271
b0020              7.963        8.0731         0.11          1.38       0.33759
b0040              9.975        10.044         0.0685        0.687      0.41964
          AM 5-25-00
S     :180.731    (186)
```



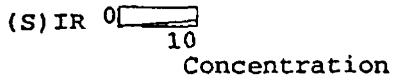
```
El Name      Slope        Y-int        Correlation     Date Stdized
S_1820       0.0130       0.0008       0.9996870       09/28/99 11:11:30

Standard          Concentration         Difference          Signal
  Name   6-25-00  Stated    Found       Conc      %         (S)IR
0000              0         0.0012923   0         0         0.0007984
0002              1.995     1.8757      -0.119    -5.98     0.025233
0004              3.964     3.8363      -0.128    -3.22     0.050793
0020              7.963     8.0616      0.0986    1.24      0.10588
0040              9.975     10.123      0.148     1.49      0.13275

     182.034   {185}

(S)IR 0[     ]
           20
          Concentration
   5-25-00
El Name      Slope        Y-int        Correlation     Date Stdized
S_1826       0.0150       -0.0010      0.9998521       09/28/99 11:11:30

Standard          Concentration         Difference          Signal
  Name            Stated    Found       Conc      %         (S)IR
a0000             0         0.000822310           0         -0.001015
b0002             1.995     1.9298      -0.0652   -3.27     0.027879
b0004             3.964     3.8537      -0.11     -2.78     0.056697
b0020             7.963     8.0302      0.0672    0.843     0.11926
b0040             9.975     10.083      0.108     1.09      0.15001
        5-25-00
S      182.624   {184}

(S)IR 0[     ]
           20
          Concentration
      5-25-00
El Name      Slope        Y-int        Correlation     Date Stdized
Si_2124      0.1291       0.0196       0.9999949       09/28/99 11:11:44

Standard          Concentration         Difference          Signal
  Name            Stated    Found       Conc      %         (S)IR
a0000             0         0.000135940           0         0.01964
a0002             2.001     1.9891      -0.0119   -0.594    0.27645
a0004             4.02      4.0081      -0.0119   -0.295    0.53714
a0008             8.015     8.0037      -0.0113   -0.141    1.053
a0010             10.008    10.043      0.035     0.35      1.3163
        5-25-00
Si     212.412   {159}

(S)IR 0[     ]
           20
          Concentration

El Name      Slope        Y-int        Correlation     Date Stdized
Si2516       1.2276       0.1855       0.9999245       09/28/99 11:11:44

Standard          Concentration         Difference          Signal
  Name            Stated    Found       Conc      %         (S)IR
a0000             0         0.000586360           0         0.1862
a0002             2.001     1.9548      -0.0462   -2.31     2.5853
a0004             4.02      3.9408      -0.0792   -1.97     5.0233
a0008             8.015     8.0533      0.0383    0.478     10.072
a0010             10.008    10.095      0.0871    0.87      12.579

Si     251.612   {134}

(S)IR 0[     ]
           20
          Concentration
   5-25-00
```

AM 5-25-00

```
El Name      Slope        Y-int        Correlation     Date Stdized
Si2881       0.0338       0.0051       0.9999926       09/28/99 11:11:44

Standard         Concentration          Difference               Signal
  Name          Stated      Found       Conc          %          (S)IR
a0000           0           0.000129520               0          0.0051245
a0002           2.001       1.9864      -0.0146       -0.731     0.072221
a0004           4.02        4.0201      7.05e-05      0.00175    0.14092
a0008           8.015       7.9895      -0.0255       -0.318     0.27501
a0010           10.008      10.048      0.0401        0.4        0.34455

Si    288.158   (117)
```

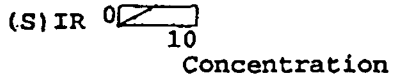


```
El Name      Slope        Y-int        Correlation     Date Stdized
Sr3464       0.3084       -0.0049      0.9999970       09/28/99 11:11:30

Standard         Concentration          Difference               Signal
  Name          Stated      Found       Conc          %          (S)IR
a0000           0           1.885e-05   0             0          -0.0049204
b0002           0.198       0.19681     -0.00119      -0.6       0.055766
b0004           0.394       0.39168     -0.00232      -0.588     0.11586
b0020           1.991       1.9969      0.00589       0.296      0.61086
b0040           3.961       3.9586      -0.00239      -0.0603    1.2158

Sr    346.446   (97)
```



AM 5-25-00

```
El Name      Slope        Y-int        Correlation     Date Stdized
Sr4215       12.5839      -0.5264      0.9999845       09/28/99 11:11:30

Standard         Concentration          Difference               Signal
  Name          Stated      Found       Conc          %          (S)IR
a0000           0           4.5888e-050               0          -0.52582
b0002           0.198       0.19468     -0.00332      -1.68      1.9234
b0004           0.394       0.38941     -0.00459      -1.16      4.3739
b0020           1.991       2.004       0.013         0.654      24.692
b0040           3.961       3.9559      -0.00511      -0.129     49.254

Sr    421.552   (80)
```



APPENDIX E: ION CHROMATOGRAPHY REPORT (LLNL/ASD); CASE# 609

ION CHROMATOGRAPHY

awrence Livermore National Laboratory
Analytical Sciences Division

To:	Roger Martinelli	Account #:	8781-80
From:	Nora Butler-Briant	Case#:	609
Analysis Date:	12/7/98		
Report Date:	12/8/98		

IC #	Requester	Fluoride		Chloride		Nitrite		Bromide		Nitrate		Phosphate		Sulfate	
	ID	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
980589	PERM BLANK	<0.007	0.00	0.07	0.00	<0.04	0.00	<0.03	0.00	0.0	0.00	<0.07	0.00	0.22	0.02
980590	PERM 1	0.09	0.03	30.70	0.03	<0.04	0.00	0.15	0.01	5.43	0.04	<0.07	0.00	31.10	0.01
980591	PERM 2	0.24	0.01	27.80	0.37	<0.04	0.00	0.19	0.02	0.63	0.01	<0.07	0.00	27.90	0.04
980592	PERM 3	0.19	0.01	30.8	0.76	<0.04	0.00	0.30	0.05	2.6	0.11	<0.07	0.00	30	0.01

1/10/00 I HAVE REVIEWED
AND ACCEPT THIS DATA
Roger A. Martinelli

Note: All anions were analyzed by ion chromatography using an AS4A column with an AG4A guard. The eluant was 1.7 mm $NaHCO_3$/1.8 Na_2CO_3 at a flow rate of 0.5 ml/min.

PERMS 1-3 WERE
1:4 DILUTIONS
12/10/98 RM

Nora Butler-Briant — Analyst

12-8-98 — Date

Alltech

Alltech Associates, Inc.
2051 Waukegan Road • Deerfield, IL 60015-1899
Phone: 847-948-8600 • Fax: 847-948-1078

EXPIRES
09 01 99

CERTIFICATE OF ANALYSIS

I-CAL ION CHROMATOGRAPHY SOLUTION 1000 µg/mL Bromide in H_2O
Catalog No: 37005

Starting Material:	Potassium Bromide
Starting Material Lot No:	09014BY

TRACEABILITY DOCUMENTATION FOR SOLUTION STANDARD - Lot No. M-BR01026

Certified Value: 1003 µg/mL

The certified value is the average of the classical wet assay and instrument analysis unless otherwise specified. All Standards are accurate to within ± 1.0% relative unless otherwise specified.

Method 1:
Actual Value: 998 µg/mL
Method: Ion Chromatography vs NIST SRM 3184

Method 2:
Actual Value: 1007 µg/mL
Method: Volhard Titration vs NIST SRM 999

We use purified acids, where required, 18 meg-ohm double deionized water, calibrated Class A glassware & meticulously cleaned bottles in the manufacturing of I-Cal standards. Balances are calibrated with registered NJ Weight Sets #NJ89074, NJ89034, NJ90292 and NJ91091. These weights are registered with the NJ Office of Weights and Measures and are traceable through the standards of the State of NJ to NIST (formerly NBS).

ANALYZED DENSITY OF SOLUTION (measured at 22°C): 0.998 g/mL

Signature:

Date: 12-04-97

Reviewed and accepted by
Nora L. Briant
10-2-98

for Calibration

CERTIFICATE OF ANALYSIS

SPEX CertiPrep

Catalog Number: ICMIX2-100
Description: IC Instrument Check Standard 2
Lot Number: 14-120AS

IC CHECK:

Component	Labeled[ug/ml]	Measured[ug/ml]
HPO_4^{-2}	600	616
Br^-	400	415
NO_3^-	400	390
SO_4^{-2}	400	398
Cl^-	200	200
F^-	100	98

Instrumental Analysis Conducted by Ion Chromatography:

The following SRM's were used in establishing the above results:

HPO_4^{-2} :	NIST 3186	Br^- :	NIST 3184	NO_3^- :	NIST 3185
SO_4^{-2} :	NIST 3181	Cl^- :	NIST 3182	F^- :	NIST 3183

Spex Reference Multi: Lot #4-6VY

Reviewed and accepted by Nora L Briant Date 11-11-98

Balances are calibrated regularly with weight sets traceable to NIST.

SPEX CertiPrep reference standards are guaranteed stable and accurate to ± 0.5% of certified concentration for one year from date of shipment. This value is the sum of cumulative errors associated with analytical determinations, pipetting and diluting to final volume. For these solutions we use high purity acids, 18 megohm double deionized water and triple rinsed bottles. All glassware used is class A.

Manufacturing Manager

SEP '98
Date

SPEX CertiPrep ISO 9001 CERTIFIED

SPEX CERTIPREP, INC. 203 NORCROSS AVENUE METUCHEN, NJ 08840 732-549-7144 1-800-LAB-SPEX FAX: 732-603-9647

Alltech
Alltech Associates, Inc.
2051 Waukegan Road • Deerfield, IL 60015-1899
Phone: 847-948-8600 • Fax: 847-948-1078

EXPIRES
06-01-99

Check Std

CERTIFICATE OF ANALYSIS

I-CAL Custom Multi-Anion Solution Mixture A (Catalog No: 26910200) containing:

30 µg/mL ea: PO_4^{-3}, SO_4^{-2}
20 µg/mL ea: Br^-, Cl^-, NO_3^-, NO_2^-,
10 µg/mL F^-

Matrix: ASTM Type I water filtered thru 0.2 micron filter
Lot No: N-ION04113

Certified Value:		Method and NIST Traceability:
F^-:	9.86 ± 0.17 µg/mL	Ion Chromatography vs NIST SRM 3183
Cl^-:	20.00 ± 0.12 µg/mL	Ion Chromatography vs NIST SRM 3182
NO_2^-:	20.26 ± 0.13 µg/mL	Ion Chromatography Checked vs Independent Standard
Br^-:	20.05 ± 0.12 µg/mL	Ion Chromatography vs NIST SRM 3184
NO_3^-:	19.95 ± 0.16 µg/mL	Ion Chromatography vs NIST SRM 3185
PO_4^{-3}:	30.08 ± 0.89 µg/mL	Ion Chromatography vs NIST SRM 3186
SO_4^{-2}:	30.05 ± 0.42 µg/mL	Ion Chromatography vs NIST SRM 3181

This certifies all the above concentrations to be accurate to an uncertainty expressed at the 95% confidence interval.

Concentrates for all the above elements were analyzed by IC against the following NIST SRM's:
Elemental Symbol (NIST SRM No.)
SO_4^{-2}(3181); Cl^-(3182); F^-(3183); Br^-(3184); NO_3^-(3185); PO_4^{-3}(3186); NO_2^-(N/A)

Concentrates for all the above anions were checked by one of the following classical wet chemical methods and are traceable as listed:

Concentrate	Method:	Checked Against:
Br^-	Volhard Titration	NIST SRM 999
Cl^-	Volhard Titration	NIST SRM 999
F^-	Ion Selective Electrode	NIST SRM 3183
NO_3^-	Acidimetric Titration	NIST KHP 84j
PO_4^{-3}	Acidimetric Titration	NIST KHP 84j
SO_4^{-2}	Acidimetric Titration	NIST KHP 84j
NO_2^-	Redox Titration	NIST SRM 40h

Signature:

Date: 03-11-98

reviewed and
accepted by
Nora L. Briant
11-11-98

EXPIRES
09 01 99

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Calibration

CERTIFICATE OF ANALYSIS

I-CAL ION CHROMATOGRAPHY SOLUTION 1000 μg/mL Nitrite in H_2O
Catalog No: 37021

Starting Material:	Sodium Nitrite
Starting Material Lot No:	02018PY

TRACEABILITY DOCUMENTATION FOR SOLUTION STANDARD - Lot No. N-NOX01086

Certified Value: 1002 μg/mL

The certified value is the average of the classical wet assay and instrument analysis unless otherwise specified. All Standards are accurate to within ± 1.0% relative unless otherwise specified.

Method 1:
Actual Value: 1001 μg/mL
Method: Calculated, based on starting material

Method 2:
Actual Value: 1003 μg/mL
Method: Ion Chromatography vs in-house standard

We use purified acids, where required, 18 meg-ohm double deionized water, calibrated Class A glassware & meticulously cleaned bottles in the manufacturing of I-Cal standards. Balances are calibrated with registered NJ Weight Sets #NJ89074, NJ89034, NJ90292 and NJ91091. These weights are registered with the NJ Office of Weights and Measures and are traceable through the standards of the State of NJ to NIST (formerly NBS).

ANALYZED DENSITY OF SOLUTION (measured at 22°C): 0.999 g/mL

Signature:

Date: 01-26-98

reviewed and accepted
by Nora L. Briant
10-2-98

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Alltech Associates, Inc.
2051 Waukegan Road • Deerfield, IL 60015-1899
Phone: 847-948-8600 • Fax: 847-948-1078

EXPIRES
09 01 99

CERTIFICATE OF ANALYSIS

I-CAL ION CHROMATOGRAPHY SOLUTION 1000 µg/mL Chloride in H_2O
Catalog No: 37009

Starting Material:	Potassium Chloride
Starting Material Lot No:	05606PW

TRACEABILITY DOCUMENTATION FOR SOLUTION STANDARD - Lot No. M-CL01040

Certified Value: 999 µg/mL

The certified value is the average of the classical wet assay and instrument analysis unless otherwise specified. All Standards are accurate to within ± 1.0% relative unless otherwise specified.

Method 1:
Actual Value: 1000 µg/mL
Method: Ion Chromatography vs NIST SRM 3182

Method 2:
Actual Value: 994 µg/mL
Method: Volhard Titration vs NIST SRM 999 Potassium Chloride

We use purified acids, where required, 18 meg-ohm double deionized water, calibrated Class A glassware & meticulously cleaned bottles in the manufacturing of I-Cal standards. Balances are calibrated with registered NJ Weight Sets #NJ89074, NJ89034, NJ90292 and NJ91091. These weights are registered with the NJ Office of Weights and Measures and are traceable through the standards of the State of NJ to NIST (formerly NBS).

ANALYZED DENSITY OF SOLUTION (measured at 22°C): 0.998 g/mL

Signature:

Date: 11-10-97

Reviewed and accepted
by Nora L. Briant
10-2-98

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Alltech Associates, Inc.
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Phone: 847-948-8600 • Fax: 847-948-1078

EXPIRES
09 01 99

CERTIFICATE OF ANALYSIS

I-CAL ION CHROMATOGRAPHY SOLUTION 1000 µg/mL Fluoride in H_2O
Catalog No: 37011

Starting Material:	Sodium Fluoride
Starting Material Lot No:	04408EZ

TRACEABILITY DOCUMENTATION FOR SOLUTION STANDARD - Lot No. N-F01028

Certified Value: 999 µg/mL

The certified value is the average of the classical wet assay and instrument analysis unless otherwise specified. All Standards are accurate to within ± 1.0% relative unless otherwise specified.

Method 1:
Actual Value: 998 µg/mL
Method: Ion Chromatography vs NIST SRM 3183

Method 2:
Actual Value: 999 µg/mL
Method: Calculated, based on starting material

We use purified acids, where required, 18 meg-ohm double deionized water, calibrated Class A glassware & meticulously cleaned bottles in the manufacturing of I-Cal standards. Balances are calibrated with registered NJ Weight Sets #NJ89074, NJ89034, NJ90292 and NJ91091. These weights are registered with the NJ Office of Weights and Measures and are traceable through the standards of the State of NJ to NIST (formerly NBS).

ANALYZED DENSITY OF SOLUTION (measured at 22°C): 0.999 g/mL

Signature: Date: 06-24-98

Reviewed and Accepted
by Nora L. Briant
10-2-98

Calibration Update Report

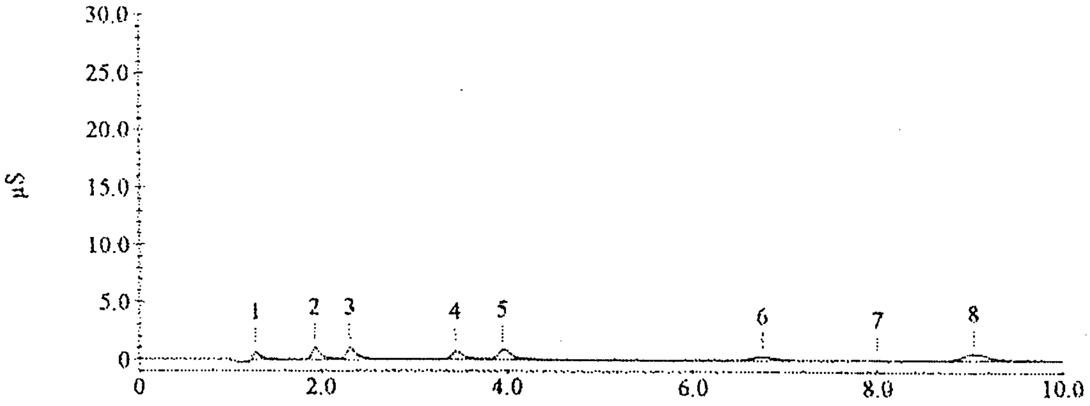
Sample Name : Std 1
Data File Name : C:\PEAKNET\DATA\rmarb_001.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 11:15:06 AM
Calibration Date : 12/7/98 11:26:14 AM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
1	F	1.28	41680	45452	45452	0.5000
2	Cl	1.93	75554	73204	73204	1.0000
3	NO2	2.32	104993	83644	83644	2.0000
4	Br	3.45	68945	58614	58614	2.0000
5	NO3	3.95	99448	77597	77597	2.0000
6	HPO4	6.75	52172	48010	48010	3.0000
8	SO4	9.03	115409	110873	110873	2.0000

Std 1



PeakNet 5.1 **Page 1 of 1** **Current Date : 12/7/98**
Current Time : 11:26:15

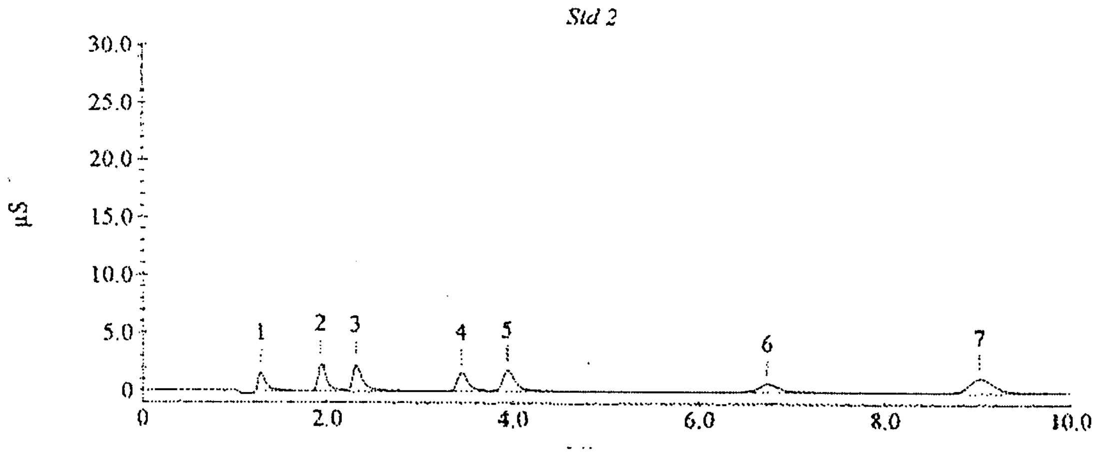
Calibration Update Report

Sample Name : Std 2
Data File Name : C:\PEAKNET\DATA\rmarb_002.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 11:27:24 AM
Calibration Date : 12/7/98 11:38:34 AM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
1	F	1.28	88269	100244	100244	1.0000
2	Cl	1.93	144741	154989	154989	2.0000
3	NO2	2.32	186821	196574	196574	4.0000
4	Br	3.45	132298	141480	141480	4.0000
5	NO3	3.93	194899	191433	191433	4.0000
6	HPO4	6.73	113816	123181	123181	6.0000
7	SO4	9.02	228095	235835	235835	4.0000



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 11:38:35

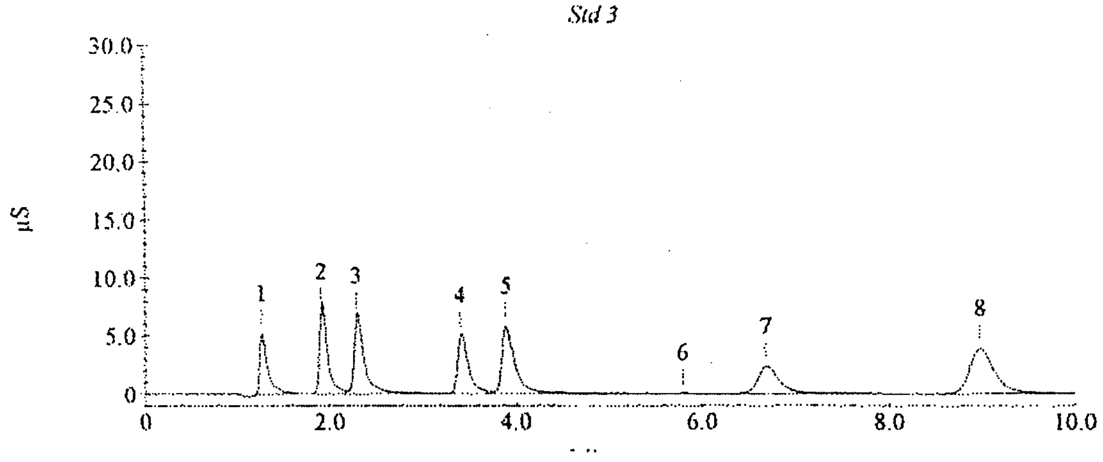
Calibration Update Report

Sample Name : Std 3
Data File Name : C:\PEAKNET\DATA\rmarb_003.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 11:39:46 AM
Calibration Date : 12/7/98 11:50:57 AM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
1	F	1.27	298421	318389	318389	3.0000
2	Cl	1.92	440519	463872	463872	6.0000
3	NO2	2.30	536374	546524	546524	12.0000
4	Br	3.42	393825	414164	414164	12.0000
5	NO3	3.90	565490	568432	568432	12.0000
7	HPO4	6.68	351539	371066	371066	18.0000
8	SO4	8.98	688271	716295	716295	12.0000



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 11:50:57

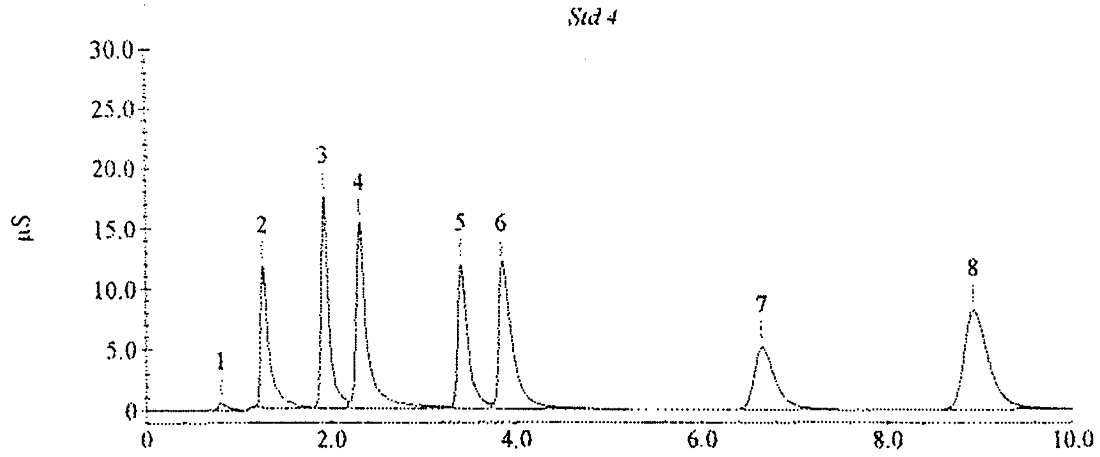
Calibration Update Report

Sample Name : Std 4
Data File Name : C:\PEAKNET\DATA\rmarb_004.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 11:52:06 AM
Calibration Date : 12/7/98 12:03:15 PM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
2	F	1.27	646113	773834	773834	6.0000
3	Cl	1.93	967897	1026248	1026248	12.0000
4	NO2	2.32	1114368	1244942	1244942	24.0000
5	Br	3.42	848544	908761	908761	24.0000
6	NO3	3.85	1196663	1227725	1227725	24.0000
7	HPO4	6.65	788507	807088	807088	36.0000
8	SO4	8.93	1455015	1496551	1496551	24.0000



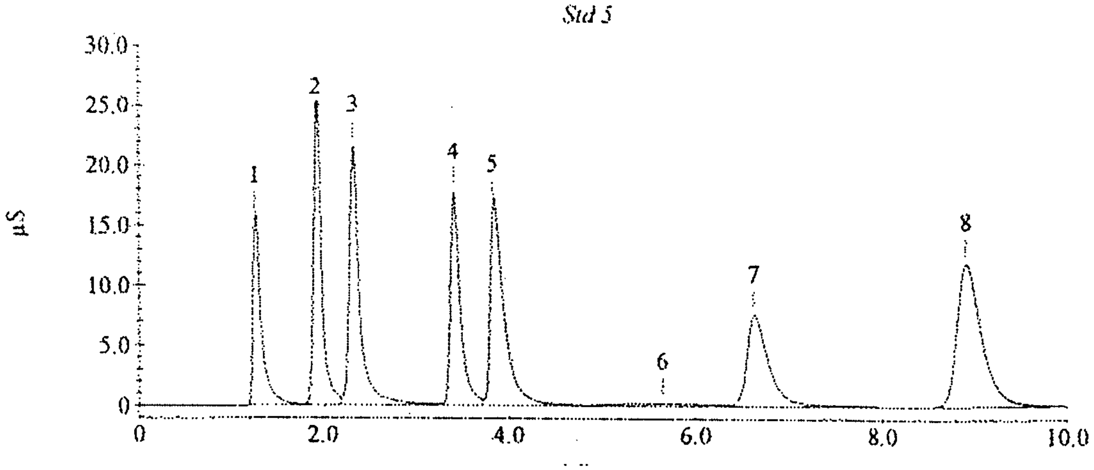
Calibration Update Report

Sample Name : Std 5
Data File Name : C:\PEAKNET\DATA\rmarb_005.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 12:04:26 PM
Calibration Date : 12/7/98 12:15:36 PM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
1	F	1.27	950405	1010366	1010366	8.0000
2	Cl	1.93	1421413	1504999	1504999	16.0000
3	NO2	2.33	1621127	1651345	1651345	32.0000
4	Br	3.42	1240702	1306209	1306209	32.0000
5	NO3	3.83	1754549	1764731	1764731	32.0000
7	HPO4	6.62	1153583	1240180	1240180	48.0000
8	SO4	8.92	2096245	2178756	2178756	32.0000



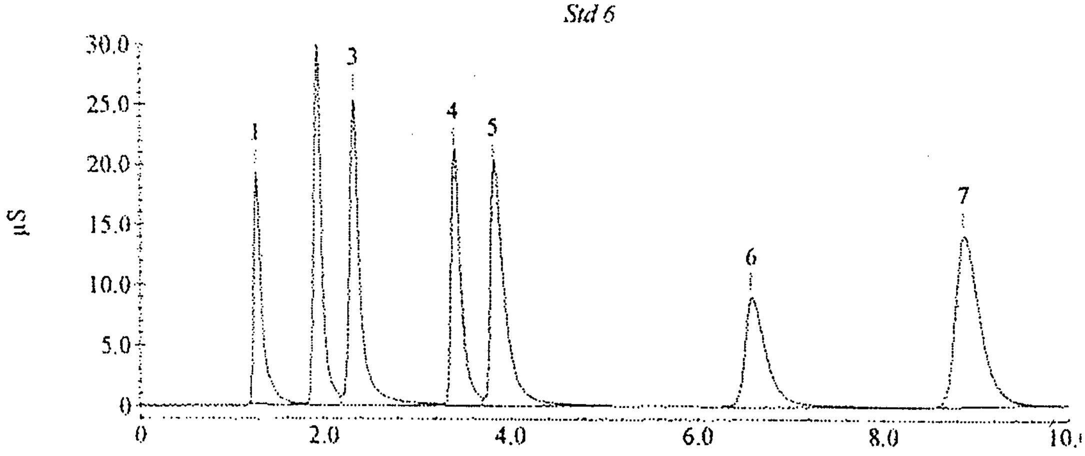
Calibration Update Report

Sample Name : Std 6
Data File Name : C:\PEAKNET\DATA\rmarb_006.DXD

Method File Name : c:\peaknet\method\anions.met
Schedule File Name : c:\peaknet\schedule\rmar.as3
Date Time Collected : 12/7/98 12:16:47 PM
Calibration Date : 12/7/98 12:27:57 PM
System Operator : NL Briant

Peak Information : All Components

Peak #	Component Name	Retention Time	Cal Response (Previous)	Cal Response (Measured)	Cal Response (New)	Component Amount (mg/L)
1	F	1.27	1113093	1225143	1225143	10.0000
2	Cl	1.93	1699857	1817552	1817552	20.0000
3	NO2	2.33	1906046	2001404	2001404	40.0000
4	Br	3.40	1484700	1585309	1585309	40.0000
5	NO3	3.82	2077117	2163096	2163096	40.0000
6	HPO4	6.58	1387747	1456615	1456615	60.0000
7	SO4	8.87	2512832	2588481	2588481	40.0000



PeakNet 5.1

Page 1 of 1

Current Date : 12/7/98
Current Time : 12:27:57

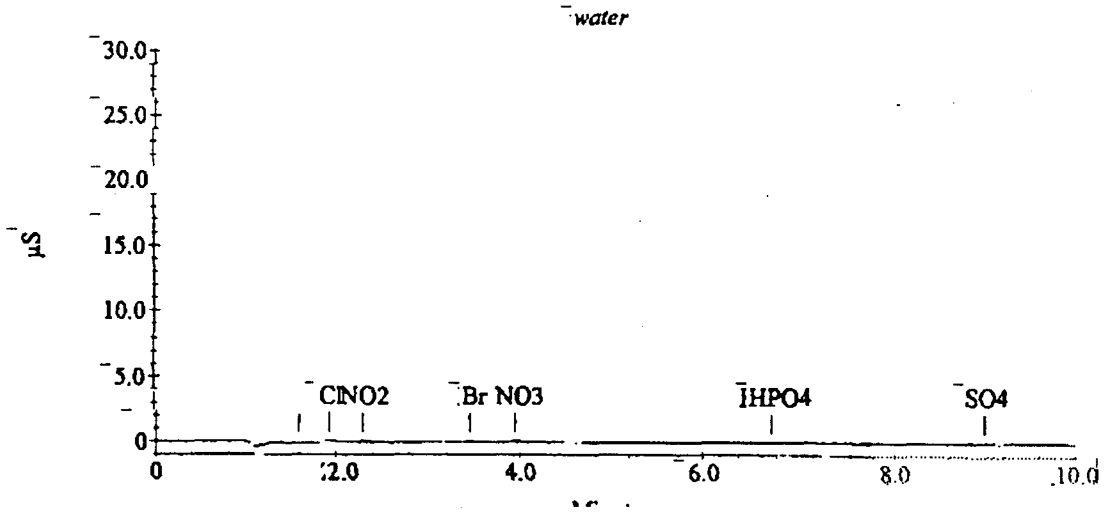
Sample Analysis Report

Sample Name : water
Data File Name : C:\PEAKNET\DATA\rmarb_007.DXD

Date Time Collected : 12/7/98 12:29:07 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1		1.60	129.3400	1293	177
2	Cl	1.93	0.1636	12936	1387
3	NO2	2.30	0.2481	12414	1112
4	Br	3.45	0.2043	7222	847
5	NO3	3.95	0.2131	10174	977
6	HPO4	6.75	0.2239	4633	294
7	SO4	9.07	0.3236	19465	1069



PeakNet 5.1

Page 1 of 1

Current Date: 12/7/98
Current Time: 12:40:18

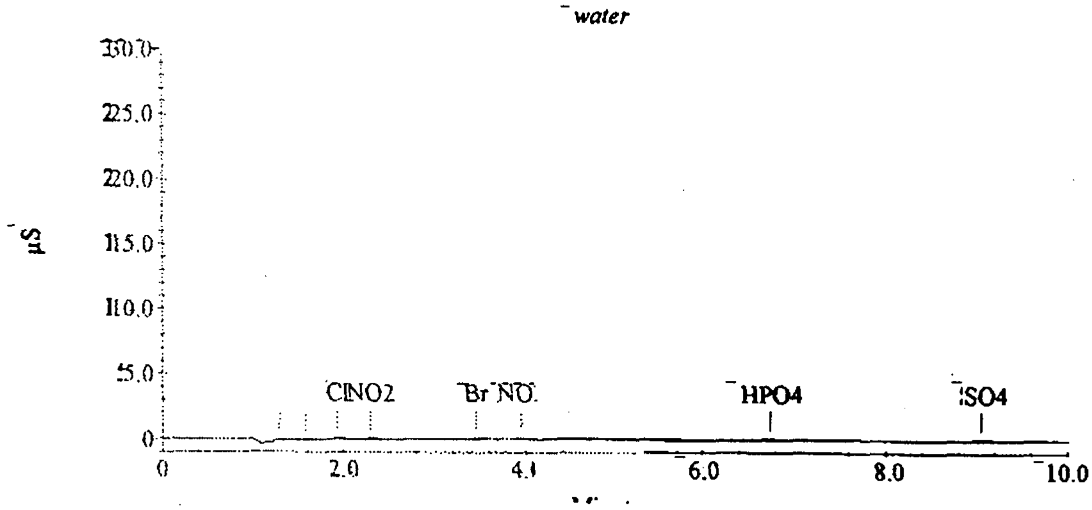
Sample Analysis Report

Sample Name : water
Data File Name : C:\PEAKNET\DATA\rmarb_008.DXD

Date Time Collected : 12/7/98 12:41:28 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1		1.28	0.0000	417	143
3	Cl	1.93	0.1675	13245	1387
4	NO2	2.30	0.2244	11227	1118
5	Br	3.45	0.2479	8766	871
6	NO3	3.95	0.1868	8917	945
7	HPO4	6.75	0.1777	3677	235
8	SO4	9.05	0.3675	22114	1070



PeakNet 5.1

Page 1 of 1

Current Date : 12/7/98
Current Time : 12:52:36

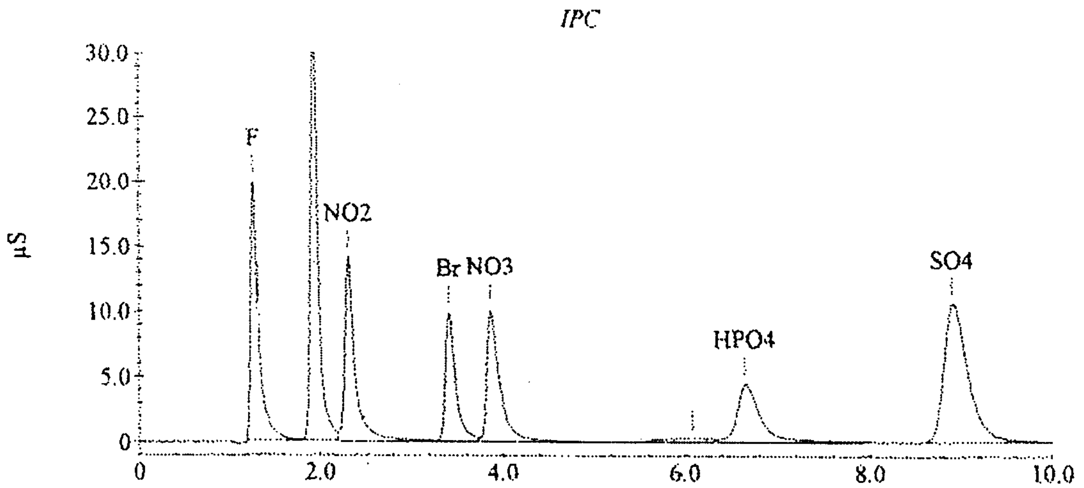
Sample Analysis Report

Sample Name : IPC
Data File Name : C:\PEAKNET\DATA\rmarb_009.DXD

Date Time Collected : 12/7/98 12:53:42 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.27	9.9249	1240086	197752
2	Cl	1.93	20.3583	1906534	306794
3	NO2	2.32	21.5566	1087121	140310
4	Br	3.42	20.0432	752638	98092
5	NO3	3.87	19.6645	998541	99672
7	HPO4	6.65	35.3561	810075	44498
8	SO4	8.90	30.2658	1953882	105433



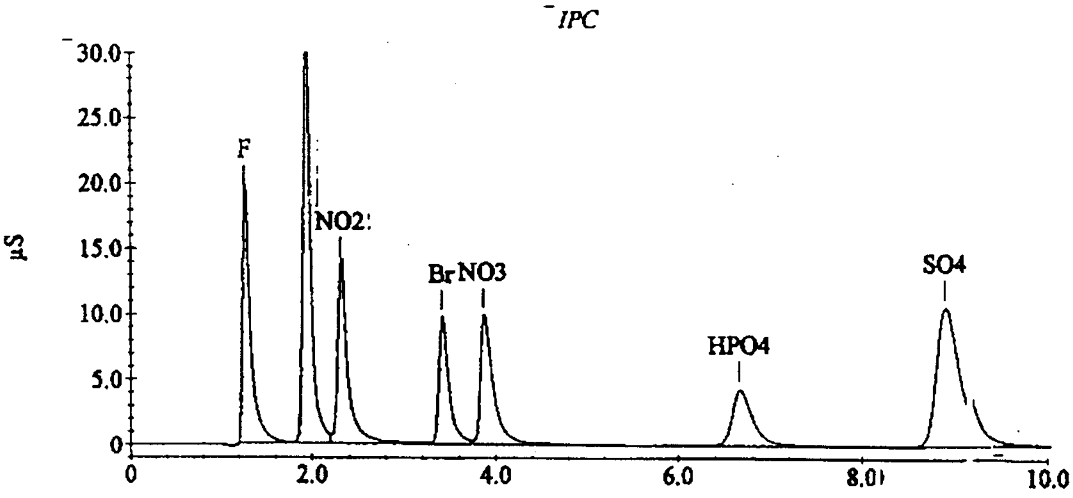
Sample Analysis Report

Sample Name : IPC
Data File Name : C:\PEAKNET\DATA\rmarb_010.DXD

Date Time Collected : 12/7/98 1:06:00 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
	F	1.27	9.8355	1228435	190057
2	Cl	1.95	20.2909	1898787	329680
3	NO2	2.32	21.5245	1085492	135512
4	Br	3.42	20.0000	750909	95787
5	NO3	3.87	19.7756	1004574	97456
6	HPO4	6.67	30.5612	689105	42624
7	SO4	8.92	30.2534	1953020	105474



Sample Analysis Report

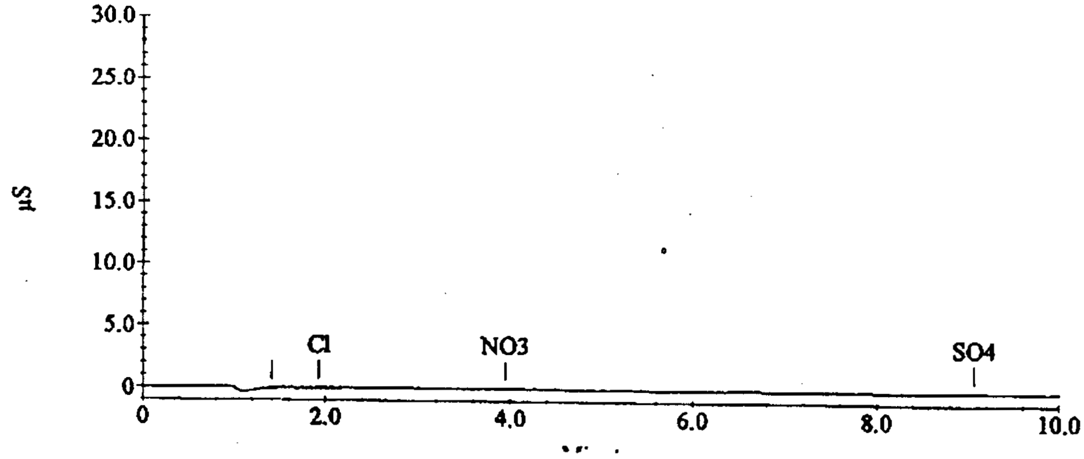
Sample Name : 980589
Data File Name : C:\PEAKNET\DATA\rmarb_011.DXD

Date Time Collected : 12/7/98 1:18:19 PM
Method File Name : c:\peaknet\method\anions.mct
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1		1.42	335.3700	3354	384
2	Cl	1.93	0.0702	5546	549
	NO2				
	Br				
3	NO3	3.95	0.0259	1235	147
	HPO4				
4	SO4	9.07	0.2286	13751	703

980589



PeakNet 5.1

Page 1 of 1

Current Date : 12/7/98
Current Time : 13:29:29

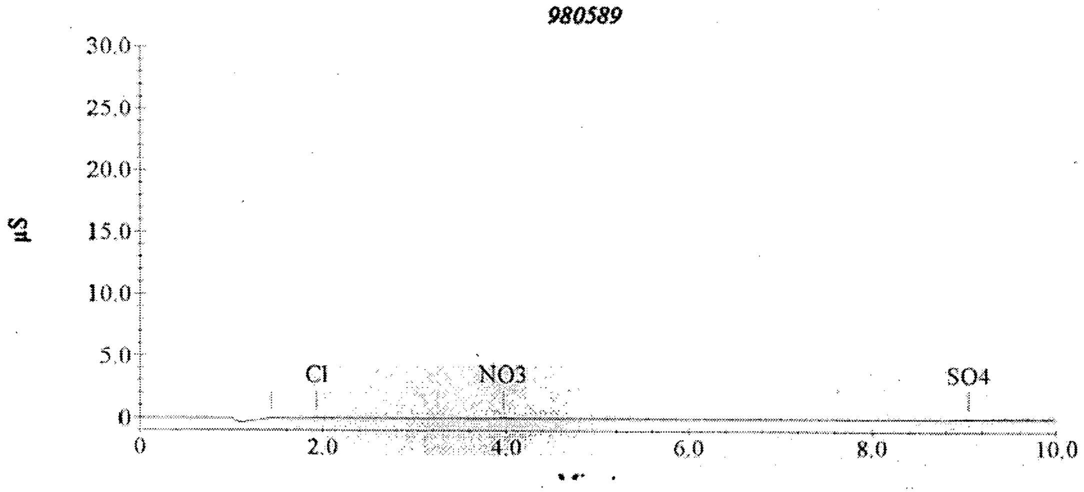
Sample Analysis Report

Sample Name : 980589
Data File Name : C:\PEAKNET\DATA\rmarb_012.DXD

Date Time Collected : 12/7/98 1:30:36 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1		1.43	307.2800	3073	363
2	Cl	1.93	0.0670	5296	578
	NO2				
	Br				
3	NO3	3.97	0.0269	1283	156
	HPO4				
4	SO4	9.05	0.1968	11837	635



: PeakNet 5.1

Page 1 of 1

Current Date : 12/7/98
Current Time : 13:41:45

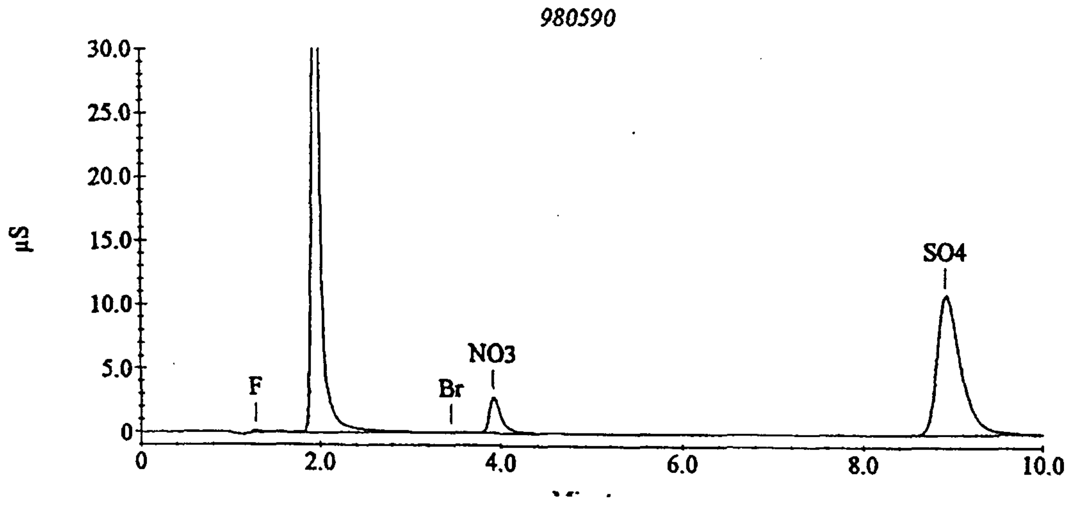
Sample Analysis Report

Sample Name : 980590
Data File Name : C:\PEAKNET\DATA\rmarb_013.DXD

Date Time Collected : 12/7/98 1:42:55 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0683	8196	1527
2	Cl	1.97	29.2443	3098484	522594
	NO2				
3	Br	3.45	0.1634	5775	482
4	NO3	3.92	5.3971	261639	27711
	HPO4				
5	SO4	8.92	31.1114	2012968	108808



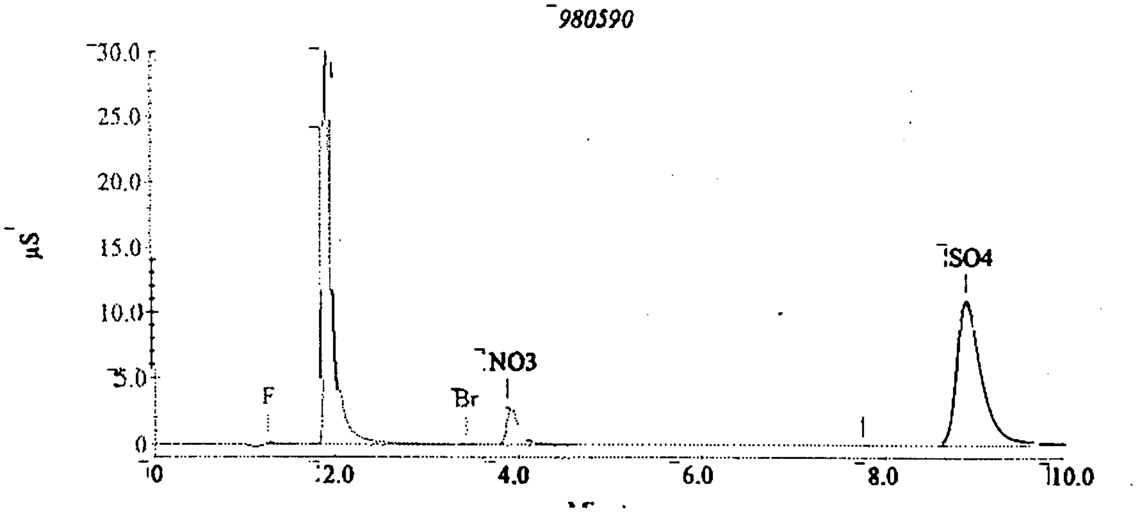
Sample Analysis Report

Sample Name : 980590
Data File Name : C:\PEAKNET\DATA\rmarb_014.DXD

Date Time Collected : 12/7/98 1:55:14 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.27	0.1066	12793	1557
2	Cl	1.97	29.2516	3099662	523166
	NO2				
3	Br	3.43	0.1420	5020	438
4	NO3	3.92	5.4457	264031	27696
	HPO4				
6	SO4	8.92	31.1032	2012395	108832



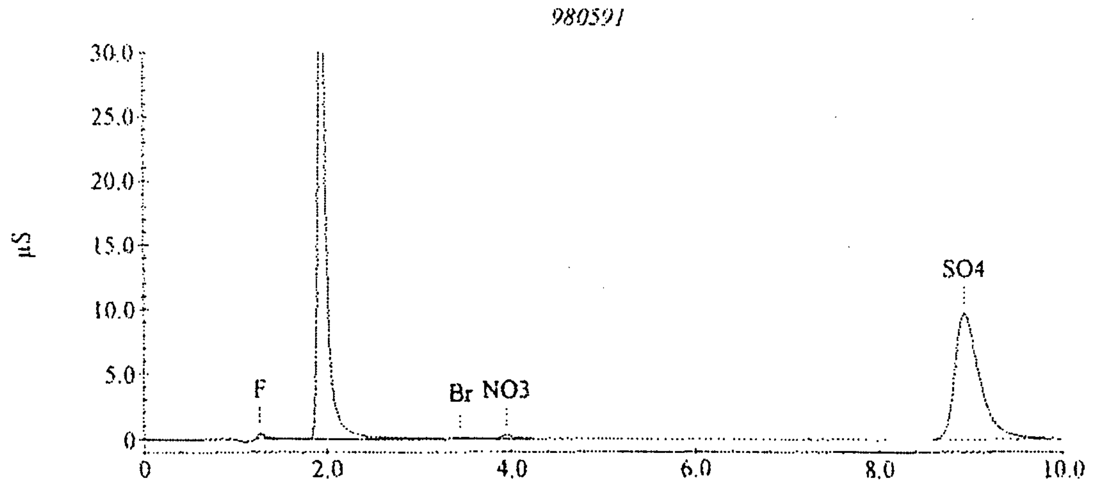
Sample Analysis Report

Sample Name : 980591
Data File Name : C:\PEAKNET\DATA\rmarb_015.DXD

Date Time Collected : 12/7/98 2:07:34 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.27	0.2266	27213	3790
2	Cl	1.95	26.2098	2644704	426570
	NO2				
3	Br	3.45	0.1651	5834	534
4	NO3	3.95	0.6443	30795	3055
	HPO4				
5	SO4	8.93	27.9161	1791177	96628



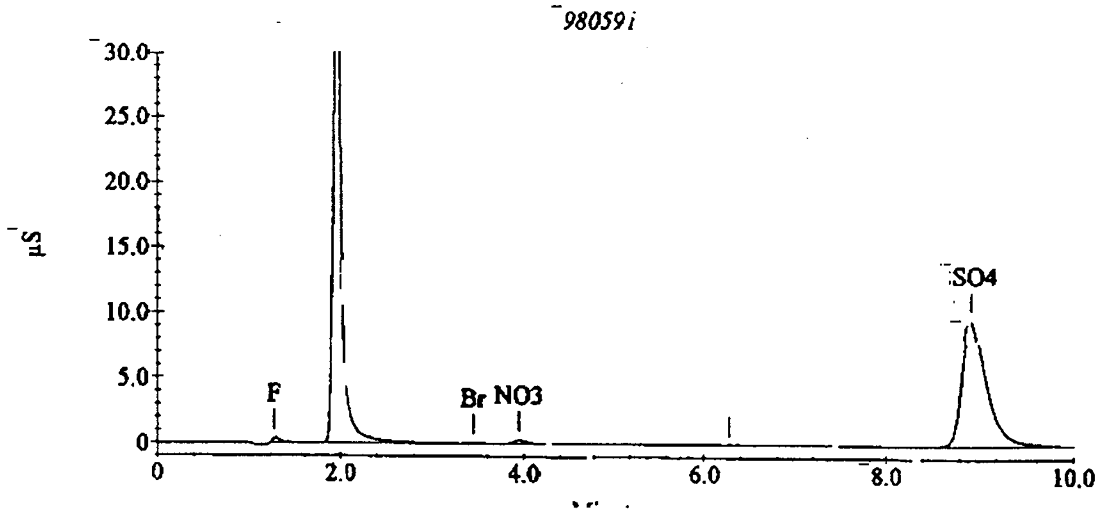
Sample Analysis Report

Sample Name : 980591
Data File Name : C:\PEAKNET\DATA\rmarb_016.DXD

Date Time Collected : 12/7/98 2:19:49 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.27	0.2407	28911	3718
2	Cl	1.97	26.2330	2647942	454883
	NO2				
3	Br	3.45	0.2042	7220	596
4	NO3	3.95	0.6157	29425	2958
	HPO4				
6	SO4	8.93	27.8644	1787626	96447



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 14:30:57

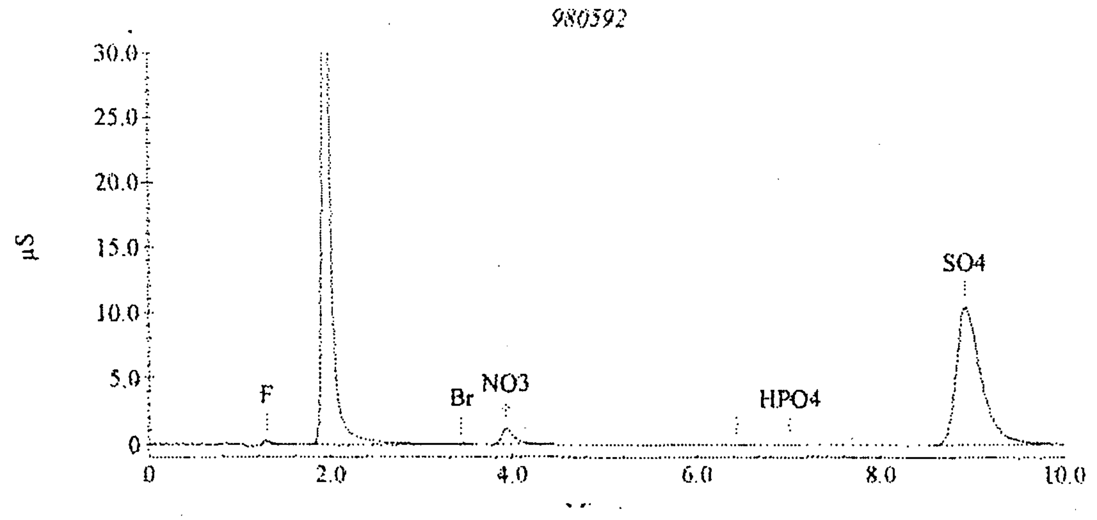
Sample Analysis Report

Sample Name : 980592
Data File Name : C:\PEAKNET\DATA\rmarb_017.DXD

Date Time Collected : 12/7/98 2:32:14 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.1808	21710	2892
2	Cl	1.97	28.9346	3049072	510126
	NO2				
3	Br	3.45	0.2586	9144	728
4	NO3	3.93	2.4759	118981	11857
6	HPO4	7.02	0.0527	1090	85
7	SO4	8.93	29.9166	1929563	104034



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 14:43:25

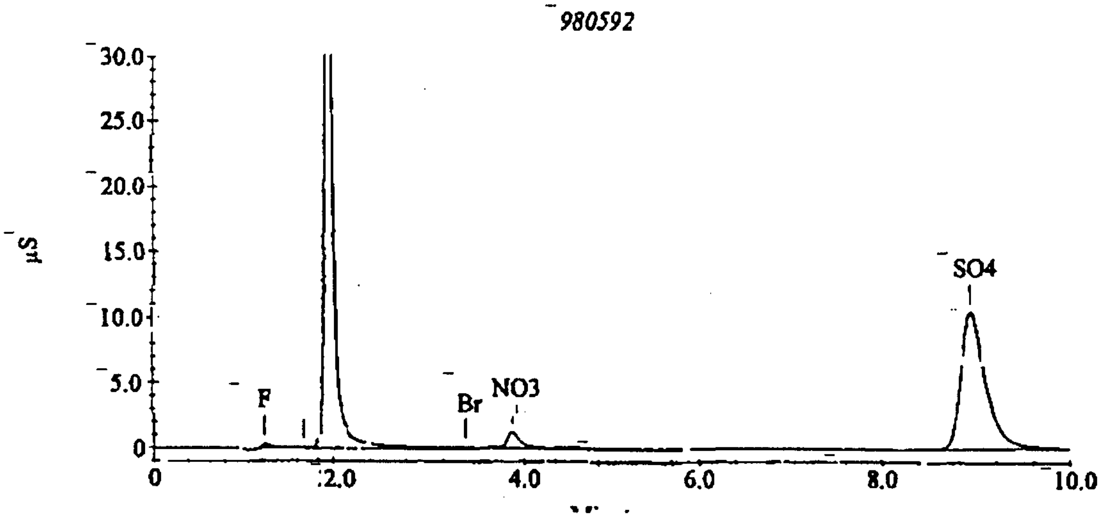
Sample Analysis Report

Sample Name : 980592
Data File Name : C:\PEAKNET\DATA\rmarb_018.DXD

Date Time Collected : 12/7/98 2:44:34 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	**Component Name**	**Retention Time:**	**Amount (mg/L)**	**Peak Area**	**Peak Height**
1	F	1.27	0.1909	22918	2713
3	Cl	1.97	28.9815	3056498	512646
	NO2				
4	Br	3.43	0.3265	11545	839
5	NO3	3.93	2.6387	126864	12116
	HPO4				
6	SO4	8.92	29.9073	1928922	103656



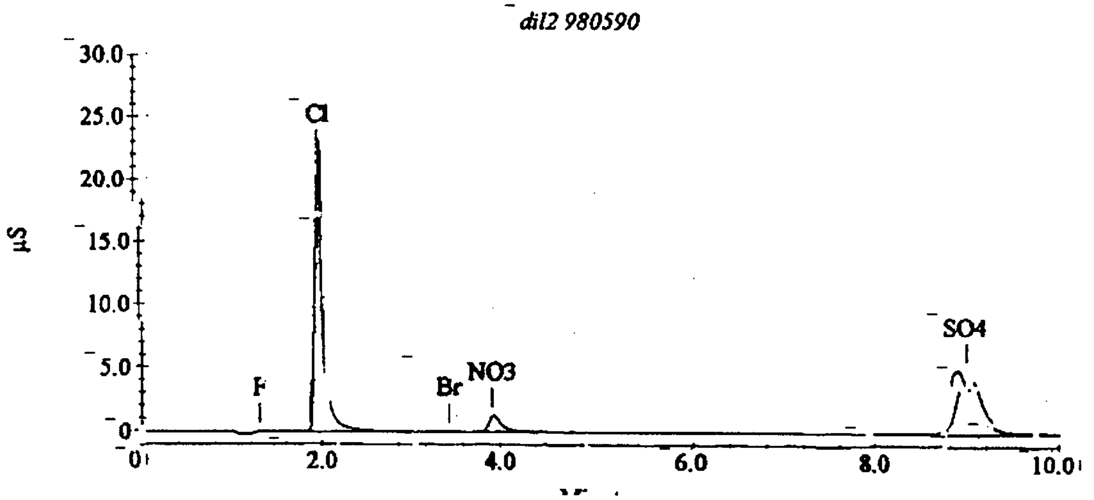
Sample Analysis Report

Sample Name : dil2 980590
Data File Name : C:\PEAKNET\DATA\rmarb_019.DXD

Date Time Collected : 12/7/98 2:56:52 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0101	1212	350
2	Cl	1.93	15.3332	1363829	217538
	NO2				
3	Br	3.45	0.1631	5764	454
4	NO3	3.92	2.7643	132953	12286
	HPO4				
5	SO4	8.98	14.9949	932044	49631



PeakNet 5.

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Current Date : 12/7/98
Current Time : 15:08:00

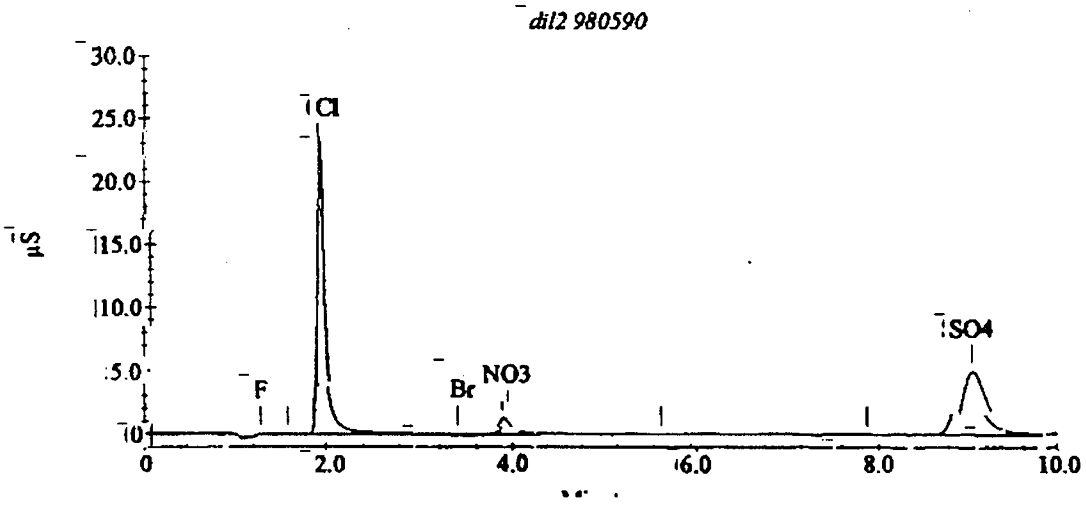
Sample Analysis Report

Sample Name : dil2 980590
Data File Name : C:\PEAKNET\DATA\rmarb_020.DXD

Date Time Collected : 12/7/98 3:09:09 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0095	1137	304
3	Cl	1.93	15.3560	1366154	223424
	NO2				
4	Br	3.43	0.1979	6997	421
5	NO3	3.92	2.7697	133215	12362
	HPO4				
8	SO4	8.98	15.0265	934079	49401



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 15:20:17

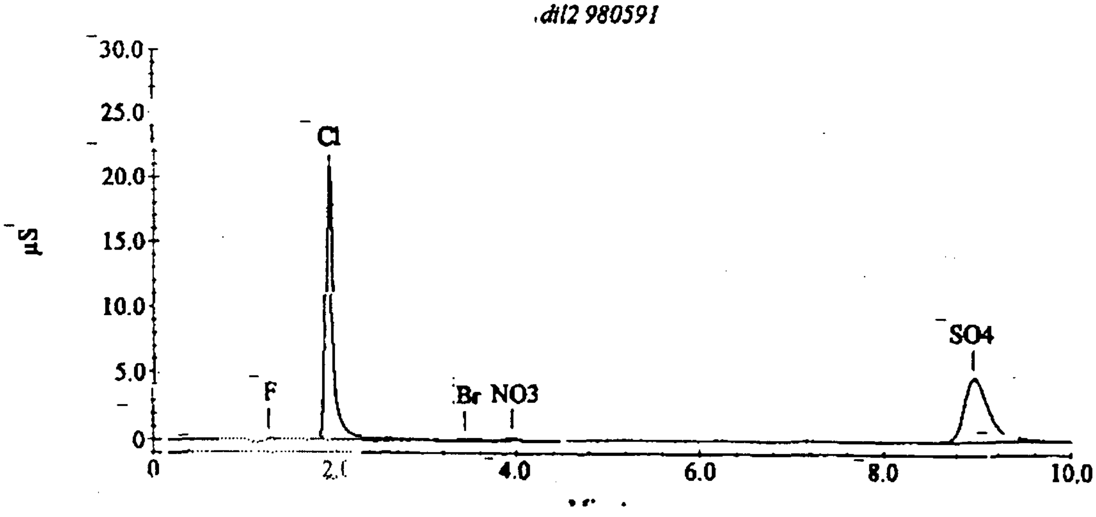
Sample Analysis Report

Sample Name : dil2 980591
Data File Name : C:\PEAKNET\DATA\rmarb_021.DXD

Date Time Collected : 12/7/98 3:21:27 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0572	6868	1384
2	Cl	1.93	13.8917	1219306	196841
	NO2				
3	Br	3.43	0.1481	5234	345
4	NO3	3.95	0.4015	19179	1874
	HPO4				
5	SO4	8.98	14.8444	922366	48508



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 15:32:39

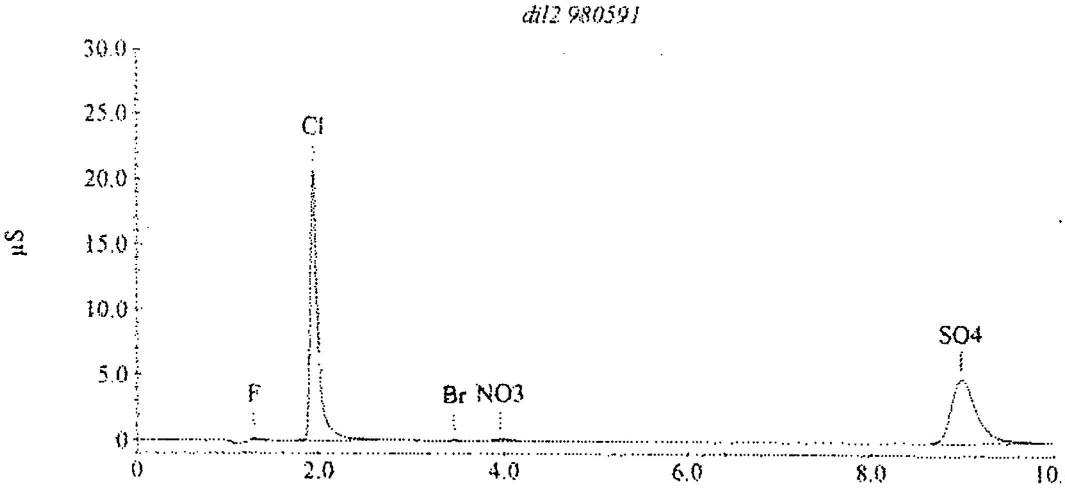
Sample Analysis Report

Sample Name : dil2 980591
Data File Name : C:\PEAKNET\DATA\rmarb_022.DXD

Date Time Collected : 12/7/98 3:33:45 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0850	10202	1364
2	Cl	1.95	13.6251	1193048	205731
	NO2				
3	Br	3.47	0.0620	2190	231
4	NO3	3.97	0.3596	17175	1848
	HPO4				
5	SO4	8.98	14.7906	918908	48602



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 15:44:56

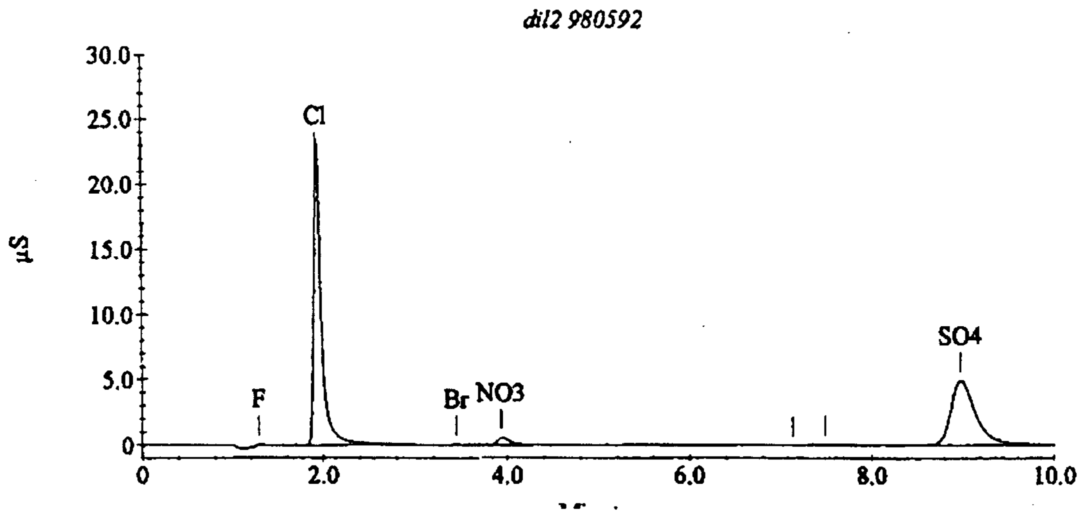
Sample Analysis Report

Sample Name : dil2 980592
Data File Name : C:\PEAKNET\DATA\rmarb_023.DXD

Date Time Collected : 12/7/98 3:46:06 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421,AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0267	3199	731
2	Cl	1.93	15.1118	1341351	218005
	NO2				
3	Br	3.45	0.0736	2600	300
4	NO3	3.93	1.2171	58275	5356
	HPO4				
7	SO4	8.98	14.8369	921881	48869



PeakNet 5.1

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Current Date: 12/7/98
Current Time: 15:57:15

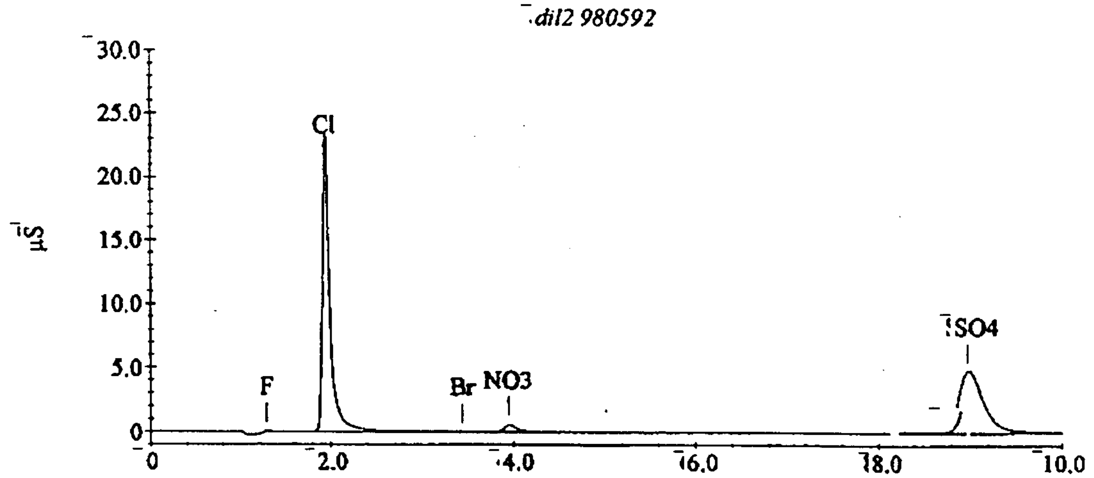
Sample Analysis Report

Sample Name : dil2 980592
Data File Name : C:\PEAKNET\DATA\rmarb_024.DXD

Date Time Collected : 12/7/98 3:58:24 PM
Method File Name : c:\peaknet\method\anions.met
Column ID : AG4A #2421.AS4A 2018 2mm
System Operator : NL Briant
Dilution Factor : 1.00

Peak Information : All Components

Peak #	Component Name	Retention Time	Amount (mg/L)	Peak Area	Peak Height
1	F	1.28	0.0341	4092	838
2	Cl	1.93	15.6453	1395712	206159
	NO2				
3	Br	3.45	0.2261	7994	484
4	NO3	3.95	1.3621	65241	5712
	HPO4				
5	SO4	8.98	14.8259	921176	48592



PeakNet 5.1

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Current Date : 12/7/98
Current Time : 16:09:32

APPENDIX F: CORRELATION OF AMR *DRIFT-SCALE COUPLED PROCESSES (DST AND THC SEEPAGE) MODELS* DATA (TABLE 3, MDL-NBS-HS-000001, REV00) WITH ASD SAMPLE DATA

Correlation of AMR Data (Table 3, MDL-NBS-HS-000001, Rev 00) with ASD Sample Data

Parameter/ Species	Concentration: Table 3/AMR (mg/l)	ASD Analytical Data [1,2,3]		Case No. [4,5]
		PERM-2 + PERM-3	PERM-1 + PERM-2	
F^-	0.86	0.86	0.66	609
Cl^-	117	116.6	116.4	609
SO_4^{2-}	116	115.6	117.2	609
K^+	8.0	8.0	6.5	579
Mg^{2+}	17	17.0	21.2	579
Ca^{2+}	101	101.8	102.5	579
SiO_2(aq)[6]	70.5	70.8	72.9	579
Na^+	61.3	61.3	60.8	579

[1] ASD Analytical Data PERM-2 + PERM-3 is the average of the concentration values reported by ASD for PERM-2 + PERM-3 samples multiplied by the dilution faction.

[2] ASD Analytical Data PERM-1 + PERM-2 is the average of the concentration values reported by ASD for PERM-1 + PERM-2 samples multiplied by dilution factor.

[3] Dilution factor for IC data is 4; dilution factor for ICP/AES is 5.

[4] Case 579 is ICP/AES data.

[5] Case 609 is IC data.

[6] SiO_2(mg/l) = Si(mg/l) × 2.145.

APPENDIX G: TABLE 15, “MAJOR ION CONCENTRATION REPORTED FOR TSW PORE WATER AT AMBIENT TEMPERATURE,” FROM AMR: *ENVIRONMENT ON THE SURFACES OF THE DRIP SHIELD AND WASTE PACKAGE OUTER BARRIER,*” ANL-EBS-MD-000001 REV00

Table 15. Major ion concentrations reported for TSw pore water at ambient temperature.

Ions	ESF-HD PERM-2	ESF-HD PERM-1
	Concentration (mg/L)	Concentration (mg/L)
Na^+	81	62
K^+	7	9
Mg^{++}	16.8	17.4
Ca^{++}	106	97
$SiO_2(aq)$	66	75
HCO_3^-		
SO_4^{--}	111	120
Cl^-	110	123
NO_3^-	3	10
pH	8.32	8.31

DTN: LL990702804244.100

4.1.17 Henry's Law Constants for the Solubility of Oxygen in Several Aqueous Solutions

Table 16 lists parameters for calculating the Henry's Law Constant for oxygen solubility in pure water and three aqueous NaCl solutions. The Henry's Law constant, k, in MPa, was determined experimentally, and the variation with temperature fit to the following equation:

$$\ln k = a_0 + a_1/T + a_2/T^2 + a_3/T^3 + a_4/T^4 \qquad \text{(Eq. 6)}$$

where a_0, a_1, a_3, and a_4 are experimentally determined constants, and T is temperature in Kelvin.

Also included in Table 16 are the characteristics of the fluids for which the k values were determined.

Table 16. Coefficients for Henry's Law Constants for the Oxygen Solubility in the NaCl Solutions and Demineralized Water (Cramer 1980, Tables I & V)

Solution	Molality	Molarity	Coefficients					
	(moles/ 1,000 g)	(moles/ L)	a_0	$a_1(10^4)$	$a_2(10^7)$	$a_3(10^9)$	$a_4(10^{11})$	Std dev (%)
Demineralized water	0	0	-35.4406	5.58970	-2.67211	5.60947	-4.91667	5.6
NaCl-1	0.87	0.85	-23.8312	4.05434	-1.89168	4.02544	-3.35511	4.6
NaCl-2	2.97	2.78	-14.7706	2.95905	-1.38197	2.97589	-2.51663	5.3
NaCl-3	5.69	5.09	18.7594	-2.02638	1.38823	-3.75034	3.62602	4.9

DTN: LL000202705924.115

APPENDIX H: CORRELATION OF AMR DATA (TABLE 15, ANL-EBS-MD-000001, REV00) WITH ASD SAMPLE DATA

Correlation of AMR Data (Table 15, ANL-EBS-MD-000001, Rev 00) with ASD Sample Data

Parameter/ Species	Case No. [2,3]	Reported Conc. (mg/l) Table 15 of AMR ESF-HD-PERM-2	Reported Conc. (mg/l) Table 15 of AMR ESF-HD-PERM-1	ASD Analytical Data [1,4]		
				ESF-HD-PERM-1	ESF-HD-PERM-2	ESF-HD-PERM-3
NO_3^-	609	3.0	10	21.0	3.0	10.0
Cl^-	609	110	123	122.8	110.0	123.0
SO_4^{2}-	609	111	120	124.4	111.6	120.0
K^+	579	7	9	6.0	7.0	9.0
Mg^{2+}	579	16.6	17.4	25.7	16.6	17.4
Ca^{2+}	579	106	97	98.5	106.5	97.0
$SiO_2(aq)$[5]	579	66	75	79.2	66.3	74.9
Na^+	579	61	62	60.5	61.0	61.5

[1] Values shown are the ASD Analytical values from ICP/AES and IC Analyses multiplied by the dilution factor.

[2] Case 579 is ICP/AES Data.

[3] Case 609 is IC Data.

[4] Dilution factor for IC data is 4; dilution factor for ICP/AES data is 5.

[5] SiO_2(mg/l) = Si(mg/l) × 2.145.

APPENDIX I: CAR-006 REVALIDATION EFFORT APPROVALS CONTINUED

CAR-006 re-validation effort approvals continued:

Nomenclature	CSCI / STN Number	Responsible Organization	Responsible Manager
SOLVEQ/CHILLER V1.0	10057-1.0-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
SUPCRT92 V1.0	10058-1.0-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
T2R3D V1.4	10006-1.4-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
THEMM V1.0	10049-1.0-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGH2 V1.11MEOS1.2.3.4.5	10059-1.11MEOS1.2.3.4.5-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGH2 V1.11MEOS7RV0.3R	10064-1.11MEOS7RV0.3R-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGH2 V1.11MEOS7V0.12	10063-1.11MEOS7V0.12-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGH2 V1.3	10061-1.3-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo), C. Ho (Cliff)
TOUGH2 V1.3MEOS4V1.0	10062-1.3MEOS4V1.0-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGH2 V3.1.1	10149-3.1.1-00	Sandia National Laboratories	C. Ho (Cliff)
TOUGH2 V3.1.2	10151-3.1.2-00	Sandia National Laboratories	C. Ho (Cliff)
TOUGH2 V3.3	10152-3.3-00	Sandia National Laboratories	C. Ho (Cliff)
TOUGH2 V3.4.1	10147-3.4.1-00	Sandia National Laboratories	C. Ho (Cliff)
TOUGH2 V3.4.2	10146-3.4.2-00	Sandia National Laboratories	C. Ho (Cliff)
TOUGHREACT V1.0	10067-1.0-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TOUGHREACT V2.1	10042-2.1-00	Lawrence Berkeley National Laboratories, Earth Sciences Division, Nuclear Waste	G. Bodvarsson (Bo)
TRACRN V1.0	10106-1.0-00	Los Alamos National Laboratories, CST	B. Travis (Bryan)

APPENDIX J: RE: DISTRIBUTION OF PORE WATER SAMPLES AND RESULTS/PH OF PORE WATER SAMPLES

X-Sender: e212074@popgun.llnl.gov
X-Mailer: QUALCOMM Windows Eudora Pro Version 3.0.5 (32)
Date: Mon, 01 May 2000 10:48:51 -0700
To: "Holly H. Miller" <miller23@llnl.gov>
From: Laura Deloach <deloach2@llnl.gov>
Subject: Re: Distribution of Pore Water Samples

>X-Sender: ufa_james@ufaventures.com
>Date: Thu, 1 Oct 1998 15:14:25 -0700
>To: deloach2@llnl.gov
>From: "James L. Conca" <james@ufaventures.com>
>Subject: Re: Distribution of Pore Water Samples

>Hi Laura

>The cores are on their way.
>
>Here's what we did.
>
>Porewater was extracted from Yucca Mountain rock cores using a whole body
>acceleration as it should not alter the porewater chemistry during
>extraction. Handling of the core, loading into the UFA sample holders and
>buckets, and handling of the porewater were done in a glove box under an
>argon atmosphere in the absence of oxygen and air. The pH of the extracted
>porewater was measured immediately upon extraction in the glove box using a
>needle pH electrode with a battery-operated Beckman pH meter. The
>porewater was then sealed in vials under the argon atmosphere, and the
>vials were then vacuum-sealed in plastic to be sent to the appropriate
>analytical laboratory selected by TRW for further chemical analysis. Vials
>were kept under refrigeration until shipping. The rock cores will be
>returned to TRW after the project is completed.
>
>Jim
>
>**
>UFA Ventures/NESTT http://www.ufaventures.com
>   Come to us with all your
>   fluid flow questions.
>   We have the answers.
>   Email: james@ufaventures.com
>   (509) 375-3268 phone
>**

C:\Results\pH-Watb.XLS

	A	B	C	D	E	F	G
1	Core Sample	BH ID	Depth~(ft)	Vol. Water~ (ml)	PH	Ini.Water Content~(Wt %)	
2	1002581	ESF-HD-PERM-2	22.7-23	0.09	7.77	2.72	
3	1002595	ESF-HD-PERM-2	41.5-41.8	0.11	7.96	3.4	
4	1002486	ESF-HD-PERM-1	19.9-20.1	0.22	8.32	3.09	
5	1002522	ESF-HD-PERM-3	30.7-31	0.25	7.98	3.82	
6	1002585	ESF-HD-PERM-2	26.2-26.4	0.3	7.89	2.94	
7	1002584	ESF-HD-PERM-2	25.9-26.2	0.32	8.13	3.24	
8	1002489	ESF-HD-PERM-1	25.9-26.1	0.41	7.76	2.88	
9	1002598	ESF-HD-PERM-2	46.5-46.8	0.41	7.8	3.69	
10	1002587	ESF-HD-PERM-2	30.5-30.9	0.5	7.51	2.88	
11	1002599	ESF-HD-PERM-2	46.8-47.1	0.6	7.7	3.59	
12	1002594	ESF-HD-PERM-2	41.1-41.5	0.6	7.7	3.26	
13	1002590	ESF-HD-PERM-1	26.1-26.4	0.61	8.02	2.92	
14	1002539	ESF-HD-PERM-3	56.3-56.7	0.66	7.6	3.02	
15	1002537	ESF-HD-PERM-3	52.7-53	0.68	7.6	2.93	
16	1002519	ESF-HD-PERM-3	26.1-26.4	0.86	7.99	4.14	
17	1002582	ESF-HD-PERM-2	23-23.3	0.9	8.39	3.59	
18	1002521	ESF-HD-PERM-3	30.3-30.7	1.85	8.23	4.1	
19	1002509	ESF-HD-PERM-1	56.6-57	2.04	8.21	5.25	
20	1002488	ESF-HD-PERM-1	23.1-23.3	2.49	7.79	2.51	
21	1002586	ESF-HD-PERM-2	30.1-30.5	2.84	8.32	6.25	
22	1002508	ESF-HD-PERM-1	54.4-54.8	0.01	NR	2.8	
23	1002510	ESF-HD-PERM-1	57-57.5	0.05	NR	3.4	
24	1002597	ESF-HD-PERM-2	44.3-44.6	0	NR	1.9	
25	1002534	ESF-HD-PERM-3	46.4-46.6	0	NR	2.24	
26	1002531	ESF-HD-PERM-3	44.3-44.6	0.05	NR	1.55	
27	1002533	ESF-HD-PERM-3	46.1-46.4	0	NR	2.85	
28							
29	Core Sample	BH ID	Depth~(ft)	Vol. Water~ (ml)	PH	Ini.Water Content~(Wt %)	
30	1002581	ESF-HD-PERM-2	22.7-23	0.09	7.77	2.72	
31	1002595	ESF-HD-PERM-2	41.5-41.8	0.11	7.96	3.4	
32	1002486	ESF-HD-PERM-1	19.9-20.1	0.22	8.32	3.09	
33	1002522	ESF-HD-PERM-3	30.7-31	0.25	7.98	3.82	
34	1002585	ESF-HD-PERM-2	26.2-26.4	0.3	7.89	2.94	
35	1002584	ESF-HD-PERM-2	25.9-26.2	0.32	8.13	3.24	
36	1002489	ESF-HD-PERM-1	25.9-26.1	0.41	7.76	2.88	
37	1002598	ESF-HD-PERM-2	46.5-46.8	0.41	7.8	3.69	
38	1002587	ESF-HD-PERM-2	30.5-30.9	0.5	7.51	2.88	
39	1002599	ESF-HD-PERM-2	46.8-47.1	0.6	7.7	3.59	
40	1002594	ESF-HD-PERM-2	41.1-41.5	0.6	7.7	3.26	
41	1002590	ESF-HD-PERM-1	26.1-26.4	0.61	8.02	2.92	
42	1002539	ESF-HD-PERM-3	56.3-56.7	0.66	7.6	3.02	
43	1002537	ESF-HD-PERM-3	52.7-53	0.68	7.6	2.93	
44	1002519	ESF-HD-PERM-3	26.1-26.4	0.86	7.99	4.14	
45	1002582	ESF-HD-PERM-2	23-23.3	0.9	8.39	3.59	
46	1002521	ESF-HD-PERM-3	30.3-30.7	1.85	8.23	4.1	
47	1002509	ESF-HD-PERM-1	56.6-57	2.04	8.21	5.25	
48	1002488	ESF-HD-PERM-1	23.1-23.3	2.49	7.79	2.51	
49	1002586	ESF-HD-PERM-2	30.1-30.5	2.84	8.32	6.25	
50	1002508	ESF-HD-PERM-1	54.4-54.8	0.01	NR	2.8	
51	1002510	ESF-HD-PERM-1	57-57.5	0.05	NR	3.4	
52	1002597	ESF-HD-PERM-2	44.3-44.6	0	NR	1.9	
53	1002534	ESF-HD-PERM-3	46.4-46.6	0	NR	2.24	
54	1002531	ESF-HD-PERM-3	44.3-44.6	0.05	NR	1.55	
55	1002533	ESF-HD-PERM-3	46.1-46.4	0	NR	2.85	

APPENDIX K: RECOMMENDATION OF UFA VENTURES, INC. AS A QUALIFIED SUPPLIER AND SAMPLE TRACEABILITY DOCUMENTATION

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SUPPLIER EVALUATION REPORT

QA:L

Page 1 of 2

1 PURPOSE:
☐ INITIAL EVALUATION
☑ INITIAL AUDIT
☐ ANNUAL EVALUATION
☐ TRIENNIAL AUDIT
☐ SCOPE CHANGE
☑ PROGRAM CHANGE
☐ REMOVE SUPPLIER

2 SUPPLIER INFORMATION

SUPPLIER NAME/ADDRESS
UFA Ventures, Inc.
2000 Logston Blvd.
Richland, WA 99352

CONTACT NAME/TITLE: Dr. James Conca, President

TELEPHONE: 509 - 375 - 3268

ITEM(S): N/A

SERVICE(S): Analytical testing of Rock Samples

PROCUREMENT DOCUMENT NUMBER(S): N/A

QA MANUAL: QA Manual

REVISION LEVEL OR DATE: rev. 2 dated 12/18/97

CODES/STD COMMITTED TO IN QA MANUAL
☐ 10 CFR 50B
☐ ANSI N 45.2
☐ NQA-1
☐ ISO 9000
☑ QARD
☐

3 TYPE
☑ QUALITY RECORDS REVIEW
☐ SUPPLIER HISTORY
☐ SURVEY
☑ AUDIT

4 RESTRICTIONS & COMMITMENTS
NONE

Continued ☐

5 REMARKS
SER issued to document results of OQA Supplier Audit OQA-SA-97-028 and to document evaluation of Revision 2 of UFA's QA manual.

Continued ☐

6 APPROVAL
REEVALUATION DUE DATE 7/11/98 AUDIT DUE DATE 7/11/2000

DIRECTOR, OQA: Signature 1/9/98 Date

☑ QUALIFIED ☐ QUALIFIED WITH RESTRICTION(S) ☐ NOT QUALIFIED

REQUESTOR: Robert W. Craig Signature 3/27/98 Date

7 VERIFICATION
VERIFIED CORRECT INPUT OF DATA TO OSL [illegible] 4/1/98

VERIFIER: Signature 4/1/98 Date

Exhibit QAP-7.2.1

Rev. 06/02/97

ENCLOSURE

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SUPPLIER EVALUATION REPORT

Page 2 of 2

1 PURPOSE: ☑ AUDIT ☐ SURVEY ☑ QUALITY RECORDS EVALUATION

2
SUPPLIER NAME: UFA Ventures, Inc.

3 RECORDS / AUDIT / SURVEY

	QA PROGRAM ELEMENT	SAT	UNSAT	N/A
1	ORGANIZATION	✓		
2	QUALITY ASSURANCE PROGRAM	✓		
3	DESIGN CONTROL			✓
4	PROCUREMENT DOCUMENT CONTROL	✓		
5	IMPLEMENTING DOCUMENTS	✓		
6	DOCUMENT CONTROL	✓		
7	CONTROL OF PURCHASED ITEMS AND SERVICES	✓		
8	IDENTIFICATION AND CONTROL OF ITEMS			✓
9	CONTROL OF SPECIAL PROCESSES			✓
10	INSPECTION			✓
11	TEST CONTROL			✓
12	CONTROL OF MEASURING AND TEST EQUIPMENT	✓		
13	HANDLING, STORAGE AND SHIPPING			✓
14	INSPECTION, TEST AND OPERATING STATUS			✓
15	NONCONFORMANCES			✓
16	CORRECTIVE ACTION	✓		
17	QUALITY ASSURANCE RECORDS	✓		
18	AUDITS	✓		
SUPPLEMENT I	SOFTWARE	✓		
SUPPLEMENT II	SAMPLE CONTROL	✓		
SUPPLEMENT III	SCIENTIFIC INVESTIGATION	✓		
SUPPLEMENT IV	FIELD SURVEYING			✓
SUPPLEMENT V	CONTROL OF THE ELECTRONIC MANAGEMENT OF DATA			✓

DESCRIPTION OF QUALITY ASSURANCE PROGRAM PROCEDURES OR OTHER SIMILAR DOCUMENT(S) REVIEWED/EVALUATED

TITLE/REVISION: UFA's Manual 001, Revision 2 was used during the supplier audit. After the audit, UFA revised their manual completely and issued a new Quality Assurance Manual as Revision 1 dated 7/21/97.. On 12/18/97, UFA issued Revision 2 of their QA Manual and the OQA QA records evaluation was performed on this revision of the manual..

Continued ☐

4 EVALUATION RESULTS

AUDIT/SURVEY: OQA-SA-97-028 DATE: 07/11/97 PERFORMED BY: Hasson/Maudlin

The QA records evaluation review of the UFA QA Manual, Revision 2 was found to comply with the QA requirements for Suppliers of Analytical Services(Rev 0). The results of the supplier audit OQA-SA-97-028 indicated effective implementation of the UFA QA program. Deficiency Report (DR) YM-97-D-070 was issued to document specific conditions that did not result in unsatisfactory implementation of the QA program elements. Corrective Actions of the Deficiency Report (DR) YM-97-D-070 have been completed and a recommendation for closure was submitted on 12/19/97.

Continued ☐

IF RESTRICTIONS OR DOCUMENTED COMMITMENTS ARE APPLICABLE, IDENTIFY ON SUPPLIER EVALUATION SHEET, PAGE 1.

EVALUATOR Robert D. Habbe 01/06/98
SIGNATURE DATE

Exhibit QAP-7.2.1 Rev. 08/02/97

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SUPPLIER EVALUATION REPORT

Page 1 of 2

1 PURPOSE: ☐ INITIAL EVALUATION ☑ INITIAL AUDIT ☐ ANNUAL EVALUATION ☐ TRIENNIAL AUDIT ☐ SCOPE CHANGE ☑ PROGRAM CHANGE ☐ REMOVE SUPPLIER

2 SUPPLIER INFORMATION

SUPPLIER NAME/ADDRESS UFA Ventures, Inc. 2000 Logston Blvd. Richland, WA 99352	CONTACT NAME/TITLE Dr. James Conca, President TELEPHONE 509 - 375 - 3268
ITEM(S) N/A	SERVICE(S) Analytical testing of Rock Samples
PROCUREMENT DOCUMENT NUMBER(S) N/A	QA MANUAL QA Manual REVISION LEVEL OR DATE rev. 2 dated 12/18/97
	CODES/STD COMMITTED TO IN QA MANUAL ☐ 10 CFR 50B ☐ ISO 9000 ☐ ANSI N 45.2 ☑ QARD ☐ NQA-1 ☐

3 TYPE: ☑ QUALITY RECORDS REVIEW ☐ SUPPLIER HISTORY ☐ SURVEY ☑ AUDIT

4 RESTRICTIONS & COMMITMENTS

NONE

Continued ☐

5 REMARKS

SER issued to document results of OQA Supplier Audit OQA-SA-97-028 and to document evaluation of Revision 2 of UFA's QA manual.

Continued ☐

6 APPROVAL

REEVALUATION DUE DATE 7/11/98 AUDIT DUE DATE 7/11/2000

DIRECTOR, OQA: Signature 1/9/98 Date

☑ QUALIFIED ☐ QUALIFIED WITH RESTRICTION(S) ☐ NOT QUALIFIED

REQUESTOR: ______ Signature ______ Date

7 VERIFICATION

VERIFIED CORRECT INPUT OF DATA TO QSL

VERIFIER: ______ Signature ______ Date

Exhibit QAP-7.2.1

Rev. 06/02/97

ENCLOSURE

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
SUPPLIER EVALUATION REPORT

Page 2 of 2

1 PURPOSE: ☑ AUDIT ☐ SURVEY ☑ QUALITY RECORDS EVALUATION

2 SUPPLIER NAME: UFA Ventures, Inc.

3 RECORDS / AUDIT / SURVEY

	QA PROGRAM ELEMENT	SAT	UNSAT	N/A
1	ORGANIZATION	✓		
2	QUALITY ASSURANCE PROGRAM	✓		
3	DESIGN CONTROL			✓
4	PROCUREMENT DOCUMENT CONTROL	✓		
5	IMPLEMENTING DOCUMENTS	✓		
6	DOCUMENT CONTROL	✓		
7	CONTROL OF PURCHASED ITEMS AND SERVICES	✓		
8	IDENTIFICATION AND CONTROL OF ITEMS			✓
9	CONTROL OF SPECIAL PROCESSES			✓
10	INSPECTION			✓
11	TEST CONTROL			✓
12	CONTROL OF MEASURING AND TEST EQUIPMENT	✓		
13	HANDLING, STORAGE AND SHIPPING			✓
14	INSPECTION, TEST AND OPERATING STATUS			✓
15	NONCONFORMANCES			✓
16	CORRECTIVE ACTION	✓		
17	QUALITY ASSURANCE RECORDS	✓		
18	AUDITS	✓		
SUPPLEMENT I	SOFTWARE	✓		
SUPPLEMENT II	SAMPLE CONTROL	✓		
SUPPLEMENT III	SCIENTIFIC INVESTIGATION	✓		
SUPPLEMENT IV	FIELD SURVEYING			✓
SUPPLEMENT V	CONTROL OF THE ELECTRONIC MANAGEMENT OF DATA			✓

DESCRIPTION OF QUALITY ASSURANCE PROGRAM PROCEDURES OR OTHER SIMILAR DOCUMENT(S) REVIEWED/EVALUATED

TITLE/REVISION: UFA's Manual 001, Revision 2 was used during the supplier audit. After the audit, UFA revised their manual completely and issued a new Quality Assurance Manual as Revision 1 dated 7/21/97. On 12/18/97, UFA issued Revision 2 of their QA Manual and the OQA QA records evaluation was performed on this revision of the manual.

Continued ☐

4 EVALUATION RESULTS

AUDIT/SURVEY: OQA-SA-97-028 DATE: 07/11/97 PERFORMED BY: Hasson/Maudlin

The QA records evaluation review of the UFA QA Manual, Revision 2 was found to comply with the QA requirements for Suppliers of Analytical Services(Rev 0). The results of the supplier audit OQA-SA-97-028 indicated effective implementation of the UFA QA program. Deficiency Report (DR) YM-97-D-070 was issued to document specific conditions that did not result in unsatisfactory implementation of the QA program elements. Corrective Actions of the Deficiency Report (DR) YM-97-D-070 have been completed and a recommendation for closure was submitted on 12/19/97.

Continued ☐

IF RESTRICTIONS OR DOCUMENTED COMMITMENTS ARE APPLICABLE, IDENTIFY ON SUPPLIER EVALUATION SHEET, PAGE 1.

EVALUATOR RD Habbe Robert D. Habbe 01/06/98

SIGNATURE DATE

Exhibit QAP-7.2.1 Rev. 06/02/97

```
>Date: 23 Mar 1998 10:17:52 -0800
>From: "Wunan Lin" <lin1@llnl.gov>
>Subject: FWD>Alcove 5 samples to USGS
>To: "l deloach" <deloach2@llnl.gov>, "Nina D. Rosenberg"
<rosenberg4@llnl.gov>,
>	"Steve Blair" <Steve.Blair@quickmail.llnl.gov>,
>	"Tom Buscheck" <Tom.Buscheck@quickmail.llnl.gov>,
>	"Greg Gdowski" <Greg.Gdowski@quickmail.llnl.gov>,
>	"Bill Glassley" <Bill.Glassley@quickmail.llnl.gov>,
>	"Kenrick 'Ken' Lee" <Kenrick.'Ken'.Lee@quickmail.llnl.gov>,
>	"Annmarie Meike" <Annmarie.Meike@quickmail.llnl.gov>,
>	"Abe Ramirez" <Abe.Ramirez@quickmail.llnl.gov>,
>	"Jeff Roberts" <Jeff.Roberts@quickmail.llnl.gov>
>Cc: "Joseph C. Farmer" <farmer4@llnl.gov>,
>	"mike fernandez" <fernandez4@llnl.gov>,
>	"ernie hardin" <ernest_hardin@notes.ymp.gov>,
>	"Cynthia E. Palmer" <palmer2@llnl.gov>,
>	"dale wilder" <wilder1@llnl.gov>,
>	"Jim Blink" <Jim.Blink@quickmail.llnl.gov>
>X-Mailer: Mail*Link SMTP-QM 4.1.0
>
>Mail*Link. SMTP             FWD>Alcove 5 samples to USGS
>
>For your information.
>
>WL
>
>--------------------------------------
>Date: 3/20/98 3:53 PM
>From: Mark_Peters@notes.ymp.gov
>
>Chris,
>
>Please ship the following samples from the Thermal Testing Facility to Jim
>Conca at the following address:
>
>James Conca
>UFA Ventures, Inc.
>2000 Logston Blvd.
>Richland, WA 99352
>
>The samples are as follows:
>
>ESF-HD-PERM-1 - Sample ID 1001122 - Specimen ID 1002485
>ESF-HD-PERM-1 - Sample ID 1001123 - Specimen ID 1002486
>ESF-HD-PERM-1 - Sample ID 1001126 - Specimen ID 1002488
>ESF-HD-PERM-1 - Sample ID 1001129 - Specimen ID 1002489
>ESF-HD-PERM-1 - Sample ID 1001130 - Specimen ID 1002490
>ESF-HD-PERM-1 - Sample ID 1001176 - Specimen ID 1002508
>ESF-HD-PERM-1 - Sample ID 1001181 - Specimen ID 1002509
>ESF-HD-PERM-1 - Sample ID 1001182 - Specimen ID 1002510
>ESF-HD-PERM-2 - Sample ID 1001434 - Specimen ID 1002581
>ESF-HD-PERM-2 - Sample ID 1001435 - Specimen ID 1002582
>ESF-HD-PERM-2 - Sample ID 1001441 - Specimen ID 1002584
>ESF-HD-PERM-2 - Sample ID 1001442 - Specimen ID 1002585
>ESF-HD-PERM-2 - Sample ID 1001448 - Specimen ID 1002586
>ESF-HD-PERM-2 - Sample ID 1001449 - Specimen ID 1002587
```

```
>ESF-HD-PERM-2 - Sample ID 1001466 - Specimen ID 1002594
>ESF-HD-PERM-2 - Sample ID 1001467 - Specimen ID 1002595
>ESF-HD-PERM-2 - Sample ID 1001473 - Specimen ID 1002596
>ESF-HD-PERM-2 - Sample ID 1001474 - Specimen ID 1002597
>ESF-HD-PERM-2 - Sample ID 1001480 - Specimen ID 1002598
>ESF-HD-PERM-2 - Sample ID 1001481 - Specimen ID 1002599
>ESF-HD-PERM-3 - Sample ID 1001235 - Specimen ID 1002519
>ESF-HD-PERM-3 - Sample ID 1001236 - Specimen ID 1002520
>ESF-HD-PERM-3 - Sample ID 1001240 - Specimen ID 1002521
>ESF-HD-PERM-3 - Sample ID 1001241 - Specimen ID 1002522
>ESF-HD-PERM-3 - Sample ID 1001249 - Specimen ID 1002525
>ESF-HD-PERM-3 - Sample ID 1001255 - Specimen ID 1002527
>ESF-HD-PERM-3 - Sample ID 1001270 - Specimen ID 1002531
>ESF-HD-PERM-3 - Sample ID 1001271 - Specimen ID 1002532
>ESF-HD-PERM-3 - Sample ID 1001275 - Specimen ID 1002533
>ESF-HD-PERM-3 - Sample ID 1001276 - Specimen ID 1002534
>ESF-HD-PERM-3 - Sample ID 1001284 - Specimen ID 1002537
>ESF-HD-PERM-3 - Sample ID 1001290 - Specimen ID 1002539
>
>Please expedite this shipment by utilizing overnight shipping.  Please also
>ship these sample under controlled conditions (i.e. blue ice and
>temperature probe).  Thanks.
>
>Mark Peters
>
>
>
>---------------- RFC822 Header Follows ----------------
>Received: by quickmail.llnl.gov with ADMIN;20 Mar 1998 15:52:35 -0800
>Received: from ymps5 by pierce.llnl.gov (8.8.5/LLNL-1.18/llnl.gov-04.01)
>        id PAA12499; Fri, 20 Mar 1998 15:52:34 -0800 (PST)
>From: Mark_Peters@notes.ymp.gov
>Received: from ymln11.ymp.gov by ymps5.ymp.gov (PMDF V5.1-7 #23027)
> with SMTP id <0EQ5685BQ004H5@ymps5.ymp.gov> for lin1@llnl.gov; Fri,
> 20 Mar 1998 15:50:29 -0800 (PST)
>Received: by ymln11.ymp.gov(Lotus SMTP MTA v1.1 (385.6 5-6-1997))
> id 882565CD.00831FCD ; Fri, 20 Mar 1998 15:52:13 -0800
>Date: Fri, 20 Mar 1998 15:47:35 -0800
>Subject: Alcove 5 samples to USGS
>To: Chris_Lewis@notes.ymp.gov
>Cc: Robin_Datta@notes.ymp.gov, Douglas_Weaver@notes.ymp.gov,
>     Alan_Mitchell@notes.ymp.gov, lin1@llnl.gov,
>Yvonne_Tsang@notes.ymp.gov,
>     Michael_Riggins@notes.ymp.gov, Ardyth_Simmons@notes.ymp.gov,
>     sslevy@lanl.gov, Cynthia_Palmer@notes.ymp.gov,
>     Zell_Peterman@notes.ymp.gov, Thomas_Reynolds@notes.ymp.gov
>Message-id: <882565CD.00809F0C.00@ymln11.ymp.gov>
>MIME-version: 1.0
>Content-type: text/plain; charset=US-ASCII
>X-Lotus-FromDomain: CRWMS
>
>
>
>
>
```

UFA Ventures, Inc.
2000 Logston Boulevard
Richland, Washington 99352
james@ufaventures.com

(509) 375-3268
FAX 375-7451
http://www.ufaventures.com

August 11, 1998

Dr.Robin Datta
1180 Town Center Drive
Mail Stop 423
Las Vegas, Nevada 89134 FAX (702) 295-3554
Re: UFA Ventures Letter Report Subcontract/PO No. DE-AC01-91RW000134

Dear Dr. Datta:

All of the samples sent to us have been completed. The vials containing the extracted water under argon gas are vacuumed sealed and ready to be sent to whomever you wish. The rock cores are also crated and ready to be shipped to whomever you wish.

Just looking at the data, the 6 samples that yielded more than 1 ml of water had a pH of 8.14 ± 0.21, while the 17 samples with less than 1 ml had a pH of 7.88 ± 0.25. This may be coincidental, but I feel better with the measurements on 1 ml or greater. I did a quick volume calibration today to see the deviation in our microelectrode with volume size changes from 10 ml to 0.06 ml.

Sample Volume Calibration on Microelectrode Using Buffer Solution at pH 7

Sample Volume	pH
10.0 ml	6.98
5.0 ml	7.07
2.0 ml	6.97
1.5 ml	7.03
1.0 ml	7.02
0.8 ml	7.04
0.5 ml	7.04
0.2 ml	7.07
0.1 ml	7.08
0.06 ml	7.08

These were done in air, not under argon, which a worst case because drift is more problematic in contact with any CO_2 in the gas phase. There appears to be no significant error with volume changes down to 0.06 ml, so I would say the pH results for the pore water extractions are good to at least ±0.1 pH units.

Let me know what you think.

Jim Conca

Core Sample Specimen ID#	pH	Volume (ml) Extracted	Initial Water Content (Wt%)
01002486 ESF-HD-PERM-1 19.9'-20.1'	8.32	0.22	3.31
01002488 ESF-HD-PERM-1 23.1'-23.3'	7.79	2.49	5.00
01002489 ESF-HD-PERM-1 25.9'-26.1'	7.76	0.41	2.88
01002590 ESF-HD-PERM-1 26.1'-26.4'	8.02	0.61	2.92
01002508 ESF-HD-PERM-1 54.4'-54.8'	NR	0.01	2.80
01002509 ESF-HD-PERM-1 56.6' - 57'	8.21	2.04	5.25
01002510 ESF-HD-PERM-1 57'-57.5'	NR	0.05	3.40
01002581 ESF-HD-PERM-2 22.7'-23.0'	7.77	0.09	2.72
01002582 ESF-HD-PERM-2 23.0'-23.3'	8.39	0.90	3.59
01002584 ESF-HD-PERM-2 25.9'-26.2'	8.13	0.32	3.24
01002585 ESF-HD-PERM-2 26.2'-26.4'	7.89	0.30	2.94
01002586 ESF-HD-PERM-2 30.1'-30.5'	8.32	2.84	6.25
01002587 ESF-HD-PERM-2 30.5'-30.9'	7.51	0.50	2.88
01002594 ESF-HD-PERM-2 41.1' 41.5'	7.70	0.60	3.26
01002595 ESF-HD-PERM-2 41.5'-41.8'	7.96	0.11	3.40
01002597 ESF-HD-PERM-2 44.3'-44.6'	NR	0	1.90
01002598 ESF-HD-PERM-2 46.5'-46.8'	7.80	0.41	3.69
01002599 ESF-HD-PERM-2 46.8'-47.1'	7.70	0.60	3.59
01002519 ESF-HD-PERM-3 26.1'-26.4'	7.99	0.86	4.14
01002520 ESF-HD-PERM-3 26.4'-26.7'	8.00	1.46	5.14
01002521 ESF-HD-PERM-3 30.3'-30.7'	8.23	1.85	4.10
01002522 ESF-HD-PERM-3 30.7'-31.0'	7.98	0.25	3.82
01002525 ESF-HD-PERM-3 34.8'-35.1'	8.31	2.69	6.62
01002527 ESF-HD-PERM-3 37.7'-38.0'	NR	0	2.98
01002531 ESF-HD-PERM-3 44.3'-44.6'	7.77	0.13	3.18
01002532 ESF-HD-PERM-3 44.6'-44.9'	NR	0.05	1.55
01002533 ESF-HD-PERM-3 46.1'-46.4'	NR	0	2.85
01002534 ESF-HD-PERM-3 46.4'-46.6'	NR	0	2.24
01002537 ESF-HD-PERM-3 52.7'-53.0'	7.60	0.68	2.93
01002539 ESF-HD-PERM-3 56.3'-56.7'	7.60	0.66	3.02

NR means not enough sample to analyze.

UFA Ventures, Inc. QA MANUAL, REVISION 4 1-2, 4-7, 12, 16-18, AUDIT
*USGS
2000 Logston Blvd, #133 DATED OCTOBER 1999 SUPP I, II & III QUALITY
LVMO
Richland,WA 99352 USA RECORDS
REVIEW
509-375-3268

NEXT EVALUATION DATE 08/18/00
LAST AUDIT SA -99-022 DATE: 08/18/99
NEXT TRIENNIAL AUDIT DATE 08/19/00
SCOPE OF WORK : ANALYTICAL TESTING OF PORE WATER IN ROCK SAMPLES AND TESTING TO DETERMINE DIFFUSION
COEFFICIENTS FOR
INVERT MATERIALS
RESTRICTION None

ULTRA Scientific, Inc. ULTRA SCIENTIFIC, INC 1,2,4-8,10-13,14-18 QUALITY
*LVMO
250 Smith Street QAULITY ASSURANCE RECORDS
REVIEW
North Kingstown,RI 02852 MANUAL, REVISION 5.4
401-294-9400 DATED 10/99 SURVEY

NEXT EVALUATION DATE : 12/17/99
LAST AUDIT : SFE-00-002 DATE: 12/17/99
NEXT TRIENNIAL AUDIT DATE: 08/01/00
SCOPE OF WORK : ORGANIC AND INORGANIC CHEMICAL STANDARDS EXAMPLES - POTASSIUM, MOLYBDENUM, COPPER, NICKEL,
BORAN,
SODIUM, BENZINE, PCBS, EPA METHODS STANDARDS)
RESTRICTION All recommendations from survey to be resolved and verified prior to doing quality affecting
work.

APPENDIX L: ORIGINAL PORE WATER DATA TABLES FROM DTN LL990702804244.100

MOL.20000316.0688

LLYMP0002068 (C) QA: QA

Title: Pore Water Data
Tables from DTN LL990702804244.100

Record Date: 02/18/00

Author: DeLoach, L.D.

Organization: LLNL

DTN: LL990702804244.100

TDIF 308632

Record Information System

.100 5-25-00

Accession #: MOL.20000316.0688

Title: PORE WATER DATA TABLES FROM DTN LL990702804244.10, TDIF 308632 (C)

Date: 20000218

Author(s): DELOACH LD - LLNL

Trace #: LL990702804244.100
LLYMP0002068C PKG #(LLNL's)

Package(s): MOY-000316-02-01 LV PKG NO. 5-25-00

Related Record(s): MOL.20000316.0693 (ATT-TO)

Type: DATA

rev, 02/15/00	*Thermal testing program waters*					*as received*	*LLNL filtered*
sample	BH 60-2	BH 60-3	BH 60-2	BH 60-3	BH 77-3	BH 59-4*	BH 59-4 (a)*
identification	HYD	HYD	HYD	HYD	HYD	HYD	HYD
SMF number	SPC00527969	SPC00527977	SPC00527916	SPC00527916	SPC00527917	SPC00541803	SPC00541803
collection date	6/4/98	6/4/98	8/12/98	8/12/98	8/12/98	11/12/98	11/12/98
field pH	7.5	7.7	6.9	6.8	5.6	6.63	6.63
field Br (ppm)*	0.75	0.96	0.385	0.345			
Na (mg/L)	20.0	24.0	20.4	17	2.4	22.6	135
Si (mg/L)	56	41	52	44	1.48	34	44
Ca (mg/L)	20	25	19.9	19	2.09	478	450
K (mg/L)	6.0	4.5	5.4	4.5	1.4	29.5	37.8
Mg (mg/L)	2.9	5.7	1.21	4.0	0.21	64.1	83.9
Al (mg/L)	0.12, 0.071	0.017	n.d.< 0.06	0.003	n.d.< 0.06	0.01	n.d. < 0.06
B (mg/L)	1.2	0.92	1.84	1.1	0.13	4.47	4.13
S (mg/L)	5.5	9.2	4.5	5.2	1.4	50.7	64.8
Fe (mg/L)	0.04	n.d. < 0.02	0.02	0.12	n.d. < 0.02	n.d. < 0.02	n.d. < 0.02
Li (mg/L)	0.07	0.07	0.03	0.04	n.d. < 0.01	0.21	0.20
Sr (mg/L)	0.18	0.34	0.11	2.2	0.05	4.02	3.71
HCO3							
F (mg/L)	1.00	0.82	0.71	0.43	0.41	0.79	4.34
Cl (mg/L)	10	16	6.14	5.52	2.15	1,130	1,250
Br (mg/L)	0.84	0.73	0.05	0.21	0.03	1.13	n.d. < 0.07
SO4 (mg/L)	17	30	4.88	8.81	1.86	226	213
PO4 (mg/L)	n.d. < 0.07	n.d. < 0.07	0.25	0.16	1.06	n.d. < 5	n.d. < 0.2
NO2 (mg/L)	n.d. < 0.01	n.d. < 0.01	n.d.<0.04	n.d.<0.04	n.d.< 0.04	n.d. < 3	n.d. < 10
NO3 (mg/L)	3.00	3.6	0.46	0.6	0.22	3.12	7.81

Water collection from borehole 77-3 appears to be consistent with moisture condensing from hot gases in the pump tubing.

rev. 02/15/00	*as received*	*LLNL filtered*	*as received*	*LLNL filtered*			
sample	BH 60-3	BH 60-3 (a)	BH 186-3	BH 186-3 (a)	BH 60-3	BH 59-4	BH 186-3
identification	HYD	HYD	HYD	HYD	HYD	HYD	HYD
SMF number	SPC00541804	SPC00541804	SPC00541805	SPC00541805	SPC00504396	SPC00504396	SPC00527961
collection date	11/12/98	11/12/98	11/12/98	11/12/98	1/26/99	1/26/99	1/26/99
field pH	6.92	6.92	6.83	6.83	7.4		7.2
field EC (µS)							
Na (mg/L)	10.1	20.3	*105*	17	19.1	219	25.9
Si (mg/L)	60	54	16	27.2	65	12	49.3
Ca (mg/L)	15.3	13.9	11.5	20.2	5.9	429	2.92
K (mg/L)	8.7	7.8	3.5	3.9	4.1	29.7	5.9
Mg (mg/L)	3.4	3.0	5.1	5.7	1.2	164.0	6.3
Al (mg/L)	0.033	0.033	n.d. < 0.003	n.d. < 0.003	n.d. < 0.06	0.086	n.d. < 0.06
B (mg/L)	1.58	1.41	0.51	0.58	1.76	6.68	0.84
S (mg/L)	11.6	10.5	8.47	9.42	6.4	109	7.9
Fe (mg/L)	0.02	n.d. < 0.02	0.02	0.02	n.d. < 0.02	n.d. < 0.02	0.09
Li (mg/L)	0.04	0.04	0.05	0.05	0.02	0.33	0.05
Sr (mg/L)	0.22	0.20	0.30	0.34	0.09	5.84	0.37
HCO3					41		116
F (mg/L)	0.49	0.5	0.56	0.62	1.27	0.51	1.2
Cl (mg/L)	20	20	19	19	10	1,160	23.30
Br (mg/L)	0.60	0.51	0.67	0.6	0.15	1.51	0.32
SO4 (mg/L)	30.6	30.8	26.3	26.2	13.5	240	21
PO4 (mg/L)	n.d. < 0.2	n.d. < 0.2	n.d. < 0.2	n.d. < 0.2	n.d. < 0.05	n.d. < 0.5	n.d. < 0.1
NO2 (mg/L)	n.d. < .10	n.d. < .10	n.d. < .10	n.d. < .10	n.d. < .03	n.d. < .3	n.d. < 0.05
NO3 (mg/L)	3.38	3.17	7.47	7.27	2.56	11.6	6.73

rev. 02/15/00				
sample	BH 60-3	BH 60-3	BH 60-3	[redacted]
identification	HYD	HYD	HYD	HYD
SMF number	SPC00529637	SPC00529637	SPC00529637	SPC00529634
collection date	3/30/99 9:50	3/30/99 9:55	3/30/99 10:10	3/30/99
field pH	8.0			4.8
field EC (µS)				
Na (mg/L)	11.2	11.0	2.2	n.d. < 0.2
Si (mg/L)	62.8	59.8	12.1	1.03
Ca (mg/L)	2.06	2.27	1.22	0.41
K (mg/L)	2.4	2.4	0.5	n.d. < 0.5
Mg (mg/L)	0.27	0.26	0.01	0.02
Al (mg/L)	0.27, 0.36	0.27, 0.36	0.07, 0.08	0.005
B (mg/L)	2.1	2.11	1.23	0.09
S (mg/L)	1.83	1.82	0.42	n.d. < 0.02
Fe (mg/L)	n.d. < 0.02	n.d. < 0.02	n.d. < 0.02	0.05
Li (mg/L)	0.02	n.d. < 0.01	n.d. < 0.01	n.d. < 0.01
Sr (mg/L)	0.02	0.02	n.d. < 0.01	n.d. < 0.01
HCO3 (mg/L)	25.0			1.3
F (mg/L)	1.02	0.97	0.11	
Cl (mg/L)	4.15	3.92	0.72	
Br (mg/L)	n.d.< 0.04	n.d.< 0.04	n.d.< 0.04	
SO4 (mg/L)	3.83	3.75	0.79	
PO4 (mg/L)	n.d. < 0.05	n.d. < 0.05	n.d. < 0.05	
NO2 (mg/L)	n.d.< 0.03	n.d.< 0.03	n.d.< 0.03	
NO3 (mg/L)	0.92	0.84	0.17	

rev. 02/15/00	*ESF Pore waters*		
sample	Pore water	Pore water	Pore water
identification	ESF-HD-PERM-1 23.1'-23.3'	ESF-HD-PERM-2 30.1'-30.5'	ESF-HD-PERM-1 34.8'-35.1'
collection date			
field pH	7.79	8.32	8.31
Na (mg/L)	61	61	62
SiO2 (mg/L)*	79	66	75
Ca (mg/L)	98	106	97
K (mg/L)	6	7	9
Mg (mg/L)	25.7	16.6	17.4
Al (mg/L)	n.d. < 0.06	n.d. < 0.06	n.d. < 0.06
B (mg/L)	3.05	2.75	2.75
S (mg/L)	42.3	38.6	38.7
Fe (mg/L)	n.d. < 0.02	n.d. < 0.02	n.d. < 0.02
Li (mg/L)	0.1	0.45	0.05
Sr (mg/L)	1.4	1.0	1.1
HCO3			
F (mg/L)	0.36	0.96	0.76
Cl (mg/L)	123	110	123
Br (mg/L)	0.60	0.76	1.20
SO4 (mg/L)	124	111	120
PO4 (mg/L)	n.d. < 0.07	n.d. < 0.07	n.d. < 0.07
NO2 (mg/L)	n.d. < 0.04	n.d. < 0.04	n.d. < 0.04
NO3 (mg/L)	22	3	10

* SiO2(mg/L) = Si (mg/L)*2.145

APPENDIX M: YMSCO-00-0055 YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT NONCONFORMANCE REPORT

YMP-006-R6
06/02/97

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
NONCONFORMANCE REPORT

ORIGINAL
red

CR No. Ym SCO-00-0055

Page 1 of 11

1.
Initiator Name: George Hampton Organization: LLNL Date: 2/16/00

2. Description of Non-Conformance:
Analysis of samples in scientific notebooks #00342 and #00349 was performed by LLNL Chemistry and Material Science Department analytical laboratories (Analytical and Nuclear Chemistry Division). the analytical laboratories were not qualified under the YMP QA program.

☐ Hold Tag Applied No. of Hold Tags Applied: N/A Field Work Package/ Job Package/ Test Planning Package No.: N/A

3. OQA: ☑ Validation ☐ Invalidation ☑ Q ☐ Non-Q
Name: C.C. Warren Date: 02-16-00

4. Disposition Evaluation
☐ Rework ☐ Repair ☒ Use-As-Is ☐ Conditional Release
☐ Reject/Strap ☐ Limited Use ☐ Discard Potentially Reportable ☐ Yes ☑ No

Justification/Comments:
See attached justification

5. Recommended Disposition by:
Name: Organization: LLNL Date: 2/22/00
Recommended Disposition Wunan Lin

Name: Cynthia E. A. Palmer Organization: LLNL Date: 2/23/00
Approval of Disposition

6. OQA Concurrence with Disposition: Corrective Action: ☐ No ☑ Yes No. LLNL-98-D-092
Name: C.C. Warren (SEE NOTE ON PAGE 2) Date: 3-2-00

7. Completion of Disposition: ☐ Hold Tag Removed N/A No. of Hold Tags Removed N/A
Name: Organization: Date:
OQA Concurrence:
Name: Date:

8. OQA Final Review:
Name: Date:

Exhibit YAP-15.1Q.1

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Disposition Evaluation
Justification:

Nonconformance issues for LLNL Chemistry and Material Science Department - Analytical Laboratories Division (ASD) were: (1) lack of YMP approved analytical procedures, and (2) the use of non-Q certified chemical standard suppliers. The actions taken in response to these concerns are listed below.

(1) The absence of YMP analytical procedures was corrected with the issuance of the following Technical Implementing Procedures (TIPs) approved by a Technical Area Leader and the OCRWM Office of Quality Assurance Representative.

1. TIP-AC-02: Solutions Analysis – Cations by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP/AES)
2. TIP-AC-03: Determination of Inorganic Anions by Ion Chromatography (IC)
3. TIP-AC-06: Total Organic / Total Inorganic Carbon Analysis (TOC/TIC)
4. TIP-AC-07: Elemental Analysis by Inductively Coupled Plasma and Mass Spectrometry (ICP/MS)

(2) As of December 6, 1999, a QAP-2-0 Activity Evaluation (attached) approved by the OCRWMS Waste Package Department Manager (Hugh Benton) authorizes the procurement and use of chemical standards for Q work as long as NIST-traceability is documented.

For years ASD has employed techniques listed in the above TIPs and has used chemical standards traceable to NIST reference materials for measuring analyte concentrations with ICP/AES, IC, TOC/TIC, and ICP/MS analytical instruments. ASD practiced these same protocols for the samples listed in the three tables that follow. In addition, the scientific notebooks and their supplements cited in the tables contain chemical calibration standard documentation as well as instrument printouts that validate analytical results and adherence to TIP methods. Therefore, the analyses performed on these samples meet Q criteria and should be dispositioned "Use-As-Is".

3-2-00

NOTE! Completion of this disposition ~~well~~ as "Use-As-Is" wil be dependent on the DOE Office of Project Execution performing qualification of data addressed in this NCR using the Equivalent QA Program Method of AP-SIII.2Q. If qualification of data cannot be performed using this method, this NCR will be revised to change the disposition.

C.C. Warren 3-2-00
OQA On-Site.

Table 1
ICP/AES Analysis Performed by ASD

Sample Number	Analysis Case #	Analysis Date	SNB #, Page(s) & Supp. #
Perm-1, Perm-2, Perm-3	579	12/8/98	#00349, Page 30 & Supp. 1
54-1 1/20/99 filtered, 56-2D 12/8/98 filtered, ~~59-4~~: 1/99 filtered, ~~60-3~~: 1/99 filtered, ~~186-3~~: 1/99 filtered, 54-1 1/20/99 unfiltered, ~~59-4~~ 1/99 unfiltered, ~~60-3~~: 1/99 unfiltered, ~~186-3~~ 1/99 unfiltered	826	1/22/99	#00342, Pages 105, 106,112 & Supp. 3
~~186-3~~ 1/26, ~~60-3~~ 1/26/99, ~~59-4~~ 1/26/99, D56-3 1/22/99, D56-1 1/22/99, ~~D54-3~~ 1/22/99	1034	3/18/99	#00342, Pages 113, 114,118 & 126 Supp. 3
DST 60-2, DST 60-3, DST 77-3	422	9/21/98	#00349, Page 30 & Supp. 1
59-4 11/98, 60-2 6/98, 60-3 #1, 60-3 #2, 60-3 #3, 60-3 6/98, 60-3 8/98, 60-3 11/98, 60-3 1/26, 77-3 3/99, 186-3 11/98	1101	4/21/99	#00342, Pages 81, 111,112, 118,125 & Supp. 3
D54-1, 60-3 #1, 60-3 #2 0955, 60-3 #3 10:10 3/31, 77-3 3/99	1102	4/22/99	#00342, Pages 123,125 & Supp. 3

Table 2
IC Analysis Performed by ASD

Sample Number	Analysis Case #	Analysis Date	SNB #, Page(s) & Supp. #
Perm-1, Perm-2, Perm-3	609	12/7/98	#00349, Page 30 & Supp. 1
54-1 filtered, 56-2 filtered, 56-3 filtered, 59-4 filtered, 60-3 filtered, 60-3 unfiltered, 186-3 filtered, 186-3 unfiltered	813	1/25/99	#00342, Pages 105,106, 112 & Supp. 3
D54-3 1/22/99, D56-1 1/22/99, D56-3 1/22/99, 59-4 1/26/99, 60-3 1/26/99, 186-3 1/26/99	1020	3/18/99	#00342, Pages 113,114, 118 & Supp. 3
60-3F	N/A	8/13/98	#00342,, Page 81 & Supp. 3
DST 60-2 8/12/98, DST 60-3 8/12/98, DST 77-3 8/12/98	399	10/8/98	#00349,, Page 30 & Supp. 1
D54-1 3/30, D54-4 3/31/99, 59-4 11/98, 60-3 #1 0950 3/30, 60-3 #2 0955 3/30, 60-3 #3 1010 3/30, D71-3 3/31/99, 77-3 3/99	1029	4/14/99	#00342, Pages 112,123, 124,125 & Supp. 3

Table 3
TIC Analysis Performed by ASD

Sample Number	Analysis Case #	Analysis Date	SNB #, Page(s) & Supp. #
54-1 filtered 1/19/99, 54-1 unfiltered 1/19/99, 54-1 filtered 1/20/99, 54-3 filtered, 56-2 filtered, 56-3 filtered, 56-3 unfiltered	8141	1/26/99	#00342, Pages 105,106 & Supp. 3
60-3 10:10 3/30	1029	4/15/99	#00342, Page 125 & Supp. 3

CRWMS/M&O

Activity Evaluation

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QA:
Page: 1 Of: 2

is form is provided for use by managers to assist with meeting the requirements of QAP-2-0 in determining whether their workscope is bject to QARD requirements.

I. Description of Activity

Activity Title Procurement and Confirmation of Chemicals Used for the Calibration of Standards		
Originating Organization WPO/Waste Package Materials Department		Responsible Manager (Print name) David Stahl
Approval (by next level manager or higher, Print name) Hugh A. Benton	Approval Signature Hugh A Benton	Date 12/6/99

Brief Description (including relationship to licensing or site characterization):

This activity covers the procurement of chemicals utilized for the calibration of pH, conductivity and analytical standards whose purity is traceable to the NIST. The procurement itself is not subject to the QARD. However, the confirmation that the chemicals are suitable for their intended use is an activity subject to the requirements of the QARD. Solutions generated from these chemicals will be utilized to calibrate the standards using approved LLNL Technical Implementing Procedures (TIPs). Solution chemistry will be verified using an analytical laboratory on the QSL when the standards are synthesized at LLNL. When standards are purchased directly from a commercial supplier, i.e., the solutions are not synthesized, lot number traceability to NIST standards will be verified by a review of the chemical certificates and documented in the scientific notebook or other record. (See Attachment 1.)

List tasks individually, if necessary: ☑ N/A (check if individual task descriptions are not necessary)

II. Evaluation of Activity *(The following questions are used to determine the applicability of the QARD to a given activity.)*

1. Is the activity subject to QARD requirements because it affects an item on the WAST/MGDS Q-List; or because it affects an item that is assumed to be subject to QARD requirements because that item has not yet been QA-classified? (For example, does the activity consist of design, procurement, construction, fabrication, production, handling, packaging, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, modification, or decontamination of a Q-Listed item?) Yes ☐ No ☑

Rationale (justify all responses; justify by task, if necessary):

These activities do not affect items on the WAST-MGR Q-List.

2. Is the activity subject to QARD requirements because it is related to site characterization sample collection or collection and analysis of data used to support performance confirmation or performance assessments? Yes ☑ No ☐

Rationale (justify all responses, justify by task if necessary):

The confirmation activity is subject to QARD requirements because the calibration of the equipment supports a QA activity. However, the procurement can be made non-Q because the Principal Investigator or designate will confirm the chemicals prior to se.

QAP-2-0 (Effective 07/20/98)

0465 (Rev. 4/30/97)

CRWMS/M&O

Activity Evaluation (Continued)

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Page: 2 Of:

Activity Title

rocurement and Confirmation of Chemicals Used for the Calibration of Standards

Evaluation of Activity (continued)

3. Is the activity subject to QARD requirements because it is intended to provide data used to assess the potential dispersion of radioactive materials from a licensed facility? Yes ☐ No ☑

Rationale (justify all responses, justify by task if necessary)

These activities do not provide data used to assess the dispersion of radioactive materials from a licensed facility

4. Is the activity subject to QARD requirements because it is related to high-level waste form development through qualification, production, and acceptance? Yes ☐ No ☑

Rationale (justify all responses, justify by task if necessary)

These activities are not related to high-level waste form development.

5. Is the activity subject to QARD requirements because it is associated with characterization of, and conditioning through acceptance of, DOE spent nuclear fuel? Yes ☐ No ☑

Rationale (justify all responses, justify by task if necessary):

These activities are not related to characterization or conditioning of DOE spent nuclear fuel.

6. Is the activity subject to QARD requirements because it is a site-disturbing activity that can adversely impact the waste isolation function of the natural or engineered barriers or impact site characterization results (for MGDS only)? Yes ☐ No ☑

Rationale (justify all responses, justify by task if necessary):

These activities are not associated with a site disturbing activity.

7. Is the activity subject to QARD requirements because it involves tasks which are QARD-required support of other activities subject to QARD requirements? (For example, does the activity include the performance of training, development of procedures, document control, preparation or processing of records, QA functions, etc.?) Yes ☑ No ☐

Rationale (justify all responses, justify by task if necessary)

The confirmation of the critical characteristics of the chemicals supports activities that are subject to QARD requirements. However, the procurement can be made non-Q because the Principal Investigator or designate will confirm the chemicals prior to use.

If the answer to any of the questions in Section II is "yes," the activity is subject to QARD requirements. Use appropriate procedures for the conduct of those activities in accordance with QAP-2-0. If existing procedures are not adequate to control the activity, then revise or develop ew procedures in accordance with QAP-5-1 or other appropriate procedures.

New or Revised procedures required? Yes ☐ No ☑

QAP-2-0 (Effective 07/20/98) 0646 (Rev. 4/30/97)

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Attachment I

Technical Justification for the Procurement of LLNL Chemicals Supporting Studies for the Yucca Mountain Project

I. Introduction

Four types of chemical standards are discussed in this document. For the Yucca Mountain Project, these types of chemical standards will be used by Lawrence Livermore National Laboratory (LLNL) to calibrate laboratory equipment for measuring the concentration of chemicals in various matrices to support several on-going investigative studies.

These chemical standards are commercially available and are commonly used to calibrate measuring and test equipment for such purposes as the rigorous analyses required under the Environmental Protection Agency's Superfund Act. All the chemicals discussed below have a purity of composition adequately characterized for the sensitivity of their intended usage on the Yucca Mountain Project.

Based on the data presented below, reasonable assurance of quality will be maintained employing the standards described. Chemical standard usage is governed by the relevant LLNL Technical Implementing Procedure (TIP). The TIPs are based on EPA and Standard Methods routinely applied throughout the world to measure concentrations of chemicals of interest. These methods are EPA Method 6010B: Inductively Coupled Plasma – Atomic Emission Spectrometry, EPA Method 6020B: Inductively Coupled Plasma – Mass Spectrometry, EPA Method 300: Determination of Inorganic Anions by Ion Chromatography, EPA Method 9040: pH Determination, and Standard Methods 4110: Electrical Conductivity. The usage of each type of chemical is addressed separately in the following descriptions.

II. Descriptions of Chemical Usage

pH Buffers

The composition and behavior of these buffers are well understood as demonstrated by references in the CRC Handbook for Chemistry and Physics (Lide, 71st ed., 1990, pp. 8-26 to 8-32) and Standard Methods (Standard Methods for the examination of Water and Wastewater, 18th ed., 1992, pp.4-65 to 4-69). The off-the-shelf buffers are accurate to 0.01 pH units, which is better than the accuracy needed for Yucca Mountain studies.

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Attachment I

Electrical Conductivity Standards

Preparation of electrical conductivity solutions is referenced in CRC Handbook for Chemistry and Physics (Lide, 71st ed., 1990, p5-94) and Standard Methods (Standard Methods for the Examination of Water and Wastewater, 18th ed., 1992 pp. 4-65 to 4-69). Standard Methods (p1-25) further constrains the chemicals used in the preparation to "ACS grade" or "analytical reagent grade". Standards are reagent grade solutions calibrated against NIST-traceable standards. The standards selected are sufficient and adequate for making conductivity measurements.

Ion Chromatography (IC) Standards

For determination of anions by ion chromatography (EPA Method 300), standards are obtained that are used industry wide for the analyses required by EPA, and thus have a substantial track record for quality.

Inductively Coupled Plasma (ICP) Standards

EPA Methods 6010B and 6020B state that "stock solutions may be purchased or prepared from ultra-high purity grade chemicals or metals (99.99%+ pure)". The standards selected are "prepared from starting materials having a purity of 99.999% (where possible), high purity acids, and ASTM Type I water (18 megohm). All standards are traceable to NIST standard reference materials (SRM) whenever possible".

III. Analytical Method Accuracy

EPA Methods 6010B and 6020B – Typical laboratory accuracy for the TIP protocols may be assessed from the EPA Method descriptions. EPA submitted aqueous samples to 7 (Method 6010) and 10 (Method 6020) laboratories for comparison. For Method 6010, accuracies of 95 to 104% with relative standard deviations ranging from 3.1 to 9.1% were determined for the listed elements; for Method 6020, accuracies ranging from 85 to 142% with relative standard deviations ranging from 4.3 to 150% were determined. The starting material is known to five significant figures, and the stated Certified Value contains four significant figures. The concentration of the requested standard is known to a much greater precision than the accuracy of the analysis method.

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EPA Method 300 – Samples containing various anions were submitted by EPA to 19 laboratories for analysis. The results indicated that the accuracy of certified standards (± 0.2%) is better than the precision of the method.

IV. Methods of PI Chemical Qualification

Chemical Standard Handling

All chemical standards defined in this justification shall be handled and used in accordance with governing YMP QA standard laboratory procedures. All special handling and storage needs recommended by the manufacturer will be adhered to.

Independent Standard – ICP Analyses

EPA Methods 6010 and 6020 require an Initial Calibration Verification, which is "prepared from a standard source different from that of the calibration standard and at concentrations within the linear working range of the instrument". Thus, two independent standards will be used, one in calibration of the instrument, and the other in verifying the calibration. This concurrent checking and use of two independent NIST-traceable standards provide reasonable assurance of quality.

Independent Standard – IC Analyses

Independent standards will be used to verify the calibration of the IC equipment. These standards will be prepared from a standard source different from that of the calibration standard and at concentrations within the linear working range of the instrument. This concurrent checking and use of two independent NIST-traceable standards provide reasonable assurance of quality.

NIST-Traceability

To provide another supporting, corroborative line of evidence for the standards, NIST traceability is requested. Certificates of Analysis for buffers are obtained from the vendors. Certificates state that buffer lots are tested against a primary standard from NIST.

The manufacturer supplies a Certified Value for anion and ICP standards comparing them to NIST standards. There may be a deviation between the label concentration and the Certified Value, but only the Certified Value is important; it is only necessary to know what the concentration of the standard is. The purpose of NIST certification is only to provide additional corroborative evidence of the multiple standard comparison described above.

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Attachment I

V. Conclusion

The standards described above are sufficient and accurate for LLNL analyses of Yucca Mountain samples. These standards are readily and rapidly available, and widely used in many commercial laboratories with stringent quality assurance requirements. The behavior of pH buffers and conductivity standards are well understood. ICP and IC standards will be verified by a second standard. The accuracy of the standards greatly exceeds the measurement accuracy. Additionally, these standards are all NIST-traceable providing an additional high level of confidence in their quality, and documentation is available from the vendors to that end. One can comfortably rely on these standards for the analytical chemistry needs of this project when their use is governed by the Technical Implementing Procedures, and more stringent specifications for chemical standards would not result in higher confidence in the analytical results obtained.

APPENDIX N: DTN# MO0005PORWATER.000

Rev. 05/02/00	ESF Pore waters		
sample	Pore water	Pore water	Pore water
identification	ESF-HD-PERM-1 23.1'-23.3'	ESF-HD-PERM-2 30.1'-30.5'	ESF-HD-PERM-3 34.8'-35.1'
collection date			
field pH	7.79	8.32	8.31
Na (mg/L)	61	61	62
SiO2 (mg/L)*	79	66	75
Ca (mg/L)	98	106	97
K (mg/L)	6	7	9
Mg (mg/L)	25.7	16.6	17.4
Al (mg/L)	n.d. < 0.06	n.d. < 0.06	n.d. < 0.06
B (mg/L)	3.05	2.75	2.75
S (mg.L)	42.3	38.6	38.7
Fe (mg.L)	n.d. < 0.02	n.d. <0.02	n.d. < 0.02
Li (mg/L)	0.1	0.45	0.05
Sr (mg/L	1.4	1.0	1.1
HCO3			
F (mg/L)	0.36	0.96	0.76
Cl (mg/L)	123	110	123
Br (mg/L)	0.60	0.76	1.20
SO4 (mg/L)	124	111	120
PO4 (mg/L)	n.d. < 0.07	n.d. < 0.07	n.d. < 0.07
NO2 (mg/L)	n.d. < 0.04	n.d. < 0.04	n.d. < 0.04
NO3 (mg/L)	22	3	10

* SiO_2(mg/L) = Si (mg/L)*2.145