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Chemical analyses for Alcove 8 Niche 3 tracer studies

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**CHEMICAL ANALYSES FOR
ALCOVE 8/NICHE 3 TRACER STUDIES**


- TASK 35 -

FINAL REPORT

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Summary

This report details the activities performed under Task 35 of the University and Community College System of Nevada (UCCSN) Cooperative Agreement with the US Department of Energy (DOE). Task 35, titled “Chemical Analyses for Alcove 8 / Niche 3 Tracer Studies”, provided for the development of analytical procedures and the analysis of samples from the first phase of tracer testing at Alcove 8 / Niche 3 in the Exploratory Studies Facility (ESF). Two conservative tracers (bromide and pentafluorobenzoic acid) and three FD&C dye tracers (FD&C Blue #1, FD&C Yellow #5, and FD&C Red #40) were analyzed in the seepage samples collected from Niche 3. Several background constituents (chloride, phosphate, sulfate, nitrate, magnesium, potassium, sodium, and calcium) were analyzed in a subset of the collected seepage samples. Samples were collected by Lawrence Berkeley National Laboratories (LBNL) and / or the US Geological Survey (USGS) researchers and transferred using chain of custody to the Harry Reid Center for Environmental Studies (HRC). Samples were then analyzed using high performance liquid chromatography (HPLC) for pentafluorobenzoic acid (PFBA) and FD&C dyes, ion chromatography for bromide, chloride, phosphate, sulfate, nitrate, and atomic absorbance spectroscopy for magnesium, potassium, sodium, and calcium. Implementing procedures (IPLVs), approved by the UCCSN Quality Assurance Program, were followed for all aspects of sample control, sample analysis, and data reporting.

In addition, a suite of tracers was selected for the next phase of tests. Selection was based on the list of permitted tracers for use at the ESF as well as on availability. Residual tracer is available from the Alluvial Tracer Complex (ATC) testing and therefore selection was limited to these tracers when possible.

CHEMICAL ANALYSES FOR ALCOVE 8/NICHE 3 TRACER STUDIES

-Task 35- Final Report

Irene M. Farnham

1. Introduction

The Harry Reid Center for Environmental Studies (HRC) provided analytical support for the Infiltration and Seepage Studies in the Exploratory Studies Facility Niche 3 and Alcove 8. This analytical support included developing procedures for measuring tracer concentrations and then performing the analyses for the water samples generated from an Alcove 8 / Niche 3 tracer test. The tracers used for the testing include pentafluorobenzoic acid (PFBA) and bromide. In addition, seepage samples were analyzed for three FD&C dye tracers (FD&C Blue #1, FD&C Yellow #5, and FD&C Red #40) present in several of the samples from previous tests, and also several background constituents (chloride, sulfate, nitrate, magnesium, potassium, sodium, and calcium). This report documents the analyses as well as their results.

Also completed for this task was the selection of a suite of tracers for the next series of tracer tests. Selection was based on the list of permitted tracers for use at the ESF as well as on their availability. Residual tracer is available from the Alluvial Tracer Complex (ATC) testing and therefore selection was limited to these tracers when possible. Method development work was performed to determine which of the available tracer could be chromatographically separated. Chromatographic separation is required for the analyses of all tracers in the event that all are present in a given sample. Once tracers were selected, the masses and concentrations for the injection solutions were determined. Tracer selection was a collaborative effort between the HRC, Lawrence Berkeley National Laboratory (LBNL), and the US Geological Survey (USGS).

Task 35 was initiated on January 1, 2002 and activities are on-going in preparation for the next phase of tracer testing. This report describes all activities completed through August, 2003.

2. Methods

The LBNL and USGS researchers collected and transported all samples to the HRC in accordance with LBNL sample collection, transportation, and chain of custody procedures. Once samples were received at the HRC, Implementing Procedures (IPLVs), approved by the UCCSN Quality Assurance Program, were followed for sample control, sample analysis, and data reporting. The IPLVs used for this task are listed in Table 1.

Table 1 Implementing Procedures

Number	Title
IPLV-003	Analytical and Top Loading Balance Use
IPLV-004	High Performance Liquid Chromatograph Operation
IPLV-8.3 - Chain of Custody Section only	Groundwater Sample Collection and Control
IPLV-008	Measurement of Inorganic Anions in Water Samples by the Ion Chromatography System
IPLV-011	Measurement of Major Cations In Water Samples By the Flame Atomic Absorption Spectrometry System
IPLV-017	Pipettor Calibration Check

PFBA and the FD&C dyes were analyzed using a ThermoSeparation high performance liquid chromatograph (HPLC) with ultraviolet detection, the anions (Cl^- , F^- , Br^- , SO_4^{2-} , and NO_3^-) were analyzed on a Dionex ion chromatograph (IC) with a conductivity detector, and the cations (Ca^{2+} , Mg^{2+} , Na^+ , and K^+) were analyzed using a Varian flame atomic absorption (AA) spectrometer. The analyses are detailed in Volume 1 of the scientific notebooks UCCSN-UNLV-043 and UCCSN-UNLV-046.

The HPLC column, the injection volume, and the mobile phase composition varied depending on the particular suite of analytes. Specific instrument conditions were selected so that optimum separation of the analytes and any chromatographic interferences present in the sample matrix was achieved. Early analyses of PFBA were performed on a 5 μm Supelcosil LC-abz column (15cm x 4.6cm). The mobile phase

solvents consisted of 13% HPLC Grade acetonitrile (Burdick & Jackson) and 87% 0.05M KH_2PO_4 (Fisher Scientific) adjusted to a pH of 2.3 with H_3PO_4 (J.T. Baker). A flowrate of 1.5mL/min, injection volume of 100 μL , and a detection wavelength of 230nm were used. Later analyses of PFBA were performed using a 5 μm Supelcosil LC-18 column (15cm x 4.6cm). The HPLC conditions were identical to the earlier ones except that the composition of the mobile phase was slightly modified (11% acetonitrile and 89% 0.05M KH_2PO_4).

FD & C dyes were analyzed using a 5 μm Supelcosil LC-18 column (15 x 4.6). The mobile phase consisted of 0.005M tetrabutyl ammonium dihydrogen phosphate (Fluka Chemika) and HPLC Grade acetonitrile (Burdick & Jackson); compositions were approximately 65% and 35%, respectively. A flowrate of 1.5mL/min, injection volume of 100 μL , and a detection wavelength of 205nm were used.

The IC mobile phase consisted of 3.5 mM Na_2CO_3 (Fisher Scientific) / 1mM NaHCO_3 (J.T. Baker) with a Dionex AS14 ion exchange column (250mm), a Dionex AG14 guard column, a flow rate of 1.2 mL/min, and a 50 μL injection volume. Wavelengths of 330.2nm, 769.9nm, 422.7nm, and 285.2nm, for sodium, potassium, calcium, and magnesium respectively.

Each instrument was calibrated prior to analyzing the samples using five to eight calibration standards. The PFBA and FD&C dye standards used to prepare the calibration standards were prepared directly from the tracer stock used for field testing because NIST traceable standards are not available for these compounds. NIST traceable standard purchased from a Yucca Mountain approved vendor (Environmental Resource Associates) were used to prepare all other calibration standards. The accuracy of standards preparation was determined using initial calibration check (ICC) standards which were prepared independently of the calibration standards. In order to proceed with the analyses, the ICC was required to be within 10% of its prepared concentration. The precision of the measurements was determined by analyzing a subset of samples in duplicate or triplicate. A calibration standard was also analyzed at the end of the analyses (CCC) to ensure that the system remained in calibration throughout the entire analysis. The measured concentration of the CCC also must be within 10% of its prepared concentration in order to accept the analyses.

Verification of all data was performed to check compliance to the IPLVs and to verify the accuracy of data reduction and electronic data transfer. Electronic data was transferred from the instrument to a Microsoft Excel or Quattro Pro spreadsheet. This electronic data transfer was checked by comparing hardcopies of the raw data, from the instrument, to hardcopies of the spreadsheets; all concentrations and sample names were compared. This comparison is documented on the spreadsheets which are included with the raw data and attached to the scientific notebook. Internal technical review was documented on the data and in the scientific notebook. Electronic data were controlled in accordance with QAP-3.1 "Control of Electronic Data". Data were stored on the local network server and backed up daily. PCs used are password protected and reside in locked offices. No software requiring qualification was used for this task.

3. Results and Discussion

The results of the first series of analyses for PFBA and bromide in a total of eighteen samples are reported in Appendix A. These data were submitted to the UCCSN Technical Data Archive (TDA) on 9/18/02 (MO0210UCC035IF.001). An additional ninety-nine samples were analyzed for PFBA, FD&C Blue #1, FD&C Yellow #5, and FD&C Red #40. Several of the analyses were performed in triplicate; the averages of these measurements were reported to the TDA on 7/18/03 (MO0307UCC035IF.002). These results are also listed in Appendix B. The concentrations of the analytes were quite low in the majority of the samples and significant background interferences were also present in many of these samples. Several chromatographic conditions were therefore tested in order to be sure that the proper peaks were identified for each of the analytes. The detection limits for PFBA ranged between 50ppb – 100ppb, and those for the FD&C dyes ranged between 20ppb – 100ppb depending on the chromatographic conditions used for the analysis. The average concentration for each of the replicate measurements, along with the standard deviation (Std), and percent relative standard deviation (%RSD) are listed in Tables 2 and 3 for PFBA and the FD&C dyes, respectively. The Std and %RSD values (Table 2 and 3) are relatively high due the low concentrations of tracers in the majority of the replicate samples. The concentrations, in many cases, were close to the detection limit resulting in relatively poor precision.

Table 2. Mean, Standard Deviation (Std), and Percent Relative Standard Deviation (%RSD) for replicate analyses of PFBA.

SMF Sample ID	PFBA		
	Mean (ppb)	Std	%RSD
1017060	<100	NA	NA
1016754	945	19	2
1016771	179	23	13
1017077	128	13	10
1018707	99	5.5	6
1018717	101	9.1	9

NA – Not applicable

SMF – Sample Management Facility

Data Source – 035IF-003

Table 3. Mean, Standard Deviation (Std), and Percent Relative Standard Deviation (%RSD) for replicate analyses of the FD&C Dyes.

SMF Sample ID	FD&C Red #40			FD&C Blue #1			FD&C Yellow #5		
	Mean (ppm)	Std	%RSD	Mean (ppm)	Std	%RSD	Mean (ppm)	Std	%RSD
01017060	<0.1	NA	NA	<0.1	NA	NA	<0.1	NA	NA
01016754	<0.1	NA	NA	<0.1	NA	NA	<0.1	NA	NA
01016771	<0.1	NA	NA	0.301	0.020	7	0.265	0.002	1
01016781	0.022	0.001	5	0.241	0.009	4	0.306	0.002	1
01017077	0.038	0.006	15	0.089	0.006	7	0.039	0.009	22
01017087	1.40	0.02	1	1.464	0.043	3	0.060	0.007	12
01017098	<0.1	NA	NA	<0.1	NA	NA	<0.1	NA	NA
01016797	0.271	0.004	1	0.696	0.021	3	0.132	0.008	6
01018707	0.025	0.001	2	0.115	0.007	6	0.025	0.002	7
01018717	0.026	0.003	10	0.101	0.004	4	0.023	0.003	11

NA – Not applicable

SMF – Sample Management Facility

Data Source – 035IF.003

A subset of 55 samples was selected for analysis of major anions and cations. The subset was selected to be representative of all of the sampling locations for several of the sampling dates. The concentration data for these analyses are included in Appendix C “Fluoride, Bromide, Chloride, Nitrate, and Sulfate Concentration Data” (MO0307UCC035IF.002) and Appendix D “Sodium, Potassium, Calcium, and Magnesium Concentration Data” MO0307UCC035TJ.001. Only a few duplicate samples

were analyzed for anions and cations; the %RSD for all duplicate measurements were less than or equal to 2%. This low %RSD between duplicates demonstrates the excellent precision of these measurements.

A suite of tracers was selected for the next phase of tests at Alcove 8 / Niche 3. The USGS and LBNL Principle Investigators requested that these tracers include three halides and three fluorinated benzoic acids. The masses and concentrations, as well as the tracers themselves, were limited to those on the list of approved tracers (Appendix E). In addition, residual tracer is available from the Alluvial Tracer Complex (ATC) testing and therefore selection was limited to these tracers when possible. Method development work was performed to ensure the ability to analyze all tracers within a sample, assuming the likely event that all tracers may be present simultaneously in the seepage samples collected from Niche 3. Previous method development work has been performed to allow for chromatographic separation of the majority of the fluorinated benzoic acids; the analytical difficulty is the ability to quantify iodide. Several different chromatographic columns as well as several different HPLC conditions were tested to achieve simultaneous analysis of the fluorinated benzoic acids, along with iodide. A method was discovered that provided for analysis of 2,4,5-trifluorobenzoic acid (2,4,5-TFBA), pentafluorobenzoic acid, 2,5-difluorobenzoic acid (2,5-DFBA), 2,6-difluorobenzoic acid (2,6-DFBA), and iodide. These tracers were therefore selected for use in the next test. The list of tracers, zones for which they were selected, as well as the mass, volume, and concentration for the injectate solutions are listed in Table 4. The maximum allowed mass and concentrations were obtained from the list of approved tracers (Appendix E). The maximum allowed concentrations for the halides are quite low; bromide is already in the system because of the presence of lithium bromide in the water used for the injection. This may limit the ability to quantify these tracers in the case that significant dilution occurs during infiltration.

4. Conclusion

This final report summarizes activities completed to date. Work under Task 35 is still in progress to prepare for the next series of testing. The next phase of testing is expected to begin in November 2003. Analysis of samples for these tests will continue.

**Table 4. Tracers Identified for use in the Next Series
of Alcove 8 / Niche 3 Tests**

Tracer	Zone	Mass (g)	Volume		Concentration (ppm)	Concentration Halide (ppm)
			Gallons	Liters		
2,6-DFBA	1	50	264	1000	50	
Potassium Iodide	1	10	264	1000	10	7.6
2,4,5-TFBA	3	50	264	1000	50	
Potassium Fluoride	3	50	264	1000	50	16.4
2,5-DFBA	2	25	132	500	50	
Calcium Bromide	2	250	132	500	500	399.7

5. References

No references other than those listed in Table 1.

Appendix A

Pentafluorobenzoic Acid (PFBA) and Bromide Concentration Data

Sample Name	SMF Sample ID	Sampling Date	Bromide (ppm)	PFBA (ppm)
U3-T5	1016739	4/25/2002	30.46	0.378
U3-T2	1016740	4/29/2002	59.60	1.11
U3-T5	1016741	4/29/2002	31.40	0.402
U3-T5	1016742	5/2/2002	32.82	0.464
U3-T5	1016743	5/6/2002	32.14	0.432
U3-T5	1016744	5/8/2002	32.61	0.421
U3-T5	1016744	5/8/2002	32.28	0.421
U2-T1	1016745	5/20/2002	1834	24.0
U2-T1	1016745	5/20/2002	1844	24.1
U2-T1	1016745	5/20/2002	NM	24.0
U3-T2	1016746	5/20/2002	69.59	1.16
U3-T5	1016747	5/20/2002	31.71	0.406
U3-T5	1016747	5/20/2002	31.84	0.397
U3-T2	1016749	6/4/2002	34.76	0.564
U3-T2	1016750	6/10/2002	42.67	0.880
U3-T2	1017040	4/8/2002	46.44	0.939
U3-T5	1017041	4/8/2002	31.32	0.441
U3-T5	1017048	4/16/2002	31.13	0.426
U3-T2	1017049	4/16/2002	46.86	0.977
U2-T5	1017051	4/18/2002	30.43	0.383
U3-T2	1017052	4/22/2002	49.60	0.963
U3-T2	1017052	4/22/2002	NM	0.959
U3-T5	1017053	4/22/2002	30.79	0.364

NM – Not measured

SMF – Sample Management Facility.

UCCSN Data Id Number: 035IF.001 Q

YMP Data Tracking Number: MO0210UCC035IF.001

Appendix B

Pentafluorobenzoic Acid, FD&C Red #40, FD&C Blue #1, and FD&C Yellow #5
Concentration Data

SMF Sample ID	Sample Location	Collection Date	PFBA (ppm)	Red #40 (ppm)	Blue #1 (ppm)	Yellow #5 (ppm)
1016754	U3-T2	06/20/02	0.95	<0.10	<0.10	<0.10
1016764	Alcove 8	12/23/02	<0.1	<0.025	<0.025	<0.025
1016765	Alcove 8	01/07/03	<0.1	<0.025	<0.025	<0.025
1016766	U1-T5	01/07/03	<0.1	0.073	0.16	0.64
1016767	U4-T3	01/07/03	<0.1	1.65	1.36	0.078
1016768	U1-T5	01/07/03	<0.1	0.073	0.15	0.62
1016769	U4-T3	01/07/03	<0.1	1.64	1.35	0.089
1016770	U3-T4	01/07/03	0.20	<0.025	0.28	0.23
1016771	U3-T4	01/07/03	0.18	<0.025	0.30	0.26
1016772	Alcove 8	01/22/03	<0.1	<0.025	<0.025	<0.025
1016773	U1-T1	01/23/03	<0.1	0.40	0.53	0.18
1016774	U1-T4	01/23/03	<0.1	0.12	0.087	0.15
1016775	U3-T3	01/23/03	0.15	<0.025	0.35	0.59
1016776	U3-T5	01/23/03	0.11	<0.025	<0.025	<0.025
1016777	U4-T4	01/23/03	0.17	0.034	0.071	0.035
1016778	U1-T1	01/27/03	<0.1	0.25	0.54	0.15
1016779	U1-T3	01/27/03	<0.1	0.54	0.20	0.36
1016780	U1-T4	01/27/03	<0.1	0.11	0.087	0.12
1016781	U1-T5	01/27/03	<0.1	<0.025	0.24	0.31
1016782	U3-T2	01/27/03	<0.1	<0.025	0.53	0.24
1016783	U3-T3	01/27/03	0.12	<0.025	0.35	0.60
1016784	U3-T4	01/27/03	0.13	<0.025	0.34	0.29
1016785	U3-T5	01/27/03	<0.1	<0.025	<0.025	<0.025
1016786	U4-T4	01/27/03	0.12	<0.025	0.078	0.026
1016787	Alcove 8	01/28/03	<0.1	<0.025	<0.025	<0.025
1016788	U1-T3	02/13/03	<0.1	0.39	0.27	0.32
1016789	U1-T4	02/13/03	<0.1	0.095	0.13	0.14
1016790	U1-T5	02/13/03	<0.1	<0.025	0.32	0.35
1016791	U3-T2	02/13/03	<0.1	<0.025	0.56	0.18
1016792	U3-T3	02/13/03	0.14	<0.025	0.37	0.43
1016793	U3-T4	02/13/03	0.14	<0.025	0.43	0.28
1016794	U3-T5	02/13/03	<0.1	<0.025	<0.025	<0.025
1016795	U4-T3	02/13/03	<0.1	1.29	2.02	0.035
1016796	U4-T4	02/13/03	0.11	0.025	0.10	<0.025
1016797	U1-T1	02/18/03	<0.1	0.27	0.70	0.13
1016798	U1-T3	02/18/03	<0.1	0.45	0.26	0.31
1017055	Alcove 8	09/10/02	<0.1	<0.10	<0.10	<0.10
1017056	Alcove 8	09/18/02	<0.1	<0.10	<0.10	<0.10

SMF Sample ID	Sample Location	Collection Date	PFBA (ppm)	Red #40 (ppm)	Blue #1 (ppm)	Yellow #5 (ppm)
1017057	Alcove 8	09/24/02	<0.1	<0.10	<0.10	<0.10
1017058	Alcove 8	10/01/02	<0.1	<0.10	<0.10	<0.10
1017059	Alcove 8	10/08/02	<0.1	<0.10	<0.10	<0.10
1017060	Alcove 8	10/16/02	<0.1	<0.10	<0.10	<0.10
1017061	Alcove 8	10/24/02	<0.1	<0.10	<0.10	<0.10
1017062	Alcove 8	10/29/02	<0.1	<0.10	<0.10	<0.10
1017063	Alcove 8	11/05/02	<0.1	<0.10	<0.10	<0.10
1017064	U4-T2	11/06/02	<0.1	0.84	4.87	<0.10
1017065	Alcove 8	11/13/02	<0.1	<0.10	<0.10	<0.10
1017066	U4-T5	11/20/02	<0.1	0.069	0.078	0.10
1017067	U1-T5	11/20/02	<0.1	0.15	0.31	2.49
1017068	U3-T5	11/20/02	0.11	NM	NM	NM
1017069	U1-T1	01/30/03	<0.1	0.25	0.54	0.15
1017070	U1-T3	01/30/03	<0.1	0.49	0.21	0.39
1017071	U1-T4	01/30/03	<0.1	0.11	0.072	0.13
1017072	U1-T5	01/30/03	<0.1	<0.025	0.22	0.33
1017073	U3-T2	01/30/03	0.11	<0.025	0.51	0.22
1017074	U3-T3	01/30/03	0.15	<0.025	0.36	0.55
1017075	U3-T4	01/30/03	0.15	<0.025	0.36	0.26
1017076	U3-T5	01/30/03	0.13	<0.025	<0.025	<0.025
1017077	U4-T4	01/30/03	0.13	0.038	0.089	0.039
1017078	Alcove 8	02/03/03	<0.1	<0.025	<0.025	<0.025
1017079	U1-T1	02/03/03	<0.1	0.21	0.55	0.16
1017080	U1-T3	02/03/03	<0.1	0.58	0.20	0.37
1017081	U1-T4	02/03/03	<0.1	0.11	0.068	0.14
1017082	U1-T5	02/03/03	<0.1	<0.025	0.23	0.34
1017083	U3-T2	02/03/03	0.11	<0.025	0.53	0.22
1017084	U3-T3	02/03/03	0.18	<0.025	0.34	0.52
1017085	U3-T4	02/03/03	0.12	<0.025	0.35	0.29
1017086	U3-T5	02/03/03	<0.1	<0.025	<0.025	<0.025
1017087	U4-T3	02/03/03	<0.1	1.40	1.46	0.060
1017088	U1-T1	02/10/03	<0.1	0.25	0.57	0.14
1017089	U1-T3	02/10/03	<0.1	0.56	0.20	0.38
1017090	U1-T4	02/10/03	<0.1	0.089	0.092	0.15
1017091	U1-T5	02/10/03	<0.1	<0.025	0.23	0.40
1017092	U3-T2	02/10/03	0.12	<0.025	0.47	0.19
1017093	U3-T3	02/10/03	0.15	<0.025	0.32	0.55
1017094	U3-T4	02/10/03	0.15	<0.025	0.29	0.26
1017095	U3-T5	02/10/03	<0.1	<0.025	<0.025	<0.025

SMF Sample ID	Sample Location	Collection Date	PFBA (ppm)	Red #40 (ppm)	Blue #1 (ppm)	Yellow #5 (ppm)
1017096	U4-T3	02/10/03	<0.1	1.33	2.02	0.088
1017097	U4-T4	02/10/03	<0.1	<0.025	0.088	0.039
1017098	Alcove 8	02/11/03	<0.1	<0.025	<0.025	<0.025
1017099	U1-T1	02/13/03	<0.1	0.25	0.65	0.15
1018700	U1-T4	02/18/03	<0.1	0.083	0.098	0.101
1018701	U1-T5	02/18/03	<0.1	<0.025	0.31	0.33
1018702	U3-T2	02/18/03	<0.1	<0.025	0.54	0.16
1018703	U3-T3	02/18/03	0.14	<0.025	0.36	0.42
1018704	U3-T4	02/18/03	0.15	<0.025	0.39	0.27
1018705	U3-T5	02/18/03	<0.1	<0.025	<0.025	<0.025
1018706	U4-T3	02/18/03	<0.1	1.24	2.01	0.037
1018707	U4-T4	02/18/03	<0.1	0.025	0.12	0.025
1018708	Alcove 8	02/18/03	<0.1	<0.025	<0.025	<0.025
1018709	U1-T1	02/24/03	<0.1	0.26	0.66	0.11
1018710	U1-T3	02/24/03	<0.1	0.37	0.26	0.32
1018711	U1-T4	02/24/03	<0.1	0.063	0.097	0.090
1018712	U1-T5	02/24/03	<0.1	<0.025	0.34	0.26
1018713	U3-T2	02/24/03	0.10	<0.025	0.52	0.14
1018714	U3-T3	02/24/03	0.12	<0.025	0.33	0.37
1018715	U3-T5	02/24/03	0.11	<0.025	0.43	0.27
1018716	U4-T3	02/24/03	<0.1	1.18	2.11	0.026
1018717	U4-T4	02/24/03	0.10	0.027	0.10	0.025

NM – Not measured

SMF – Sample Management Facility.

UCCSN Data Id Number: 035IF.002 Q

YMP Data Tracking Number: MO0307UCC035IF.002

Appendix C

Fluoride, Bromide, Chloride, Nitrate, and Sulfate Concentration Data

SMF Sample ID	Sample Location	Collection Date	F (ppm)	Cl (ppm)	Br (ppm)	NO3 (ppm)	Sulfate (ppm)
1016754	U3-T2	06/20/02	2.41	25.4	44.4	13.5	39.6
1016764	Alcove 8	12/23/02	2.04	7.42	21.6	0.68	14.4
1016765	Alcove 8	01/07/03	2.07	7.37	21.3	0.69	14.4
1016770	U3-T4	01/07/03	2.15	29.2	13.4	16.9	50.0
1016772	Alcove 8	01/22/03	2.08	7.39	21.1	0.68	14.6
1016773	U1-T1	01/23/03	1.89	20.7	4.49	11.9	34.0
1016774	U1-T4	01/23/03	1.85	24.1	3.17	15.3	37.1
1016775	U3-T3	01/23/03	2.30	39.7	13.3	24.7	55.8
1016777	U4-T4	01/23/03	2.01	37.7	14.3	22.6	45.0
1016778	U1-T1	01/27/03	1.99	20.7	4.91	10.8	34.0
1016780	U1-T4	01/27/03	1.87	24.3	3.20	14.5	37.1
1016781	U1-T5	01/27/03	2.29	31.6	3.07	22.9	52.2
1016782	U3-T2	01/27/03	2.16	32.3	10.8	19.3	44.1
1016783	U3-T3	01/27/03	2.30	40.9	13.8	24.9	56.5
1016784	U3-T4	01/27/03	2.18	27.6	12.4	14.3	47.3
1016785	U3-T5	01/27/03	1.90	19.9	11.3	9.08	33.7
1016786	U4-T4	01/27/03	2.06	39.4	15.0	22.0	46.1
1017056	Alcove 8	09/18/02	2.04	8.26	22.7	0.84	13.4
1017058	Alcove 8	10/01/02	2.06	7.37	20.8	0.56	13.9
1017060	Alcove 8	10/16/02	2.07	7.38	21.0	0.65	14.2
1017063	Alcove 8	11/05/02	2.01	7.34	21.0	0.54	14.6
1017064	U4-T2	11/06/02	1.98	22.5	7.58	11.4	33.0
1017066	U4-T5	11/20/02	2.13	30.2	8.36	20.5	41.8
1017067	U1-T5	11/20/02	2.33	35.0	2.98	19.9	52.0
1017068	U3-T5	11/20/02	2.06	21.2	10.7	10.7	33.2
1017069	U1-T1	01/30/03	1.96	20.9	4.77	11.4	34.3
1017070	U1-T3	01/30/03	2.18	25.2	3.40	16.2	40.2
1017071	U1-T4	01/30/03	1.87	24.1	3.22	14.7	36.9
1017072	U1-T5	01/30/03	2.23	31.3	3.00	23.7	51.6
1017073	U3-T2	01/30/03	2.17	31.7	11.2	19.0	43.5
1017074	U3-T3	01/30/03	2.33	41.0	13.8	25.1	56.6
1017075	U3-T4	01/30/03	2.12	26.8	12.0	14.8	46.3
1017076	U3-T5	01/30/03	1.91	20.3	11.5	9.0	33.1
1017077	U4-T4	01/30/03	2.02	35.9	13.6	20.7	43.8
1017078	Alcove 8	02/03/03	2.10	7.63	21.6	ND	15.1
1017079	U1-T1	02/03/03	1.91	20.7	4.91	10.7	34.0
1017080	U1-T3	02/03/03	2.19	25.6	3.43	16.5	41.2
1017081	U1-T4	02/03/03	1.86	23.9	3.31	14.1	36.5
1017082	U1-T5	02/03/03	2.20	32.0	3.06	24.5	52.5
1017083	U3-T2	02/03/03	2.17	31.7	11.7	18.8	43.5

SMF Sample ID	Sample Location	Collection Date	F (ppm)	Cl (ppm)	Br (ppm)	NO3 (ppm)	Sulfate (ppm)
1017084	U3-T3	02/03/03	2.27	40.4	13.6	24.4	55.2
1017085	U3-T4	02/03/03	2.13	26.4	11.9	14.4	46.2
1017086	U3-T5	02/03/03	1.91	19.7	11.1	8.31	32.8
1017087	U4-T3	02/03/03	1.94	25.2	9.20	8.31	37.3
1017088	U1-T1	02/10/03	1.94	20.7	4.89	10.3	34.1
1017089	U1-T3	02/10/03	2.15	24.8	3.39	15.7	39.0
1017090	U1-T4	02/10/03	1.91	24.7	3.08	15.2	38.0
1017091	U1-T5	02/10/03	2.29	31.8	3.10	24.9	50.5
1017092	U3-T2	02/10/03	2.16	31.1	11.7	17.9	42.8
1017093	U3-T3	02/10/03	2.27	39.8	13.5	23.5	54.8
1017094	U3-T4	02/10/03	2.17	26.2	11.9	13.7	46.4
1017095	U3-T5	02/10/03	1.91	19.3	10.8	7.36	32.6
1017096	U4-T3	02/10/03	1.98	26.7	9.59	11.6	37.7
1017097	U4-T4	02/10/03	2.09	37.9	14.4	19.5	45.2
1017098	Alcove 8	02/11/03	2.10	7.69	21.7	0.54	15.2

SMF – Sample Management Facility.

UCCSN Data Id Number: 035IF.002 Q

YMP Data Tracking Number: MO0307UCC035IF.002

Appendix D

Sodium, Potassium, Calcium, and Magnesium Concentration Data

SMF Sample ID	Sample Location	Collection Date	Sodium (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)
1017057	Alcove 8	09/24/02	41.5	4.60	5.37	0.24
1017058	Alcove 8	10/01/02	43.6	4.37	4.10	0.19
1017059	Alcove 8	10/08/02	38.6	4.93	4.34	0.18
1017060	Alcove 8	10/16/02	40.3	4.36	4.73	0.18
1017061	Alcove 8	10/24/02	36.9	4.71	4.57	0.20
1017062	Alcove 8	10/29/02	37.1	4.37	4.71	0.19
1017063	Alcove 8	11/05/02	38.5	5.08	5.00	0.20
1017064	U4-T2	11/06/02	33.6	0.83	31.3	4.07
1017064	U4-T2	11/06/02	35.6	0.95	29.5	4.16
1017065	Alcove 8	11/13/02	41.6	4.70	4.86	0.19
1017066	U4-T5	11/20/02	32.6	0.70	33.3	4.50
1017067	U1-T5	11/20/02	34.4	0.87	40.7	5.24
1017068	U3-T5	11/20/02	26.5	0.66	29.4	3.67
1017070	U1-T3	01/30/03	33.6	0.76	28.9	4.21
1017078	Alcove 8	02/03/03	46.1	4.67	4.60	0.22
1017088	U1-T1	02/10/03	29.9	0.71	28.1	3.83
1017089	U1-T3	02/10/03	33.5	0.75	28.6	4.16
1017090	U1-T4	02/10/03	30.1	0.75	30.6	4.40
1017091	U1-T5	02/10/03	37.7	0.85	34.6	5.14
1017092	U3-T2	02/10/03	37.3	0.80	31.9	4.29
1017093	U3-T3	02/10/03	45.3	0.83	36.4	4.94
1017094	U3-T4	02/10/03	37.7	0.77	30.5	4.03
1017095	U3-T5	02/10/03	29.0	0.66	27.6	3.78
1017096	U4-T3	02/10/03	34.5	0.71	32.2	4.49
1017097	U4-T4	02/10/03	37.9	0.79	37.5	4.99
1017098	Alcove 8	02/11/03	44.6	4.69	4.65	0.22

SMF – Sample Management Facility.

UCCSN Data Id Number: 035TJ.001 Q

YMP Data Tracking Number: MO0307UCC035TJ.001

Appendix E

List of Approved Tracers

LIST OF APPROVED TRACERS

Maximum Tracer Concentrations and Quantities at Alcove 8/Niche 3
October 21, 2002

Tracer	Maximum Quantity Injected (grams or liters)	Maximum Concentration (ppm)
Lithium Bromide	1,000 g	500
Potassium Fluoride	100 g	50
Potassium Iodide	50 g	10
2,3-Difluorobenzoic Acid	50 g	50
2,4-Difluorobenzoic Acid	50 g	50
2,5-Difluorobenzoic Acid	50 g	50
2,6-Difluorobenzoic Acid	50 g	50
3,4-Difluorobenzoic Acid	50 g	50
3,5-Difluorobenzoic Acid	50 g	50
2,3,4-Trifluorobenzoic Acid	50 g	50
2,3,6-Trifluorobenzoic Acid	50 g	50
2,4,5-Trifluorobenzoic Acid	50 g	50
2,4,6-Trifluorobenzoic Acid	50 g	50
3,4,5-Trifluorobenzoic Acid	50 g	50
2,3,4,5-Tetrafluorobenzoic Acid	50 g	50
Pentafluorobenzoic Acid	50 g	50
FD&C Blue No. 1	20 g	20
Sulpho Rhodamine B	10 g	10
Fluorescein	10 g	10
Pyranine	10 g	10
Rhodamine WT	10 g	10
Fluorescent Microspheres	1 L	---