

Colorado School of Mines Research Institute Site

April 30, 2007



**Monitoring Report for CSMRI
Creekside Facility
First Quarter 2007**



Prepared for:
**Colorado School of Mines Research Institute
Golden, CO**



Prepared by:
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Stoller

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1. Introduction

This report presents the first quarter (January, February, and March) 2007 results for air monitoring, groundwater monitoring, and surface water monitoring conducted at the Colorado School of Mines Research Institute (CSMRI) site in Golden, Colorado. The monitoring was conducted by the S.M. Stoller Corporation (Stoller) under the guidance of the Colorado School of Mines (CSM). During this time period, seven additional groundwater monitor wells (CSMRI-1B, CSMRI-6B, CSMRI-7B, CSMRI-8, CSMRI-9, CSMRI-10, and CSMRI-11) were installed. Monitor wells CSMRI-6B and CSMRI-7B were installed as replacement monitor wells for two previously existing monitor wells that were abandoned due to soil excavation remediation. The 'B' series offsets for monitor wells CSMRI-6 and CSMRI-7 were installed by Stoller in February 2007 to resume groundwater characterization near their original locations. Figure 1 presents the monitor well locations on the CSMRI site.

2. Sampling and Analysis

On February 27, March 1, and March 8, 2007, Stoller obtained quarterly samples for groundwater and surface water. Water quality samples were obtained on February 27 (CSMRI 9, CSMRI-10, CSMRI-11); March 1 (CSMRI-1, CSMRI-1B partial); and March 8 (CSMRI-1B additional, CSMRI-2, CSMRI-4, CSMRI-5, CSMRI-8). Monitor well CSMRI-1B was sampled twice in order to collect sufficient volume for partial analyses. Due to the very slow recharge and the muddy conditions encountered inside this well, 5 gallons of distilled water were added to aid in the development of the well; a total of 6 gallons of water were removed prior to sample collection.

Surface water samples were collected from surface water locations SW-1 and SW-2 on March 1 and March 8, 2007, respectively. All aqueous samples were placed in iced coolers and couriered to Paragon Analytics Laboratory, Inc. of Fort Collins, Colorado for same-day delivery.

Air filter samples were obtained monthly on January 18, February 17, and March 16, 2007. Air samples were collected from filters of two onsite air monitor stations, AS-East and AS-West.

Figure 1 of the CSMRI site presents the monitor well, surface water sample, and air sampling station locations. The figure also presents a groundwater elevation map based on depth to groundwater relative to the surveyed top of casing between the time period of February 27 and March 8.

2.1 Atmospheric Monitoring

Particulate monitoring has been conducted at two locations within the CSMRI site at the locations shown on Figure 1. The monitoring was conducted using low-volume air sampling pumps with 47-millimeter-diameter filters. The pumps generally have run continuously beginning February 15, 2005. The pump filters are collected once per month and sent to Paragon Analytics Laboratory for analysis. Samples were collected following the procedures outlined in Appendix A, *Long-Lived Airborne Radioparticulate Survey*. The samples from each pump were analyzed for gross alpha, gross beta, Ra-226, Th-228, Th-230, Th-232, U-234, U-235, U-238, and total U.

The pumps are placed about 4 feet off the ground. The pumps are located in protective housing that prevents precipitation from contacting the samplers but still allows for air circulation around the samplers.

2.2 Groundwater Sampling

Groundwater samples were obtained from monitoring wells CSMRI-9, CSMRI-10, and CSMRI-11 on February 27; from CSMRI-1, CSMRI-1B (partial), and surface water SW-1 on March 1; and from CSMRI-1B (partial), CSMRI-2, CSMRI-4, CSMRI-5, CSMRI-8, and surface water SW-2 on March 8, 2007. Offset monitor wells CSMRI-6B and CSMRI-7B were dry at the time of sample collection; historically the area in the vicinity of these wells has yielded sufficient sample volume of groundwater for laboratory analyses.

Water quality samples were collected following the procedures outlined in Appendix B, *Groundwater Sampling Procedures*. All monitor wells have depth to water measured to the nearest 1/100th of a foot (0.01) prior to sample purging. Graphs of water table elevation are presented as Figure 2 for monitor wells CSMRI-1, CSMRI-4 and CSMRI-5; and as Figure 3 for monitor well CSMRI-2. The hydrograph figures (Figures 2 and 3) present data for the four monitor wells that have been measured quarterly since March 2005.

The Figure 2 hydrograph reflects the seasonal trends of flow in Clear Creek due to the proximity of the monitor wells to the creek. Monitor well CSMRI-1 is located upstream of CSMRI-4 and CSMRI-5, which accounts for some of the difference in elevation between the wells as shown on Figure 2. The Figure 3 hydrograph for monitor well CSMRI-2, located near the southeast corner of the freshman parking lot on West Campus Drive and the Welch Ditch, reflects the use of the irrigation ditch during the summer months. As potentiometric surface data are developed for the seven monitor wells that were recently installed, the data will be incorporated into the hydrographs.

Sample collection field forms that record the water quality parameters of the monitor well water as it is purged and the volume removed are provided in Appendix C. After parameter stabilization, the water samples are filtered through a 0.45 μ filter, collected in laboratory provided containers, and preserved in the field as appropriate for the analyte and analytical method.

2.3 Surface Water Sampling

Surface water samples were collected from two locations along Clear Creek: one upstream of the site and one downstream of the site as shown on Figure 1. Samples were collected on March 1 and March 8, 2007, for SW-1 and SW-2, respectively. The surface water samples were collected following the Surface Water Sampling procedures in Appendix D. Water samples are filtered through a 0.45 μ filter, collected in laboratory provided containers, and preserved in the field as appropriate for the analyte and analytical method.

A graph of the stream flow in Clear Creek during the first quarter from January 2007 through March 2007 is attached as Figure 4. Beginning about December 20, 2006 through February 20, 2007, ice along Clear Creek affected stream flow measurements. Flow in Clear Creek at the time of sample collection was measured at approximately 56 cubic feet per second (cfs) on February

27, 70 cfs on March 1, and at 56 cfs on March 8 at the USGS Golden, Colorado Clear Creek gauging station ([USGS Surface Water Online Database](#)).

2.4 Analyses

All samples collected were analyzed using a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)-certified analytical laboratory. The results received from the laboratory were evaluated based on the following parameters:

- Data completeness
- Holding times and preservation
- Instrument initial calibrations
- Instrument performance checks
- Preparation blanks
- Duplicate sample results
- Laboratory control samples results
- Compound quantitation and reporting limits (full validation only)

Data validation reports are attached in Appendix E. The January and February 2007 air filter results failed for method blank (MB) and laboratory control samples (LCS) for isotopic uranium and isotopic thorium analyses due to low quality control recoveries. The qualified air filter analytical data are presented in Table 2-1 but are in bold italicized font.

No laboratory anomalies with the groundwater and surface water samples were identified during the data validation review.

2.4.1 Atmospheric Analyses

Paragon Analytics, Inc. of Fort Collins, Colorado, performed laboratory analyses of the monthly air monitoring filters. The filters from the sampling locations were analyzed for gross alpha, gross beta, Ra-226, Th-228, Th-230, Th-232, U-234, U-235, U-238, and total U. Data are reviewed for completeness, accuracy, and calibration; results of the QA/QC review are presented in Appendix E. The results of these analyses are presented in Appendix F on a compact disk as a series of Excel spreadsheets. A summary of the results is presented in Table 2-1. Where negative values exist in the data, the values are within uncertainty boundaries.

2.4.2 Groundwater Quality Analyses

Paragon Analytics, Inc. conducted laboratory analyses of the aqueous samples. The groundwater and surface water samples were analyzed for the metals Ag, As, Ba, Ca, Cd, Cr, Hg, K, Mg, Mo, Na, Pb, Se, V, and Zn as well as the radioisotopes Ra-226, Ra-228, Th-228, Th-230, Th-232, and U. Since the first quarter of monitoring in February 2005, the concentration of total U in micrograms per liter (ug/l) had been analyzed using Paragon method 714R9. In this method, the concentration of uranium is calculated based on the activity of the uranium isotopes U-234, U-235, and U-238. Effective with the first quarter 2007 sampling event, the concentration of uranium is now analyzed using mass spectrometry method EPA 6020, which analyzes for uranium and not for the individual isotopes.

Samples of the groundwater and surface water were also collected and submitted for anions and cations analyses. The anions analyses included carbonate/bicarbonate as CaCO₃, Cl, F, NO₃/NO₂ as nitrogen, and SO₄. Cations analyses included Al, Ca, Fe, Mg, Mn, K, and Na. The analytical results of the anion and cation analyses are presented in Appendix G, which includes a Piper trilinear diagram, summary table of the analytical results, and an anion/cation balance summary report from Paragon Laboratories. A discussion of the analytical results of the anion and cation analysis is presented in Section 3.3.4, Groundwater Geochemical Analysis.

An equipment blank was also analyzed for quality control purposes, as described in the Data Validation Report. Results of the data validation analysis are included as Appendix E, and the chain-of-custody documentation are included as Appendix H. A summary of groundwater results for radioisotopes and metals is presented in Table 2-2 and Table 2-3, respectively. Groundwater parameters are reported as dissolved concentration in milligrams per liter (mg/l) for metals; picoCuries per liter (pCi/l) for radioisotopes; and micrograms per liter (ug/l) for uranium. Groundwater samples were measured onsite for temperature, pH, and specific conductance during the purging and sampling process. Onsite measurement parameters are presented on the sample collection forms in Appendix C.

2.4.3 Surface Water Analyses

A summary of surface water results for radioisotopes and metals is presented in Table 2-4 and Table 2-5, respectively. Surface water parameters are reported as dissolved concentration in mg/l for metals; pCi/l for radioisotopes; and ug/l for uranium. Surface water samples were measured onsite for temperature, pH, and specific conductance as the sampling was conducted. Onsite measurement parameters are presented on the sample collection forms in Appendix C.

2.5 *Health and Safety Program*

Stoller developed a program to protect the health and safety of field personnel for implementation of the environmental monitoring at the CSMRI site. This program has been developed in accordance with requirements of 29 CFR 1910.120.

3. Results

Results from samples collected from the CSMRI site during the first quarter 2007 are summarized on Tables 2-1 through 2-5. Table 2-6 presents historical data collected by previous consultants for select contaminants of potential concern in groundwater at the site. Table 2-7 presents the monthly historical air filter radioisotopic sample results collected by Stoller since March 2005. Tables 2-8 and 2-9 present the quarterly historical groundwater radioisotopic and metals sample results, respectively, collected by Stoller since February 2005. Tables 2-10 and 2-11 present the quarterly historical surface water radioisotopic and metals sample results, respectively, collected by Stoller since February 2005.

3.1 *Atmospheric Results*

Results from air sampling stations AS-East and AS-West are summarized in Table 2-1. Station AS-West is located adjacent to and west (upwind) of the stockpiled soil, and station AS-East is located adjacent to and east (downwind) of the stockpiled soil. The analytical results indicate no significant difference between the two sample locations. This indicates limited airborne

emissions from the site during this sampling period. All results are well below Colorado air standards as shown on Table 2-1.

3.2 Groundwater Conditions

Groundwater wells are located in areas likely to detect any impacts to groundwater emanating from the site as well as locations that represent background water quality. Wells CSMRI-4 and CSMRI-5 are located downgradient from the site near Clear Creek. Well CSMRI-1 is located along Clear Creek upstream from the site, and well CSMRI-2 is located offsite on the southeast corner of the freshman parking lot on West Campus Drive.

In February 2007, seven new groundwater monitor wells were installed to further characterize groundwater quality conditions at the CSMRI site and to assess the effectiveness of the source removal action that was conducted during the summer of 2006. Monitor well CSMRI-8 is located along Clear Creek within the flood plain area, and monitor wells CSMRI-1B, CSMRI-6B, CSMRI-7B, CSMRI-9, CSMRI-10, and CSMRI-11 are located on the upland areas and essentially encircle the CSMRI site.

3.3 Groundwater Quality

Groundwater samples were collected from nine monitor wells and tested for the presence of metals and radioisotopes as identified in Section 2.4.2. Monitor wells CSMRI-6B and CSMRI-7B were dry at the time of sample collection. Total uranium was detected in monitor wells CSMRI-4 and CSMRI-8 at concentrations of 48 ug/l and 1,100 ug/l, respectively. These values exceed the National Primary Drinking Water Standards Maximum Contaminant Levels (MCLs) for uranium in drinking water of 30 ug/l. Uranium was also detected in the remaining five monitor well samples but at concentrations significantly less than the MCL.

Uranium in groundwater in monitor well CSMRI-4 has historically had elevated concentrations of uranium, but the values have been declining since 1991. Figure 5 illustrates the decreasing concentration of uranium in CSMRI-4 since 1991. The spike in the concentration of uranium in 2003 was attributed to precipitation effects at the CSMRI site and removal of the site asphalt and concrete as discussed in Section 4.2.2 of the New Horizons RI-FS (New Horizons 2004). The recent spike in the concentration of uranium in March 2007 may be attributed to the significant snow that fell from late December 2006 through February 2007.

The historical uranium data presented in Table 2-6 are presented in pCi/l as “activity” yet recent (2005 through 2006) analytical data are presented in ug/l as “mass concentration.” The December 7, 2000 Federal Register discusses the final uranium MCL and presents a conversion factor of a geometric average mass:activity ratio of 0.9 pCi/g for values near the MCL, based on data from the National Inorganics and Radionuclides Survey.

Figure 6 presents the uranium concentration for 2005 through the first quarter (March) 2007 for monitor well CSMRI-4 and presents the elevation of the water table relative to the top of casing. The figure indicates the concentration of uranium had previously been fluctuating seasonally slightly above to below the MCL for the past eight quarterly sampling events in 2005, 2006, and 2007. The second quarter 2006 concentration of uranium at 26.8 ug/l for CSMRI-4 in Figure 6 may not be valid due to analytical laboratory tracer recoveries of less than 20 percent. A

discussion regarding the validity of this data point was presented in the second quarter 2006 report.

Uranium was also detected in monitor well CSMRI-8 at a concentration of 1,100 ug/l, which exceeds the MCL. This monitor well was installed in February 2007, and the initial sampling event was conducted shortly afterward. It is anticipated that the concentration will decrease significantly over the next several rounds of quarterly groundwater sampling events.

The groundwater at the CSMRI site will continue to be monitored on a quarterly basis, and the exceedances of uranium in monitoring wells CSMRI-4 and CSMRI-8 will continue to be evaluated as more data are made available.

3.3.1 Comparison of Upgradient and Downgradient Groundwater Quality

Wells CSMRI-4, CSMRI-5, and CSMRI-8 are downgradient from the site, and wells CSMRI-1, CSMRI-1B, CSMRI-9, CSMRI-10, and CSMRI-11 are upgradient from the site. Metals concentrations that are above detection limits vary widely regarding upgradient versus downgradient wells. Only the concentration of Ca and possibly Na appears to be slightly higher in the downgradient wells compared to the concentration in the upgradient monitor wells. The concentration of all other metals appears mixed for discerning trends in upgradient and downgradient metals. A discussion of the groundwater geochemical facies analyses from a comparison of anions and cations in groundwater at the CSMRI site is presented in Section 3.3.4, Groundwater Geochemical Analysis.

An analysis of radionuclides in downgradient well CSMRI-5 indicates levels of radium isotopes (Ra-226) greater than the upgradient wells but below the MCL. Uranium was detected in monitor well CSMRI-4 at a concentration of 48 ug/l and in CSMRI-8 at a concentration of 1,100 ug/l, which are greater than the MCL of 30 ug/l. As shown on Figure 6, there appears to be a seasonal correlation between fluctuations of the water table elevation and the concentration of uranium in monitor well CSMRI-4. The detected uranium in CSMRI-8 is for the initial sampling event and continued sampling and monitoring of water quality, geochemical parameters, and the fluctuating water table will be conducted to assess the presence of this analyte in the flood plain monitor wells.

3.3.2 Comparison with Previous Groundwater Quality Analyses

Table 2-6 presents recent groundwater analytical results with those from past sampling events for a select group of compounds. The data indicate a slight decreasing trend in contaminant concentrations over time, indicating improving groundwater quality. Only one round of sampling and data analyses has been conducted for the groundwater monitor wells that were installed in February 2007.

As additional data are collected and trends become more defined, graphs of concentration versus time will be produced and presented. This analytical data will be incorporated into Figure 6 to show longer-term trends and correlation between the detected concentration of uranium in groundwater and the fluctuating water table.

3.3.3 Comparison with Colorado Groundwater Standards

The statewide dissolved concentration standard of 5 pCi/l for the sum of Ra-226 and Ra-228 in drinking water set by the State of Colorado Water Quality Control Commission is not exceeded

in any of the sampled monitoring wells. The statewide dissolved concentration standard for drinking water for the sum of Th-230 and Th-232 at 60 pCi/l was not exceeded in any of the monitoring wells sampled. No exceedances of the MCL for tested metals were identified in any of the groundwater and surface water samples.

The EPA MCL for uranium in drinking water was exceeded in monitor wells CSMRI-4 and CSMRI-8 at a concentration of 48 ug/l and 1,100 ug/l, respectively. The CDPHE Water Quality Control (WQC) Commission will be evaluating state groundwater standards as part of their regular “triennial review” in 2007. WQC Division staff will be proposing that the Commission consider the adoption of EPA’s MCL for uranium (30 ug/l) as a state standard.

The spike in the concentration of uranium in CSMRI-4 may be attributed to the increased precipitation during the months of December 2006 through February 2007. This monitor well exhibited the same trend in 2003 during a prolonged high precipitation time period and when the asphalt cover and buildings associated with CSMRI had been removed.

The observed concentration of 1,100 µg/l measured at monitoring well CSMRI-8 may be the result of several reasons:

- The well contains residual uranium from the former pond area on the flood plain.
- There was a QC error in the sample collection or analysis.
- Uranium was disturbed and introduced into the well during well installation.
- The well contains residual uranium from the former Building 101 area at the top of the slope above the well.
- Uranium is naturally occurring in the Fox Hills bedrock formation.
- The well is located in a zone where strong mixing between creek water and groundwater occurs, and the oxidizing conditions associated with creek water cause uranium to dissolve more readily.

Monitoring well CSMRI-8 will continue to be sampled on a quarterly basis with the other site wells, and the reason for the elevated level of uranium will be evaluated.

3.3.4 Groundwater Geochemical Analysis

One round of groundwater samples from the recently installed and existing monitor wells was collected in late February and early March 2007 and submitted for anions and cations analyses as well as the regularly scheduled, quarterly monitoring sample analytes. The additional sampling was conducted to assess the geochemical facies of the groundwater and to determine types of groundwater within the CSMRI site. Ionic balance results, as a comparison of the sum of anions and of the cations as milliequivalents per liter (meq/l), ranged from 0.41 percent (CSMRI-5) to 10.46 percent (CSMRI-11). Differences greater than five percent between the sum of the anions compared to the sum of the cations within a sample may be attributed to laboratory procedures or the presence of non-analyzed ions in the groundwater sample.

Results of the ionic analyses indicate two distinct types of groundwater within the monitored area of the CSMRI site. Monitor wells located on the upland portion of the CSMRI site (CSMRI-2, CSMRI-9, CSMRI-10, CSMRI-11) are a Ca-HCO₃ type water; and monitor wells

located in the flood plain area (CSMRI-1, CSMRI-4, CSMRI-5, and CSMRI-8) and Clear Creek surface water samples (SW-1 and SW-2) are a Ca-SO₄ type water. An ionic analysis from monitor well CSMRI-1B was not conducted due to insufficient sample volume. Results of the ionic analyses are presented in Appendix G. Appendix G also presents a Piper trilinear diagram of the CSMRI groundwater and a cation-anion summary balance report from Paragon Analytics.

The groundwater sample from monitor well CSMRI-2, as shown on the Piper trilinear diagram in Appendix G as a blue diamond symbol, is distinctly different from the rest of the sample population when plotted in the center diamond of the Piper diagram. Hydrographs from quarterly groundwater monitoring of the potentiometric surface of monitor well CSMRI-2 indicate a seasonal response to flow and leakage from the adjacent Welch Ditch. During the summer months, the water table at this location typically rises almost 15 feet and then recedes during the winter months. This monitor well is located approximately 600 feet southeast of the CSMRI site.

The anion triangle on the right lower side of the Piper diagram shows groundwater from CSMRI-2 is dominated by the HCO₃ and CO₃ anion, and the groundwater sample from CSMRI-8 is dominated by the SO₄ anion. The cation triangle on the lower left of the Piper diagram indicates Ca as the slightly dominant cation.

The Piper diagram also shows the similarity of the groundwater ions for the monitor wells where the symbols representing each of the samples are plotted on top of each other. Specifically, this includes monitor wells CSMRI-9, CSMRI-10, and CSMRI-11, which are all co-located at the same position on the Piper diagram and physically are located on the upland portion of the CSMRI site. Additionally, the CSMRI-1 sample and surface water samples SW-1 and SW-2 are each co-located at the same position within the Piper diagram, which would be expected given the source of the samples and the influence Clear Creek has on CSMRI-1.

There is evidence of mixing between creek water and groundwater in the flood plain wells, as indicated by lower water temperatures, higher conductivity, higher total dissolved solids, and higher pH than the upland wells.

3.4 Surface Water Quality

Surface water samples are collected from two locations at the site. Location SW-1 is located upstream from the site and the second location, SW-2, is downstream from the site. The upstream and downstream surface-water concentrations of all metals and radionuclides detected at the CSMRI site from stations SW-1 and SW-2 are somewhat similar. The metals detected above the detection limit were Ca, K, Mg, Na, and Zn. No established MCLs were exceeded.

4. Activities for First Quarter 2007

First quarter 2007 activities at the site included the installation of seven new groundwater monitor wells. Following the installation of the monitor wells, all monitor wells on the CSMRI site were surveyed by Flatirons Survey, Inc. of Boulder, Colorado. Appendix I presents the results of the survey and identifies the GPS coordinants and the elevation of the top of casing (TOC) measuring points (north side) for each monitor well. As-built construction diagrams for each of the new monitor wells installed in February 2007 are also presented in Appendix I.

5. References

New Horizons Environmental Consultants, Inc. *Remedial Investigation/Feasibility Study and Proposed Plan, Colorado School of Mines Research Institute Site, Golden, CO*, January 21, 2004.

Stoller, *Final Site Characterization Work Plan*, May 2006.

USGS Surface Water website: <http://nwis.waterdata.usgs.gov>

Table 2-1
Summary of Radioisotopes in Air
 (All results in microcuries per milliliter)

Sample Station	Sample Date	Gross Alpha		Gross Beta		Ra-226		Th-228		Th-230		Th-232		U-234		U-235		U-238		Total U	
		Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty
AS-East	1/18/2007	1.72E-15	3.26E-16	8.95E-15	1.48E-15	8.89E-18	1.24E-16	2.96E-17	1.04E-16	1.96E-16	1.57E-16	2.67E-17	5.04E-17	6.52E-17	6.52E-17	0	5.93E-17	2.96E-18	5.04E-17	6.82E-17	1.01E-16
AS-West	1/18/2007	1.37E-15	2.82E-16	7.79E-15	1.30E-15	4.15E-17	1.19E-16	6.82E-17	8.00E-17	5.93E-17	1.16E-16	-2.96E-18	3.56E-17	5.63E-17	5.93E-17	2.96E-18	5.33E-17	2.96E-18	4.45E-17	6.22E-17	9.19E-17
AS-East	2/17/2007	1.10E-15	2.45E-16	1.21E-14	1.99E-15	1.42E-16	1.81E-16	3.20E-17	1.10E-16	1.14E-16	1.67E-16	5.69E-17	6.40E-17	1.60E-16	1.14E-16	-3.56E-18	7.11E-17	9.60E-17	8.89E-17	2.52E-16	1.64E-16
AS-West	2/17/2007	1.19E-15	2.63E-16	1.52E-14	2.49E-15	2.10E-16	1.53E-16	9.96E-17	1.32E-16	4.87E-16	2.31E-16	3.20E-17	5.33E-17	1.03E-16	8.89E-17	2.13E-17	7.47E-17	1.42E-17	6.40E-17	1.42E-16	1.32E-16
AS-East	3/16/2007	8.93E-16	2.17E-16	6.99E-15	1.19E-15	-1.98E-17	2.09E-16	-3.16E-17	7.90E-17	-7.51E-17	1.19E-16	2.37E-17	4.74E-17	2.37E-17	5.93E-17	-3.95E-18	6.72E-17	3.56E-17	5.93E-17	5.53E-17	1.07E-16
AS-West	3/16/2007	6.88E-16	1.82E-16	1.09E-14	1.82E-15	2.77E-17	1.38E-16	6.72E-17	1.15E-16	3.56E-17	1.50E-16	7.51E-17	7.11E-17	7.51E-17	7.90E-17	-3.95E-18	7.11E-17	1.15E-16	9.09E-17	1.90E-16	1.38E-16
Unrestricted use limit*	NE	NE		NE		9E-13		3E-14		2E-14		4E-15		1E-12		1E-12		1E-12		9E-13	

*6 CCR 1007-1 Part 4, Appendix 4B, Table 4B-2, assuming Class W

NE – Not Established

Bold Italicized data are qualified : See Section 2.4 in report narrative.

Table 2-2
Summary of Radioisotopes in Groundwater
 (All results in picoCuries per liter)

Sample Station	Sample Date	Ra-226		Ra-228		Th-228		Th-230		Th-232		U-234		U-235		U-238		Total U (ug/l)	
		Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty
CSMRI-1	3/1/2007	0.32	0.42	0.78	0.39	0.052	0.079	-0.031	0.057	0.012	0.025	NT	NA	NT	NA	NT	NA	1.2	NA
CSMRI-1B	3/8/2007	0.13	0.52	1.19	0.48	-0.03	0.12	-0.09	0.11	0.02	0.045	NT	NA	NT	NA	NT	NA	2.7	NA
CSMRI-2	3/8/2007	0.76	0.54	2.15	0.74	0.022	0.06	-0.01	0.045	0.011	0.015	NT	NA	NT	NA	NT	NA	0.72	NA
CSMRI-4	3/8/2007	0.09	0.29	0.37	0.32	-0.034	0.058	-0.037	0.045	0.013	0.013	NT	NA	NT	NA	NT	NA	48	NA
CSMRI-5	3/8/2007	1.78	0.6	0.39	0.33	-0.012	0.05	-0.061	0.044	0	0.012	NT	NA	NT	NA	NT	NA	5.8	NA
CSMRI-8	3/8/2007	0.7	0.42	1.06	0.45	0.072	0.051	-0.031	0.045	0.016	0.016	NT	NA	NT	NA	NT	NA	1,100	NA
CSMRI-9	3/1/2007	0.12	0.17	0.53	0.36	-0.017	0.069	0.04	0.069	0.027	0.028	NT	NA	NT	NA	NT	NA	7.9	NA
CSMRI-10	3/1/2007	0.19	0.25	0.63	0.39	0.014	0.069	-0.004	0.059	0.018	0.021	NT	NA	NT	NA	NT	NA	7.8	NA
CSMRI-11	3/1/2007	0.16	0.27	0.46	0.35	0.051	0.086	0.085	0.08	0.007	0.021	NT	NA	NT	NA	NT	NA	4.8	NA
MCL*	Total Ra = 5		NE		Th 230 + Th 232 = 60**		NE		30										

*Maximum Contaminant Level – National Primary Drinking Water Regulations

**5 CCR 1002-41 Reg 41 – Colorado Groundwater Standards

NE - Not Established

NT – Not Tested

NA – Not Applicable

Table 2-3
Summary of Metals in Groundwater
 (All results in milligrams per liter)

Sample Station	Sample Date	Ag	As	Ba	Ca	Cd	Cr	Hg	K	Mg	Mo	Na	Pb	Se	V	Zn
CSMRI-1	3/1/2007	ND	ND	0.081 (B)	39	0.00045 (B)	0.00063 (B)	0.000017 (B)	3	12	0.0059 (B)	26	ND	0.0066	ND	0.048
CSMRI-1B	3/1/2007	ND	ND	0.098 (B)	130	ND	0.00014 (B)	0.000017 (B)	52	47	0.17	91	ND	0.0058	0.0009 (B)	ND
CSMRI-2	3/8/2007	ND	0.0058 (B)	0.12	88	ND	ND	ND	8.3	39	ND	21	ND	0.03	ND	0.0011 (B)
CSMRI-4	3/8/2007	ND	0.0057 (B)	0.072 (B)	120	0.00023 (B)	ND	0.000018 (B)	11	49	0.015	47	ND	0.019	ND	0.088
CSMRI-5	3/8/2007	ND	0.0037 (B)	0.063 (B)	80	ND	ND	ND	4.5	31	0.0019 (B)	34	ND	0.015	ND	0.083
CSMRI-8	3/1/2007	ND	0.0053 (B)	0.068 (B)	230	ND	ND	ND	23	72	0.094	74	ND	0.034	ND	0.0024 (B)
CSMRI-9	3/1/2007	ND	ND	0.08 (B)	69	ND	0.0011 (B)	0.000024 (B)	12	31	0.045	33	ND	0.011	0.001 (B)	ND
CSMRI-10	3/1/2007	0.00051 (B)	ND	0.064 (B)	79	ND	0.0013 (B)	0.000024 (B)	7.3	33	0.01	36	ND	0.01	0.0011 (B)	ND
CSMRI-11	3/1/2007	ND	ND	0.073 (B)	75	ND	0.00013 (B)	0.000023 (B)	9.7	29	0.033	33	ND	0.013	0.00073 (B)	0.0023 (B)
Detection Limits		0.01	0.01	0.1	1	0.005	0.01	0.0002	1	1	0.01	1	0.003	0.005	0.01	0.02
MCL*		NE	0.010	2	NE	0.005	0.1	0.002	NE	NE	NE	NE	0.015	0.05	NE	NE

*Maximum Contaminant Level – National Primary Drinking Water Regulations
 ND – Non Detect
 NE – Not Established
 (B) – Detected above Instrument Detection Level but below Reported Detection Level

Table 2-4
Summary of Radioisotopes in Surface Water
 (All results in picoCuries per liter)

Sample Station	Sample Date	Ra-226		Ra-228		Th-228		Th-230		Th-232		U-234		U-235		U-238		Total U (ug/l)	
		Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty	Result	Uncertainty
SW-1	3/1/2007	-0.1	0.39	0.25	0.33	-0.038	0.07	0.15	0.11	0.026	0.035	NT	NA	NT	NA	NT	NA	1.7	NA
SW-2	3/8/2007	0.12	0.23	0.73	0.38	0.047	0.04	-0.055	0.043	0	0.011	NT	NA	NT	NA	NT	NA	1.7	NA
MCL*		Total Ra 5				NE		Th 230 + Th 232 = 60**				NE		NE		NE		30	

*Maximum Contaminant Level – National Primary Drinking Water Regulations
 **5 CCR 1002-31 Reg 31 – Colorado Surface Water Standards
 NE – Not Established

Table 2-5
Summary of Metals in Surface Water
 (All results in milligrams per liter)

Sample Station	Sample Date	Ag	As	Ba	Ca	Cd	Cr	Hg	K	Mg	Mo	Na	Pb	Se	V	Zn
SW-1	3/1/2007	ND	ND	0.049 (B)	44	0.0011 (B)	0.00092 (B)	0.000023 (B)	4.3	11	0.0046 (B)	26	ND	ND	ND	0.22
SW-2	3/8/2007	ND	0.0053 (B)	0.049 (B)	39	0.00064 (B)	ND	ND	4.2	9.8	0.0014 (B)	22	ND	ND	ND	0.17
Detection Limits		0.01	0.01	0.1	1	0.005	0.01	0.0002	1	1	0.01	1	0.003	0.005	0.01	0.02
MCLs*		0.01	0.010	2	NE	0.005	0.1	0.002	NE	NE	NE	NE	0.015	0.05	NE	NE

*Maximum Contaminant Level – National Primary Drinking Water Regulations
 ND – Non Detect
 NE – Not Established
 (B) – Detected above Instrument Detection Level but below Reported Detection Level

Table 2-6
CSMRI Historical Groundwater Data (Previous Consultants)
 (All results in picoCuries per liter)

Well ID (d)	Analyte	1/1991 (a)	6/1991 (a)	3/1999 (b)	6/1999 (b)	6/1999 (b)	10/1999 (b)	2/2003 (c)	4/2003 (c)	7/2003 (c)	10/2003 (c)
CSMRI-1	Ra-226			0.1	0.3	0.3	0.2	<0.55	<0.45	ND (<0.38)	ND (<0.31)
	U Total			2.09	2.59	2.59	1.44	2.4	2.9	0.87	1.4
	Th-230			0.4	0.2	0.2	0.2	<0.19	0.21	ND (<0.13)	<0.15
CSMRI-2	Ra-226		1.9	1.9	1.4	1.4	1.4	1.4	2.8	2.1	1.7
	U Total	11	5.7	0.55	1.46	1.46	0.71	1.5	1.3	1.9	1.3
	Th-230		0	0.1	0.1	0.1	0.9	<0.17	0.43	0.20	0.31
CSMRI-3	Ra-226		0.6	1.5	1.2	1.2	1.6	<0.75	<0.81	ND (<0.49)	<0.98
	U Total	17	10.4	8.41	12.4	12.4	10	12	12	9	10
	Th-230		0	0.3	0.3	0.3	1.1	<0.12	ND (<0.15)	ND (<0.17)	ND (<0.14)
CSMRI-4	Ra-226		1	<0.4	0.6	0.6	0.4	<0.85	<0.42	<0.32	ND (<0.64)
	U Total	86	57.3	23.4	58.6	58.6	33.7	16	34.2	53	19
	Th-230		0	0.7	0.3	0.3	0.4	<0.099	ND (<0.15)	ND (<0.17)	ND (<0.12)
CSMRI-5	Ra-226		0.6	2.4	3.3	3.3	2.7	ND (<0.49)	1.1	2.6	1.59
	U Total	14	16.8	3.6	3.6	3.6	4	2.8	2.3	2.7	3.3
	Th-230		0	0.2	0.2	0.2	1.4	0.062	ND (<0.14)	ND (<0.19)	ND (<0.13)

Notes: ND = Not Detected

a - Samples collected by Grant and Associates and analyzed by Barringer Labs

b - Samples collected by URS Greiner Woodward Clyde and analyzed by CORE Labs

c - Samples collected by New Horizons Environmental Consultants and analyzed by Paragon Analytics; Total U activity (pCi/l) calculated from concentration (ug/L) reported by Paragon.

d - Well Identification numbers changed from the 1991 data to the 1999 data. Data presented account for this change

Table 2-7
Historical Summary of Radioisotopes in Air (Stoller)
 (All results in microCuries per milliliter)

Sample Station	Sample Date	Gross Alpha	Gross Beta	Ra-226	Th-228	Th-230	Th-232	U-234	U-235	U-238	Total U
AS-East	3/17/05	1.3E-15	1.3E-14	1.4E-16	6.8E-17	7.1E-17	4.1E-17	2.5E-16	1.3E-17	8.2E-17	3.5E-16
	4/18/05	1.2E-15	1.2E-14	5.3E-17	1.7E-17	8.7E-17	3.0E-18	9.8E-17	1.0E-17	3.2E-17	1.4E-16
	5/11/05	6.1E-16	8.0E-15	9.3E-18	5.1E-17	1.4E-17	-3.3E-18	7.5E-17	-3.3E-17	4.8E-17	1.2E-16
	6/14/05	7.2E-16	1.1E-14	6.3 E-17	-4.4E-17	2.5E-17	1.7E-17	6.1E-17	6.0E-18	3.1E-17	9.7E-17
	7/12/05	5.11E-16	1.3E-14	0	9.5E-17	9.5 E-17	2.1E-17	9.1E-17	1.6E-17	4.5E-17	1.5E-16
	8/16/05	9.1E-16	1.6E-14	1.1E-16	1.1E-17	0	7.9E-18	1.5E-16	1.2E-18	2.8E-17	1.8E-16
	9/14/05	1.3E-15	1.5E-14	-6.3E-17	4.8E-17	4.8 E-17	3.6E-17	6.7E-17	0	3.7E-18	7.0E-17
	10/11/05	1.78E-15	1.43E-14	7.31E-16	6.32E-17	1.98E-17	-3.16E-18	8.30E-17	9.88E-18	2.77E-17	1.22E-16
	11/10/05	1.14E-15	1.31E-14	1.64E-16	3.56E-17	7.47E-17	1.60E-16	8.18E-17	1.42E-17	8.89E-17	1.85E-16
	12/20/05	9.60E-16	5.44E-15	2.03E-16	2.40E-17	-6.67E-17	2.93E-17	2.93E-17	8.00E-18	5.60E-17	9.60E-17
	1/19/06	8.71E-16	6.05E-15	1.17E-16	3.20E-17	9.96E-17	4.98E-17	2.13E-16	7.11E-18	6.76E-17	2.88E-16
	2/16/06	8.38E-16	9.79E-15	9.91E-17	-3.81E-17	-7.62E-17	2.29E-17	1.52E-16	6.48E-17	1.64E-16	3.81E-16
	3/15/06	8.30E-16	1.39E-14	-5.93E-17	2.77E-17	-4.74E-17	7.90E-18	6.32E-17	-3.95E-18	3.16E-17	9.09E-17
	4/14/06	7.93E-16	1.18E-14	-4.27E-17	0	3.56E-17	6.40E-17	4.27E-17	1.42E-17	1.78E-17	7.11E-17
	5/15/06	7.95E-16	1.17E-14	3.44E-17	3.44E-18	-1.93E-16	6.88E-18	9.29E-17	1.72E-17	6.88E-17	1.79E-16
	6/15/06	8.02E-16	1.51E-14	4.13E-17	4.47E-17	1.93E-16	5.85E-17	1.69E-16	-3.44E-18	5.16E-17	2.20E-16
	7/17/06	3.00E-15	1.20E-14	1.00E-16	3.33E-18	-1.00E-17	4.33E-17	1.47E-16	0	5.00E-17	1.97E-16
	8/7/06	2.95E-15	1.41E-14	3.00E-16	1.93E-16	-1.02E-16	-9.14E-18	1.98E-16	3.05E-17	1.12E-16	3.40E-16
	9/13/06	1.64E-15	1.28E-14	8.65E-17	8.65E-18	-2.31E-17	1.12E-17	5.48E-17	-1.15E-17	7.21E-17	1.15E-16
	10/23/2006	7.60E-16	1.10E-14	1.33E-16	-2.67E-17	8.00E-18	-5.33E-18	4.27E-17	1.33E-17	3.47E-17	9.07E-17
	11/15/2006	1.33E-15	1.50E-14	-2.78E-17	5.57E-17	3.25E-17	1.39E-17	6.03E-17	1.86E-17	2.32E-17	1.02E-16
	12/13/2006	1.57E-15	8.19E-15	1.64E-16	1.91E-17	6.86E-17	-3.81E-18	4.57E-17	1.91E-17	6.48E-17	1.26E-16
AS-West	3/17/05	1.4E-15	1.5E-14	2.5E-16	2.5E-17	0	3.3E-17	4.2E-16	7.1E-18	7.3E-17	5.0E-16
	4/18/05	1.2E-15	1.2E-14	-1.0E-17	1.7E-17	-2.3 E-17	2.5E-17	2.5E-16	1.2E-17	5.5E-17	3.1E-16
	5/11/05	5.8E-16	8.0E-15	-1.3E-16	-4.7E-18	3.3E-17	1.5E-17	1.7E-16	1.4E-17	4.6E-17	6.5E-17
	6/14/05	8.8E-16	9.8E-15	1.0E-16	8.5E-18	1.6E-17	7.5E-17	1.4E-16	1.4E-17	3.0E-17	1.9E-16
	7/12/05	8.8 E-16	1.4E-14	2.7E-17	7.6E-18	2.3E-17	3.4E-17	2.2E-16	2.3E-17	7.6E-17	3.2E-16
	8/16/05	1.2E-15	1.5E-14	2.0E-16	2.1E-17	1.0E-16	1.1E-17	4.9E-16	1.8E-17	6.4E-18	7.3E-17
	9/14/05	1.4E-15	1.5E-14	-1.1E-17	5.9E-17	7.0E-17	7.0E-18	8.1E-17	0	3.8E-17	1.2E-16
	10/11/05	1.62E-15	1.6E-14	2.29E-15	2.77E-17	3.16E-17	7.11E-18	1.86E-16	5.02E-17	9.88E-17	3.32E-16
	11/10/05	1.85E-15	1.48E-14	8.18E-17	-2.13E-17	-2.13E-17	2.49E-17	9.25E-17	1.07E-17	2.49E-17	1.28E-16
	12/20/05	7.90E-16	1.03E-14	2.67E-17	1.33E-17	-5.87E-17	1.87E-17	9.87E-17	1.60E-17	5.07E-17	1.63E-16
	1/19/06	5.09E-16	7.36E-15	1.07E-16	1.07E-17	9.96E-17	7.11E-18	1.53E-16	0	8.54E-17	2.42E-16
	2/16/06	7.85E-16	1.04E-14	-6.10E-17	3.43E-17	-2.29E-17	4.95E-17	8.38E-17	-1.14E-17	4.95E-17	1.22E-16
	3/15/06	8.46E-16	1.27E-14	-5.53E-17	7.90E-18	7.51E-17	3.16E-17	8.30E-17	2.37E-17	2.37E-17	1.34E-16
	4/14/06	1.07E-15	1.23E-14	-1.53E-16	3.20E-17	-4.62E-17	1.42E-17	8.18E-17	1.42E-17	6.05E-17	1.56E-16
	5/15/06	5.95E-16	1.23E-14	9.98E-17	1.38E-17	-5.16E-17	2.75E-17	1.96E-16	6.19E-17	6.88E-17	3.27E-16
	6/15/06	9.57E-16	1.41E-14	-1.38E-17	1.03E-17	2.44E-16	6.88E-18	8.26E-17	1.38E-17	5.51E-17	1.51E-16
	7/17/06	3.60E-15	1.23E-14	5.67E-16	2.67E-17	4.33E-17	9.67E-17	3.93E-16	3.67E-17	1.17E-16	5.47E-16
	8/7/06	2.29E-15	1.57E-14	2.24E-16	1.22E-16	-6.60E-17	3.56E-17	3.20E-16	1.02E-17	1.22E-16	4.57E-16
	9/13/06	1.07E-15	1.41E-14	-1.38E-17	1.01E-16	-2.60E-17	2.31E-17	2.31E-17	1.44E-17	8.65E-18	4.61E-17
	10/23/2006	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
	11/15/2006	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
	12/13/2006	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample
Unrestricted use limit*		NE	NE	9E-13	3E-14	2E-14	4E-15	1E-12	1E-12	1E-12	9E-13

* 6 CCR 1007-1 Part 4, Appendix 4B, Table 4B-2, assuming Class W
 NE – Not Established

**Table 2-8
 Historical Summary of Radioisotopes in Groundwater (Stoller)**

Sample Station	Sample Date	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	U-234 (pCi/l)	U-235 (pCi/l)	U-238 (pCi/l)	Total U (ug/l)	
CSMRI-1	2/25/05	-0.11	0.81	0.007	0.07	0.01	0.77	0.043	0.53	1.61	
	6/14/05	0.16	0.44	0.018	-0.021	0.012	0.43	0.011	0.217	0.64	
	9/7/05	0.1	0.63	0.068	0.167	0.114	0.85	0.053	0.43	1.3	
	12/20/05	-0.19	0.59	-0.045	0.32	0.014	0.94	0.073	0.46	1.41	
	3/15/06	-0.15	0.58	0.025	0.032	-0.004	1.76	0.11	0.92	2.8	
	6/14/06	0.42	0.05	0.15	-0.06	0.062	0.18	0.18	0.08	0.31	
CSMRI-2	9/13/06	0.25	0.34	0.11	-0.079	0.027	0.45	0.051	0.25	0.77	
	2/25/05	0.8	1.85	0.07	-0.02	0.01	0.6	0.05	0.16	0.53	
	6/14/05	1.47	3.0	0.14	0.003	0.026	0.68	0.025	0.299	0.89	
	9/7/05	1.78	2.71	0.162	0.108	0.049	0.65	0.050	0.31	0.94	
	12/20/05	1.35	1.62	0.108	0.285	0.024	0.83	0.002	0.35	1.06	
	3/15/06	1.25	2.53	0.03	0.204	0.012	0.83	0.066	0.45	1.36	
CSMRI-4	6/14/06	0.99	1.79	0.25	0.22	0.049	0.69	0.04	0.25	0.76	
	9/13/06	1.01	2.35	0.088	-0.039	-0.008	0.46	0.014	0.28	0.85	
	2/25/05	-0.03	0.16	0.019	-0.009	0.013	9.7	0.53	8.2	24.7	
	6/14/05	0.26	0.34	0.013	0.014	0.005	11.4	0.49	10.6	31.4	
	9/7/05	0.17	0.78	-0.013	0.164	0.086	6.4	0.33	6.4	19.3	
	12/20/05	0.13	0.1	0.033	0.311	0.012	11.5	0.61	11.4	34.3	
CSMRI-5	3/15/06	0	0.38	0.004	0.174	0.007	9	0.43	9	27.1	
	6/15/06	0.41	0.39	0.11	0.17	0.061	9.2	0.4	8.9	26.8	
	9/13/06	-0.05	0.79	0.056	-0.015	0.007	6.5	0.35	6	17.9	
	2/25/05	1.06	0.53	0.009	0.007	0.034	1.22	0.056	0.93	2.8	
	6/14/05	2.51	0.44	-0.018	0.039	0.011	1.51	0.086	1.2	3.57	
	9/7/05	2.50	0.76	0.06	1.25	0.051	1.85	0.051	1.47	4.4	
MCL*	12/20/05	1.97	0.52	0.032	0.126	0.01	1.45	0.066	1.21	3.63	
	3/15/06	0.57	0.45	0.038	0.144	0.019	1.81	0.058	1.38	4.1	
	6/15/06	2.13	0.87	0.145	0.08	0.043	1.03	0.13	0.92	2.8	
	9/13/06	2.29	0.56	0.053	-0.053	0.005	3.18	0.17	2.32	7	
MCL*		Total Ra = 5		NE		Th 230 + Th 232 = 60**		NE		NE	30

*Maximum Contaminant Level – National Primary Drinking Water Regulations

**5 CCR 1002-41 Reg 41 – Colorado Groundwater Standards

pCi/l - picocuries per liter

NE – Not Established

ug/l – micrograms per liter

Table 2-9
Historical Summary of Metals in Groundwater (Stoller)

(All results in milligrams per liter)

Sample Station	Sample Date	Ag	As	Ba	Ca	Cd	Cr	Hg	K	Mg	Mo	Na	Pb	Se	V	Zn
CSMRI-1	2/25/05	ND	ND	ND	28	ND	ND	ND	2.8	9.4	ND	29	ND	ND	ND	0.032
	6/14/05	ND	ND	ND	17	ND	ND	ND	2.3	5.1	ND	16	ND	ND	ND	0.032
	9/7/05	ND	ND	.055 (B)	21	ND	ND	ND	2.9	6.3	0.0021 (B)	25	ND	0.0041 (B)	ND	.034
	12/20/05	ND	ND	0.067 (B)	32	ND	ND	0.000034 (B)	2.9	10	ND	26	ND	ND	ND	0.052
	3/15/06	ND	ND	0.064 (B)	33	ND	ND	0.00002 (B)	2.6	10	0.0013 (B)	24	ND	ND	ND	0.049
	6/14/06	ND	ND	0.031 (B)	10	ND	ND	ND	1.9	3	0.0051 (B)	9.2	ND	0.0035 (B)	ND	0.015 (B)
CSMRI-2	9/13/06	ND	ND	0.061 (B)	20	ND	0.041 (B)	ND	2.7	6	0.0038 (B)	14	ND	ND	ND	0.03
	2/25/05	ND	ND	0.11	72	ND	ND	ND	7.1	32	ND	19	ND	ND	ND	0.02
	6/14/05	ND	ND	0.1	76	ND	ND	ND	6.3	32	ND	18	ND	ND	ND	ND
	9/7/05	ND	ND	0.11	81	ND	ND	ND	7.1	35	ND	19	ND	ND	ND	0.011 (B)
	12/20/05	ND	ND	0.098 (B)	76	ND	ND	0.000031 (B)	6.7	33	ND	18	ND	ND	ND	0.0043 (B)
	3/15/06	ND	ND	0.09 (B)	74	ND	ND	0.000023 (B)	6.1	31	ND	17	ND	ND	ND	0.0059 (B)
CSMRI-4	6/14/06	ND	ND	0.093 (B)	70	ND	ND	ND	6.3	31	0.0048 (B)	17	ND	0.0031 (B)	ND	0.0092 (B)
	9/13/06	ND	ND	0.11	81	ND	ND	ND	6.7	35	0.0014 (B)	19	ND	ND	ND	0.0092 (B)
	2/25/05	ND	ND	ND	72	ND	ND	ND	5.1	31	0.017	29	ND	ND	ND	0.12
	6/14/05	ND	ND	ND	86	ND	ND	ND	6.6	34	0.038	34	ND	0.0063	ND	0.068
	9/7/05	ND	0.0035 (B)	0.055 (B)	82	ND	ND	ND	7.6	33	0.035	31	ND	0.0049 (B)	ND	0.097
	12/20/05	ND	ND	0.056 (B)	100	ND	ND	0.000045 (B)	6.8	43	0.024	34	ND	ND	ND	0.18
CSMRI-5	3/15/06	ND	ND	0.042 (B)	81	ND	ND	0.000034 (B)	5	35	0.021	29	ND	ND	0.00056 (B)	0.21
	6/15/06	ND	0.0031 (B)	0.055 (B)	89	0.00085 (B)	ND	0.0000049 (B)	8.3	37	0.03	31	ND	ND	0.0011 (B)	0.11
	9/13/06	ND	ND	0.043 (B)	66	ND	ND	0.000016 (B)	8.3	27	0.038	30	ND	ND	ND	0.082
	2/25/05	ND	ND	ND	54	ND	ND	ND	3.4	22	ND	27	ND	ND	ND	0.067
	6/14/05	ND	ND	ND	63	ND	ND	ND	3.3	23	ND	28	ND	ND	ND	0.047
	9/7/05	ND	ND	0.085 (B)	85	ND	ND	ND	4.2	31	0.0042 (B)	35	ND	0.0037 (B)	0.0018 (B)	0.089
Detection Limits	12/20/05	ND	ND	0.072 (B)	79	0.00071 (B)	ND	0.000048 (B)	4.1	30	0.002 (B)	31	ND	ND	0.0012 (B)	0.17
	3/15/06	ND	ND	0.058 (B)	70	0.00037 (B)	ND	0.000029 (B)	3.5	26	0.0031 (B)	29	ND	0.0035 (B)	0.00067 (B)	0.11
	6/15/06	ND	ND	0.052 (B)	51	ND	ND	0.000012 (B)	3.6	19	0.0028 (B)	26	ND	ND	ND	0.055
	9/13/06	ND	ND	0.087 (B)	110	ND	0.0022 (B)	ND	4.5	41	0.0027 (B)	50	ND	ND	0.001 (B)	0.11
Detection Limits		0.01	0.01	0.1	1	0.005	0.01	0.0002	1	1	0.01	1	0.003	0.005	0.01	0.02
MCL*		NE	0.01	2	NE	0.005	0.1	0.002	NE	NE	NE	NE	0.015	0.05	NE	NE

*Maximum Contaminant Level – National Primary Drinking Water Regulations
 ND – non detect
 NE – not established
 (B) – Detected above Instrument Detection Level but below Reported Detection Level

Table 2-10
Historical Summary of Radioisotopes in Surface Water (Stoller)

Sample Station	Sample Date	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-228 (pCi/l)	Th-230 (pCi/l)	Th-232 (pCi/l)	U-234 (pCi/l)	U-235 (pCi/l)	U-238 (pCi/l)	Total (ug/l)	U
SW-1	2/25/05	0	0.58	0.018	-0.026	-0.001	0.89	0.083	0.65	1.97	
	6/14/05	0.14	0.05	0.05	-0.025	0.016	0.246	0.021	0.251	0.75	
	9/7/05	0.18	0.42	0.041	0.25	0.102	0.35	0.031	0.35	1.04	
	12/20/05	-0.31	0.47	0.028	0.197	-0.005	0.64	0.041	0.7	2.11	
	3/15/06	-0.16	0.35	0.059	0.125	0.005	0.6	0.029	0.53	1.59	
	6/14/06	0.13	0.45	0.16	0.53	0.062	0.11	0.08	0.19	0.61	
	9/13/06	-0.03	0.25	-0.019	-0.035	0.01	0.37	-0.005	0.34	1	
SW-2	2/25/05	0.45	0.06	0.011	-0.016	0.033	0.8	0.066	0.42	1.29	
	6/14/05	0.04	0.29	0.071	-0.028	0.007	0.259	0.032	0.23	0.69	
	9/7/05	-0.08	0.24	-0.013	0.107	0.051	0.54	0.014	0.54	1.62	
	12/20/05	0.09	0.07	-0.003	0.126	0	0.71	0.067	0.49	1.5	
	3/15/06	-0.04	-0.15	0.009	0.184	0.01	0.79	0.004	0.51	1.52	
	6/14/06	0.03	0.04	0.172	0.24	0.1	0.39	0	0.48	1.44	
	9/13/06	0.11	0.35	0.009	-0.03	0.01	0.43	-0.006	0.3	0.89	
MCL*		Total Ra = 5		NE	Th 230 + Th 232 = 60**		NE	NE	NE	30	

*Maximum Contaminant Level – National Primary Drinking Water Regulations

**5 CCR 1002-31 Reg 31 – Colorado Surface Water Standards

pCi/l - picoCuries per liter

ug/l – micrograms per liter

Table 2-11
Historical Summary of Metals in Surface Water (Stoller)

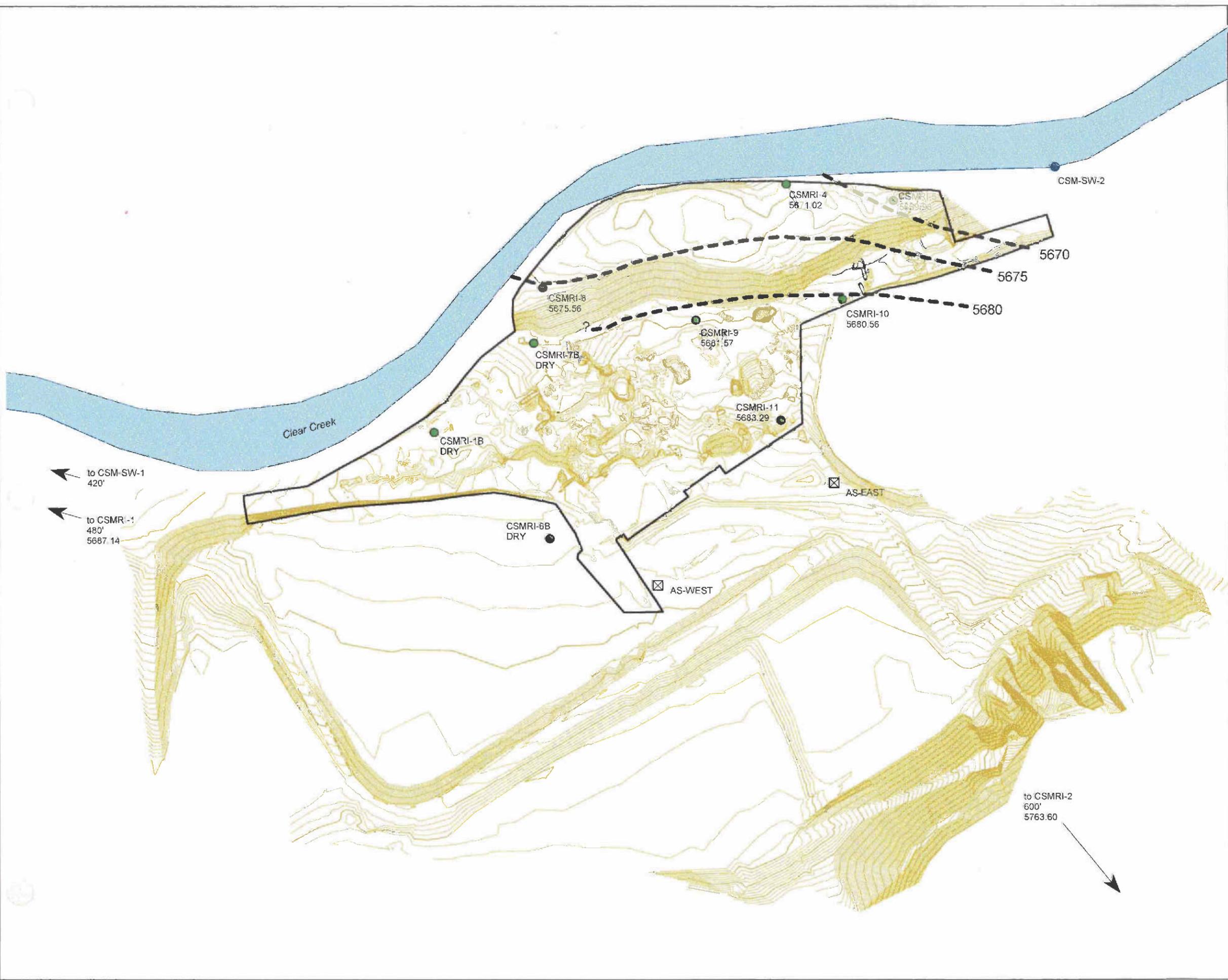
(All results in milligrams per liter)

Sample Station	Sample Date	Ag	As	Ba	Ca	Cd	Cr	Hg	K	Mg	Mo	Na	Pb	Se	V	Zn
SW-1	2/25/05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2
	6/14/05	ND	ND	ND	11	ND	ND	ND	1.1	2.8	ND	5.2	ND	ND	ND	0.09
	9/7/05	ND	0.0037 (B)	0.029 (B)	20	ND	ND	ND	2.2	4.4	0.0044 (B)	8.5	ND	0.0045 (B)	ND	0.063
	12/20/05	ND	ND	0.042 (B)	35	0.00057 (B)	ND	0.000034 (B)	3.7	7.6	0.004 (B)	19	ND	ND	ND	0.22
	3/15/06	ND	ND	0.04 (B)	37	0.00084 (B)	0.00047 (B)	0.000024 (B)	3.7	8.5	0.0048 (B)	23	ND	ND	0.00067 (B)	0.19
	6/14/06	0.0012 (B)	0.0032 (B)	0.011 (B)	8.2	ND	ND	ND	1	1.9	0.0042 (B)	3.1	ND	ND	ND	0.029
	9/13/06	ND	ND	0.03 (B)	21	ND	ND	ND	2.1	4.4	0.0049 (B)	8.6	ND	ND	ND	0.053
SW-2	2/25/05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.17
	6/14/05	ND	ND	ND	11	ND	ND	ND	1.1	2.8	ND	4.8	ND	ND	ND	0.085
	9/7/05	ND	ND	0.028 (B)	20	ND	ND	ND	2.1	4.4	0.0037 (B)	8.7	ND	0.0037 (B)	ND	0.051
	12/20/05	ND	ND	0.042 (B)	35	0.00043 (B)	ND	0.000034 (B)	3.8	8	0.0038 (B)	19	ND	ND	ND	0.21
	3/15/06	ND	ND	0.042 (B)	39	0.00053 (B)	0.00055 (B)	0.000022 (B)	3.8	8.9	0.0046 (B)	25	ND	ND	0.00053 (B)	0.2
	6/14/06	ND	0.0022 (B)	0.011 (B)	8.4	ND	ND	ND	1	1.9	0.0045 (B)	3	ND	ND	ND	0.031
	9/13/06	ND	ND	0.03 (B)	21	ND	ND	ND	2.1	4.4	0.0048 (B)	8.5	ND	ND	ND	0.04
Detection Limits		0.01	0.01	0.1	1	0.005	0.01	0.0002	1	1	0.01	1	0.003	0.005	0.01	0.02
MCL*		0.01	0.01	2	NE	0.005	0.1	0.002	NE	NE	NE	NE	0.015	0.05	NE	NE

*Maximum Contaminant Level – National Primary Drinking Water Regulations

ND – Non Detect

NE – Not Established



Explanation

- Wells
- Surface Water Sample Locations
- Ghost Wells
- ⊠ Air Sample Station
- 1 Foot Contours
- 5 Foot Index Contour
- Property Boundary
- Clear Creek
- 5669.98 Potentiometric Surface Elevation (Feb 27 and Mar 1, 2007)
- - - Elevation Contour (5 Feet)



1 inch = 150 feet

Figure 1
Groundwater Potentiometric Surface
Map - March 2007

Colorado School of Mines



Figure 2
Hydrographs
CSMRI-1, CSMRI-4 and CSMRI-5

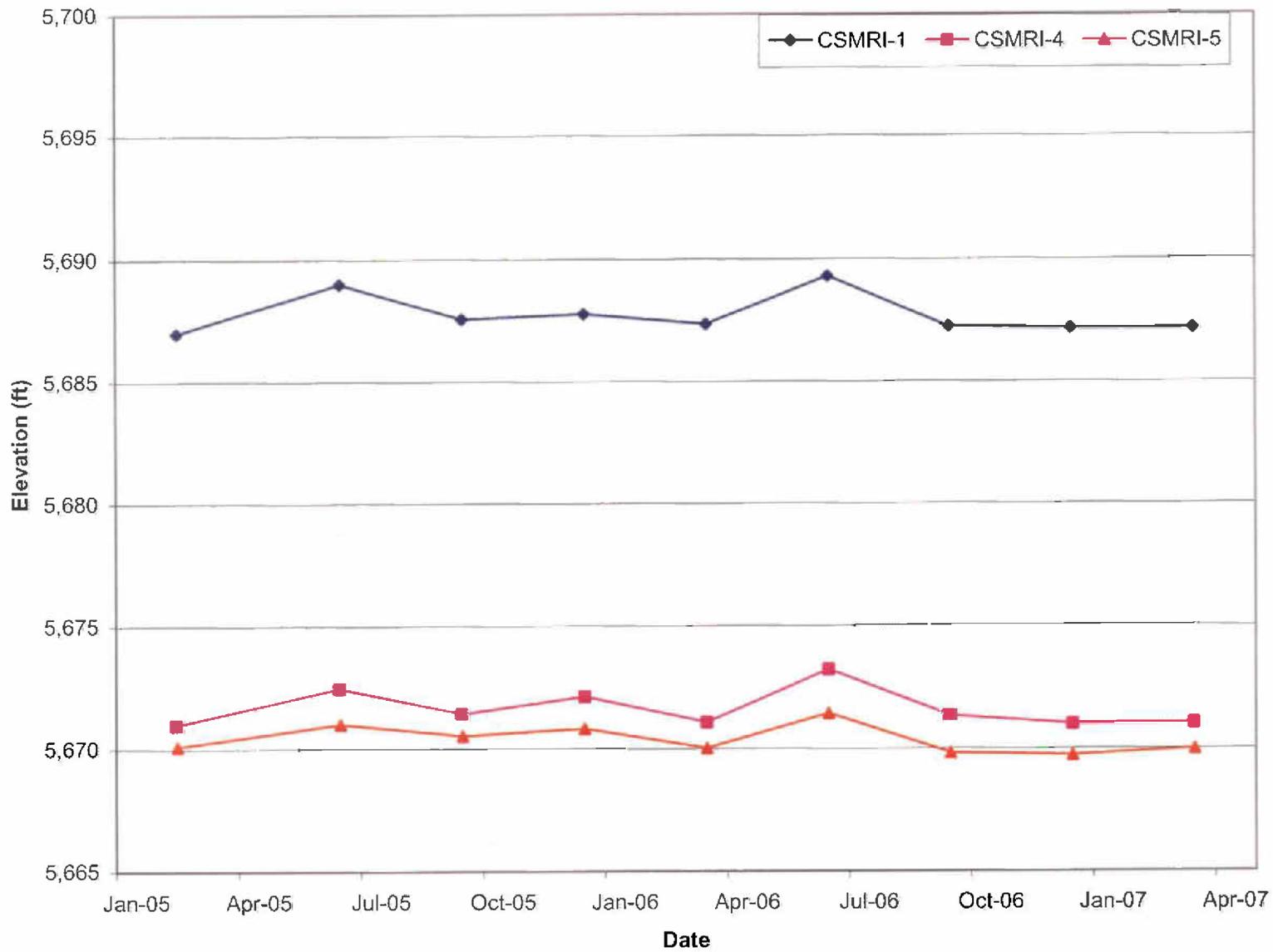


Figure 3
Hydrograph
CSRMI-2

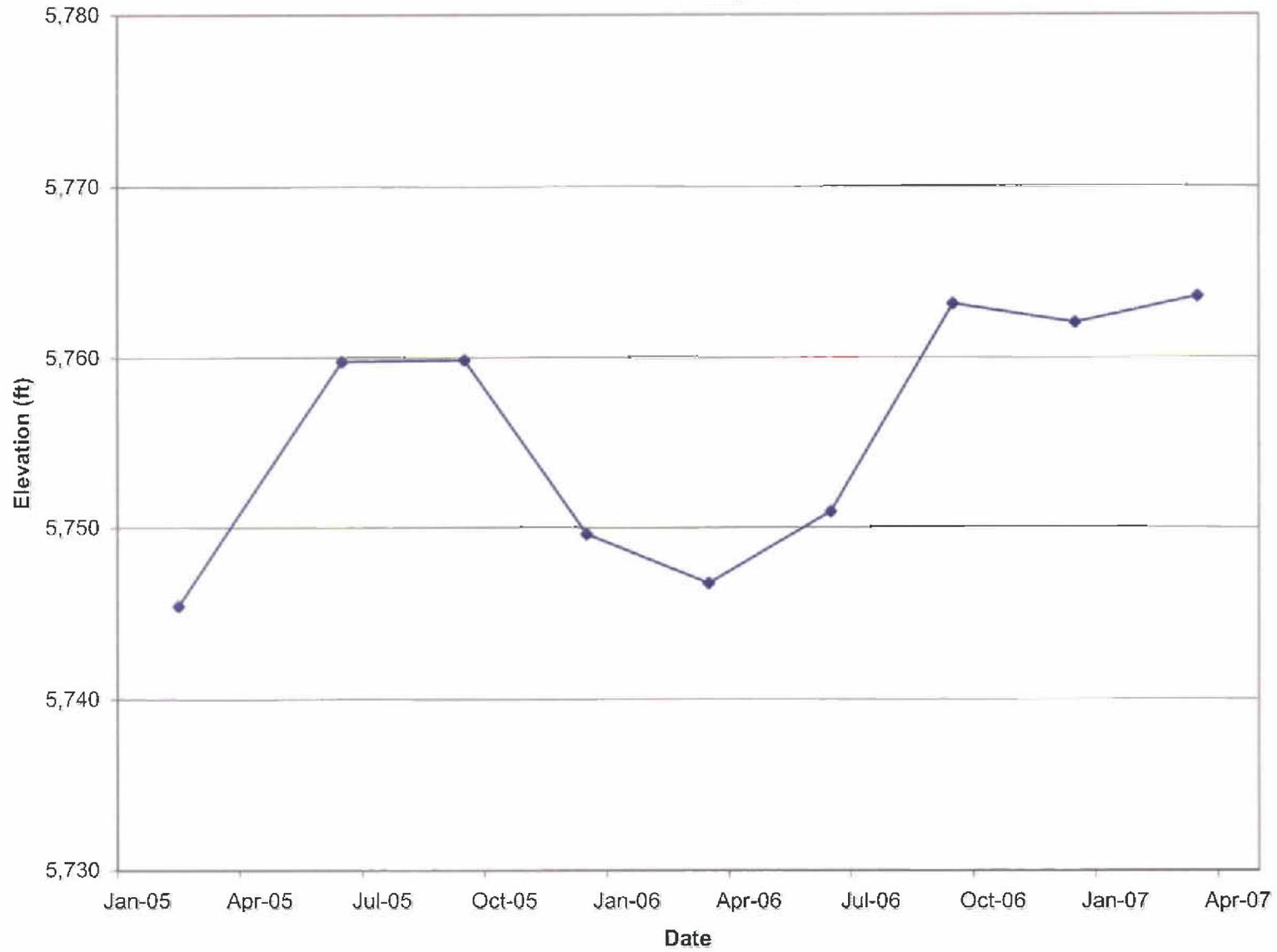


Figure 4
Clear Creek Gauging Graph

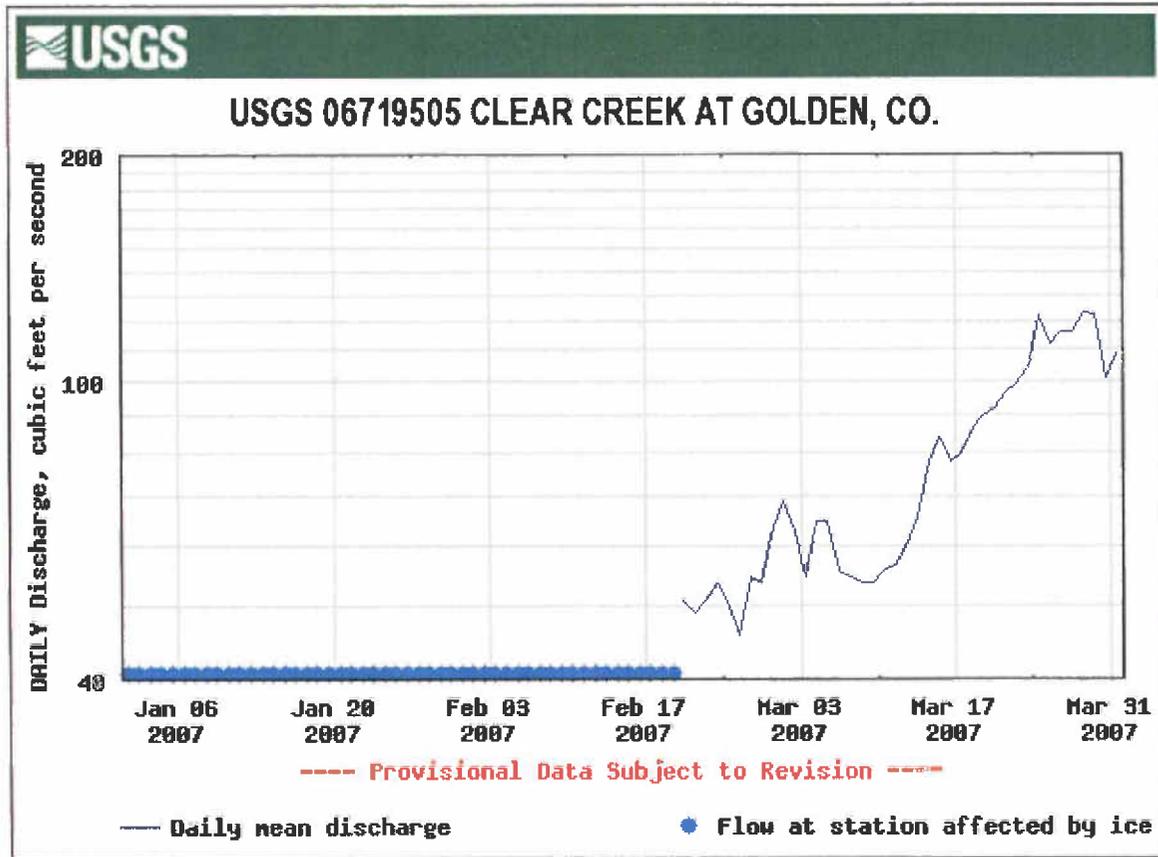


Figure 5
CSMRI-4
Historical Total Uranium Concentration

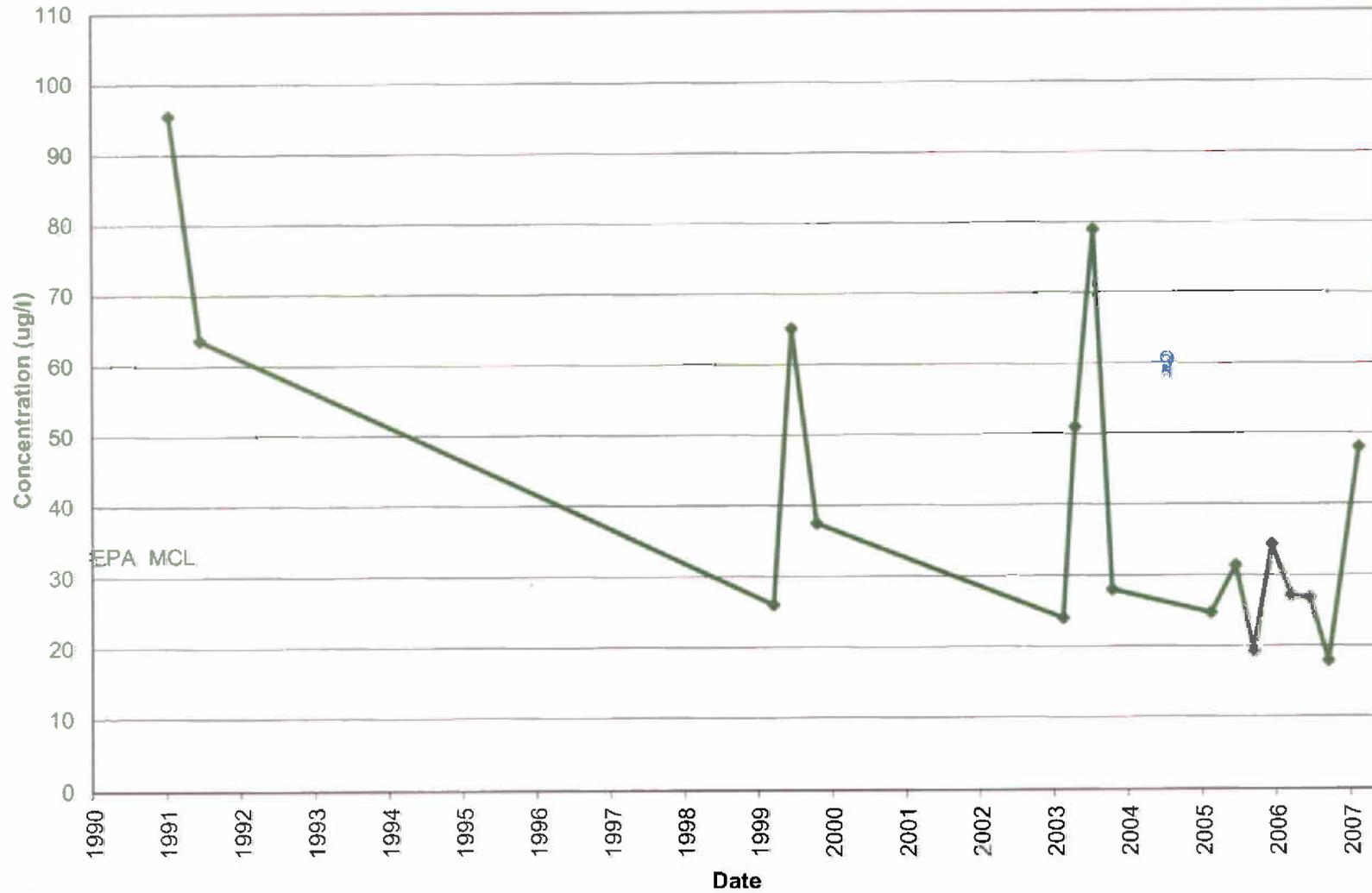
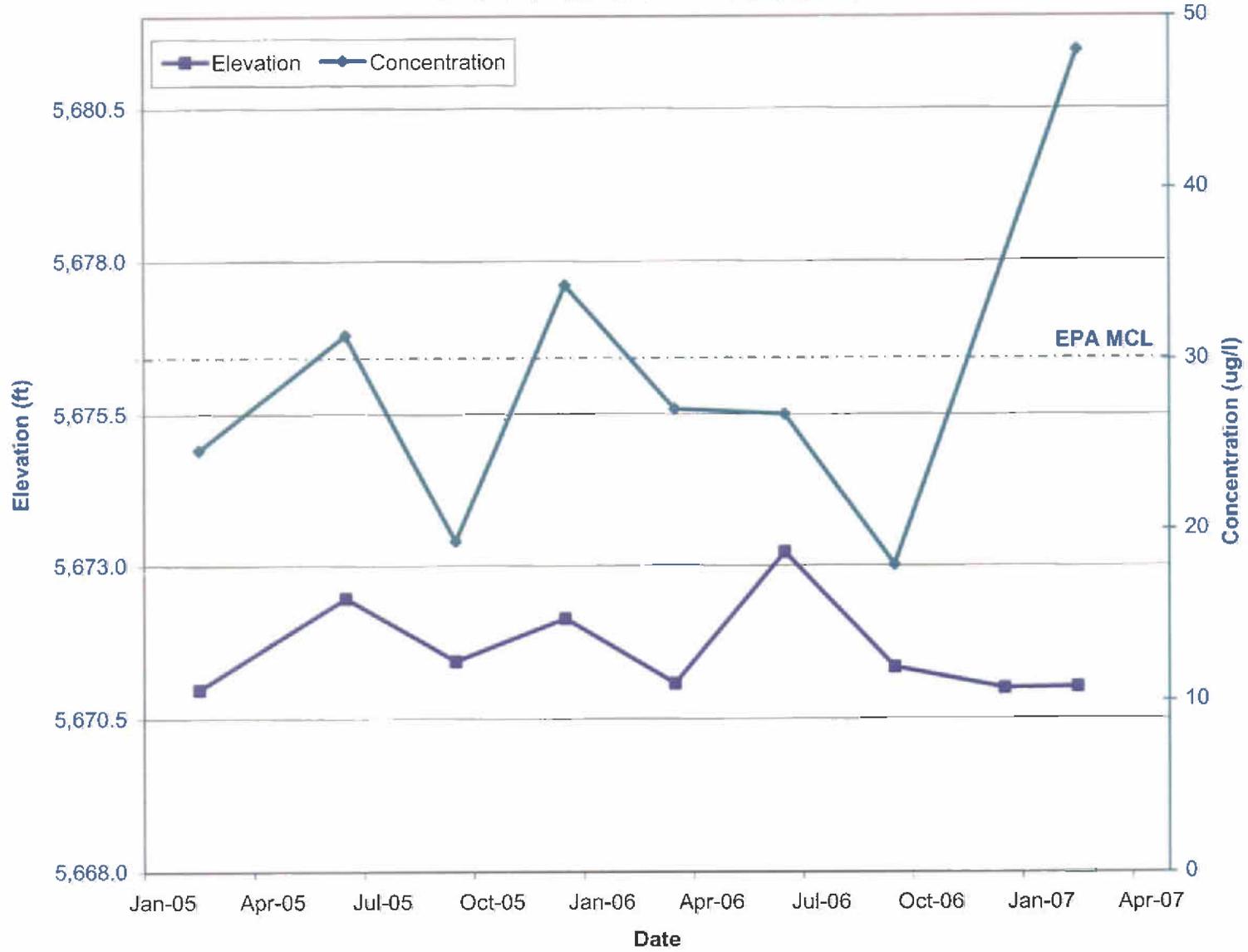


Figure 6
CSMRI-4
Total Uranium Concentration



Appendix A
Long-Lived Airborne Radioparticulate Survey
Procedures

Long-Lived Airborne Radioparticulate Surveys

1.0 Introduction

1.1 Purpose

The purpose of this procedure is to provide instructions for taking breathing zone and general area air samples to determine airborne concentrations of long-lived particulate radionuclides. It also provides instructions on reviewing the results to determine if radiological posting is required.

1.2 Scope

This procedure addresses the requirements for monitoring airborne radioactivity. It includes monitoring methods, documentation, and result analysis. This procedure does not address use of continuous air monitors, how to establish radiological posting, or access control requirements.

1.3 Applicability

This procedure is applicable to monitoring for long-lived airborne radioparticulates. This procedure is not applicable to air sampling for determining radon or radon decay product concentrations, airborne tritium concentrations, or concentrations of non-radiological materials.

2.0 Precautions, Limitations, and Notes

2.1 Precautions

Handle samples with care to prevent cross-contamination.

Do not allow an air sampler to pick up debris from the floor, ground, or other surface.

Do not operate air samplers in explosive atmospheres or where there is >25% oxygen content.

Exhaust air samplers away from workers, contaminated surfaces, and open containers of radioactive (or other hazardous) material.

2.2 Limitations

This procedure only applies to radionuclides with half-lives of 405 days (1.11 years) or longer.

2.3 Definitions

High Volume Air Sampler – Air sampler capable of collecting greater than 3 ft³/min.

Low Volume Air Sampler – Air sampler capable of collecting greater than 10 L/min but less than 3 ft³/min.

Personal Air Sampler – Air sampler capable of being worn by personnel and measuring the wearer's breathing zone. These samplers are usually capable of collecting 10 L/min or less.

Breathing Zone – The general volume of air breathed by the worker(s). The breathing zone for a personal air sample is defined as the imaginary globe of a two-foot radius surrounding a person's head. The breathing zone of an area is the general volume of air to which occupants are expected to be exposed—typically at a height of 1 to 2 meters.

Annual Limit on Intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue.

Derived Air Concentration (DAC) – For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2,000 hours (assuming a breathing volume of 2,400 m³). For the radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud.

3.0 Prerequisite Actions

Verify air sampling equipment has been calibrated and has not exceeded the calibration due date.

4.0 Monitoring Requirements

4.1 General

1. Air sampling is required in occupied areas when, under typical conditions, an individual's intake is likely to exceed 2% of an ALI. For continuously occupied areas, this is 2% of a DAC, while 50% occupancy is 4% of a DAC, while <20% occupancy is 10% of a DAC. The Radiological Control Manager is responsible for determining the appropriate air sample location and frequency of collection.
2. Evaluate air sample results as quickly as practicable to evaluate the need for respiratory protection, area evacuation, worker intake, and worker relief from respirator use.
3. Air samples do not need to be counted any further when the activity is at or below the detection limits of the instrument counting the sample. For automated scalers with built-in algorithms, this value is calculated for each sample (e.g. Protean, Tennelec). For manual scaler systems such as the Ludlum 2000, Ludlum 2929, and E-600, this corresponds to the default detection limits, which are set at 5% of the applicable DAC.

4.2 Area Sampling

1. Use high volume air samplers (greater than 3 cubic feet per minute) to obtain sensitive and prompt determinations of "instantaneous" (short time duration) air concentrations.
2. Use low volume air samplers when monitoring over an extended time period (i.e., several hours).

4.3 Personal Monitoring

Use lapel air samplers for accurate breathing zone monitoring of personnel.

5.0 Sample Volumes and Collection Time Determination

1. Determine the altitude of the sampling location using the categories in Table 1.
 - a. **IF** the location is a major fixed facility,
THEN, the actual altitude should be used.
 - b. **IF** the altitude is not well known,
THEN, estimate it to the nearest thousand feet using a topographic map or equivalent.
 - c. Record the altitude of the sampling location on the Airborne Radioactivity Data Sheet.

NOTE: *It is recognized that temperatures change during field operations, and that accurate temperature measurements may be difficult. Therefore, a simplified method has been adopted which uses descriptive categories of very cold (<10 °F), cold (10-35 °F), cool (35-55 °F), room temperature (55-80 °F), and hot (>80 °F).*

2. Determine the temperature of the sampling location using the categories in Table 1.
Record the temperature at the sampling location on the Airborne Radioactivity Data Sheet.
3. Select the appropriate pressure and temperature correction factor in Table 1.
Record the selected pressure and temperature correction factor on the Airborne Radioactivity Data Sheet.

Table 1. Pressure (altitude) and Temperature Correction Factors

Facility	Altitude (ft)	Temperature Range (°F)				
		<10 very cold	10 - 35 cold	35 - 55 cool	55 - 80 room temp	>80 hot
	0	1.10	1.07	1.04	1.00	0.96
	1,000	1.08	1.05	1.02	0.98	0.95
	2,000	1.06	1.04	1.00	0.96	0.93
	3,000	1.04	1.02	0.98	0.95	0.91
Moab	4,000	1.02	1.00	0.96	0.93	0.90
Grand Jct.	4,565	1.01	0.99	0.95	0.92	0.89
	5,000	1.01	0.98	0.95	0.91	0.88
	6,000	0.99	0.96	0.93	0.89	0.86
MMS ^a	6,900	0.97	0.95	0.91	0.88	0.85
	7,000	0.97	0.94	0.91	0.88	0.85
	8,000	0.95	0.93	0.89	0.86	0.83
	9,000	0.93	0.91	0.88	0.85	0.81
	10,000	0.91	0.89	0.86	0.83	0.80

^aMonticello Mill

4. Select the applicable DAC for the specified work locations or radionuclide type from Table 2.
 - a. **IF** the specific work location and radionuclide type are not specified in Table 2,
THEN contact the health physicist to obtain the appropriate DAC.
 - b. Record the applicable DAC on the Airborne Radioactivity Data Sheet.
5. Select the sample volume (mL) from Table 2 (or from the graphs in Appendix A when the work location and radionuclide type are not specified in Table 2), corresponding to the counting instrument planned for use in counting the air sample.
6. Correct the selected sample volume for the altitude and temperature conditions at the sample location.

Divide the selected sample volume by the pressure and temperature correction factor obtained in step 5.0[3] to obtain the corrected total sample volume.

$$SV_c = \frac{SV_U}{PT_{CF}}$$

where SV_c = Corrected total sample volume (mL)

SV_U = Uncorrected sample volume (from Table 2)

PT_{CF} = Pressure and temperature correction factor (from Table 1).

Table 2. Minimum Flow Rates and Sampling Time Required to Achieve Minimum Sample Volumes^a

Project Name or Radionuclide	DAC (µCi/mL)	Air Sample Volume (milliliters)			
		Protean / Tennelec	Ludlum 2000	Ludlum 2929	E-600
GJO ^b	5×10^{-11}	6.3×10^5	6.3×10^5	6.3×10^5	Not Available
GJORAP ^b	5×10^{-11}	6.3×10^5	6.3×10^5	6.3×10^5	Not Available
Moab	5×10^{-11}	6.3×10^5	6.3×10^5	6.3×10^5	Not Available
Monticello ^b	5×10^{-11}	6.3×10^5	6.3×10^5	6.3×10^5	Not Available
UMTRA VPs ^b	5×10^{-11}	6.3×10^5	6.3×10^5	6.3×10^5	Not Available
Uranium "yellowcake"	2×10^{-11}	1.6×10^6	1.6×10^6	1.6×10^6	Not Available
TRU ^c	2×10^{-12}	1.6×10^7	1.6×10^7	1.6×10^7	Not Available
Mixed Fission Products and Mixed Activation Products ^d	2×10^{-9}	1.7×10^4	Not Applicable	8.3×10^5	Not Available

^aSample volumes are "uncorrected values" based upon air sampler pump calibration at 70 °F and sea level altitude (29.92 inches of Hg.).

^bBased on the DAC for uranium mill tailings derived in Stoller Health and Safety Calculation.

^cBased upon Pu-239, Pu-240, or Pu-242 as the most restrictive radionuclide of this type likely to be encountered.

^dBased upon Sr-90 as the most restrictive radionuclide of this type likely to be encountered.

6.0 Long-Lived Radioparticulate Air Sampling

6.1 Preparation of Sampling Apparatus

1. **IF** the air sampler used is equipped with a programmable flow totalizer, **THEN** set the flow totalizer to collect the corrected total volume.

2. Determine the necessary sample collection time at the flow rate of interest.

NOTE: *If the time required to collect the corrected sample volume exceeds the expected work duration, contact the health physicist for guidance.*

3. Disassemble the filter housing apparatus.
4. Inspect all sealing surfaces, gaskets, o-rings, and seals.

Replace any gaskets, o-rings, or seals, which show evidence of damage or deterioration.

NOTE: *The Millipore RW 19, 47 mm filters are not identified as to which side is the flow side of the filter. The filters must be removed from the containers with the top of the filter being the side of the filter to be placed facing the atmosphere being sampled.*

5. Place the filter over the support screen in the filter housing apparatus and install the retaining ring securely over the filter.
6. Inspect the assembled filter housing apparatus to ensure that the filter did not buckle or tear during installation and that it is securely seated in the housing to provide a leak-tight seal.
7. Place a clean cover over the filter housing face to protect the filter from physical damage and incidental contamination until ready for use.
8. Attach the filter housing to the air sampler.

6.2 Collecting the Air Sample

1. Locate the air sampler on the person or in the area selected for the collection of the sample and in the breathing zone of the individual/occupants of the area being sampled.

NOTE: *When conditions warrant the collection of a personal air sample, an area air sample is also required.*

2. Remove the protective cover from the air sample filter apparatus.
3. Turn the air sampler "ON" and collect the desired sample volume.
Record the start time and date on the Airborne Radioactivity Data Sheet.
4. Turn the air sampler "OFF."
Record the stop time and date on the Airborne Radioactivity Data Sheet.
5. **IF** the air sample is collected to monitor an area rather than an individual,
THEN,
 - a. Record the location where the air sample was collected on a Radiological Survey Map, or on the Airborne Radioactivity Data Sheet.
 - b. Annotate the air sample filter ID number and time of collection in the remarks section of the Radiological Survey Map or on the Airborne Radioactivity Data Sheet.

6.3 Preparing the Sample Filter for Counting

1. Remove the sample filter media from the filter housing apparatus being careful to prevent damage and cross-contamination.
2. Place the filter in a clean filter envelope or sample container.
3. Label the envelope or sample container with a unique sample (filter) ID number.
4. Record the following data on the Airborne Radioactivity Data Sheet at a minimum.
 - a. Location, including: site, area, and specific location for area samples
 - b. Name and ID number if individual monitored for personal samples
 - c. RWP#, if applicable
 - d. Sample (filter) ID number
 - e. Air sampler type, model, and serial number
 - f. Name and signature of technician collecting the sample
 - g. Sampler flow rate (in mL/minute)
 - h. Pressure and Temperature correction factor
 - i. Sample time (in minutes)
 - j. Volume sampled (in mL)
 - k. Remarks or special conditions pertinent to the sample
5. Transport the filter media with the associated Airborne Radioactivity Data Sheet to the counting room for analysis.

7.0 Sample Analysis

7.1 Counting Samples With Short-Lived Radionuclides Present

NOTE: *If at any time during the counting sequence of an area air sample from a posted Airborne Radioactivity Area, it is determined that occupancy is not necessary, only the count for the record need be performed (step 7.1[5]).*

1. Count the sample and calculate activity concentration within 90 minutes.
 - a. **IF** the airborne concentration is <5% of the DAC,
THEN,
 1. Do not post the area as an Airborne Radioactivity Area.
 2. Proceed to step 7.1[6] of this procedure.
 - b. **IF** the airborne concentration is <10% but >5% of the DAC,
THEN,
 1. Do not post the area as an airborne radioactivity area.
 2. Perform step 7.1[5] of this procedure.
 - c. **IF** the airborne concentration is <400% but >10% of the DAC,
THEN,
 1. Do not post the area as an airborne radioactivity area.
 2. Perform step 7.1[2] of this procedure.
 - d. **IF** the airborne concentration is >400% of the DAC,
THEN,
 1. Notify the Radiological Control Manager and follow his/her instructions for follow-up sampling and posting of the area.
 2. Perform step 7.1[2] of this procedure.

NOTE: *If an area is posted as an Airborne Radioactivity Area, and follow up area air samples indicate airborne radioactivity concentrations to be < 10% of the DAC, further analysis of the initial air sample(s) need only be completed for count of record (step 7.1[5]).*
2. Recount the sample and calculate activity concentration at least 6 hours after the first count or during the next work shift.
 - a. **IF** the airborne concentration is <5% of the DAC,
THEN,
 1. Do not post the area as an Airborne Radioactivity Area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Proceed to step 7.1[6] of this procedure.

- b. **IF** the airborne concentration is <10% but >5% of the DAC,
THEN,
1. Do not post the area as an airborne radioactivity area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Perform step 7.1[5] of this procedure.
- c. **IF** the airborne concentration is <100% but >10% of the DAC,
THEN,
1. **IF** posting was not required by step [1] above,
THEN do not post the area as an Airborne Radioactivity Area.
 2. Perform step 7.1[3] of this procedure.
- d. **IF** the airborne concentration is >100% of the DAC,
THEN,
1. Post the area as an Airborne Radioactivity Area.
 2. Perform step 7.1[4] of this procedure.
 3. Notify the Radiological Control Manager.
3. Recount the sample and calculate activity concentration 72 hours after sample collection (or if more than 72 hours has elapsed, prior to allowing the area to be occupied).
- a. **IF** the airborne concentration is <5% of the DAC,
THEN,
1. Do not post the area as an Airborne Radioactivity Area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Proceed to step 7.1[6] of this procedure.
- b. **IF** the airborne concentration is <10% but >5% of the DAC,
THEN,
1. Do not post the area as an Airborne Radioactivity Area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Proceed to step 7.1[5] of this procedure.
- c. **IF** the airborne concentration is <100% but >10% of the DAC,
THEN,
1. **IF** posting was not required by step 7.1[1] or [2] above,
THEN do not post the area as an Airborne Radioactivity Area.
 2. Perform step 7.1[4] of this procedure.

- d. **IF** the airborne concentration is >100% of the DAC,
THEN,
 1. Post the area as an Airborne Radioactivity Area.
 2. Perform step 7.1[4] of this procedure.
 3. Notify the Radiological Control Manager.
4. Recount the sample and calculate activity concentration each shift worked.
 - a. **IF** the airborne concentration is <5% of the DAC,
THEN,
 1. Do not post the area as an Airborne Radioactivity Area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Proceed to step 7.1[6] of this procedure.
 - b. **IF** the airborne concentration is <10% but >5% of the DAC,
THEN,
 1. Do not post the area as an Airborne Radioactivity Area.
 2. **IF** the area was previously posted as an Airborne Radioactivity Area,
THEN, deposit the area.
 3. Proceed to step 7.1[5] of this procedure.
 - c. **IF** the airborne concentration is >10% of the DAC,
THEN,
 1. Post the area as an airborne radioactivity area.
 2. **IF** continued occupancy is required in the posted Airborne Radioactivity Area,
THEN repeat step 7.1[4] of this procedure for each shift worked.
 3. Perform step 7.1[5] of this procedure after 7 days from the time of sample collection.
5. Recount the sample ≥ 7 days after collection for record.
IF the airborne concentration is >5% of the DAC,
THEN, notify the Radiological Control Manager and Dosimetry.
6. Record sample results on the Airborne Radioactivity Data Sheet.
7. Sign and date the Airborne Radioactivity Data Sheet.

7.2 Counting Personal Samples

1. Count the sample and calculate activity concentration during the next work shift (but not sooner than 6 hours) after sample collection.
 - a. **IF** the airborne concentration is <5% of the DAC,
THEN perform step 7.2[4] of this procedure.

- b. **IF** the airborne concentration is <100% but >5% of the DAC,
THEN perform step 7.2[3] of this procedure.
- c. **IF** the airborne concentration is >10% of the DAC,
THEN,
 1. Perform step 7.2[2] of this procedure.
 2. Notify the Radiological Control Manager.
2. Recount the sample and calculate activity concentration 72 hours after sample collection.
 - a. **IF** the airborne concentration is <5% of the DAC,
THEN, perform step 7.2[4] of this procedure.
 - b. **IF** the airborne concentration is >5% of the DAC,
THEN, perform step 7.2[3] of this procedure.
3. Recount the sample >7 days after collection for record.
IF the airborne concentration is >5% of the DAC,
THEN, notify the Radiological Control Manager.
4. Record sample results on the Airborne Radioactivity Data Sheet.
5. Forward the completed Airborne Radioactivity Data Sheet and Radiological Survey Map, if used, for review and signature.

8.0 Records

8.1 Records Generated By This Procedure

Airborne Radioactivity Data Sheet
Radiological Survey Map
Chain of Sample Custody

8.2 Record Review

1. Review the completed sample documentation to ensure completeness, legibility, and reproducibility.
2. Compare the sample data with similar data to determine if trends are developing or unexpected results were obtained.
3. Notify the Radiological Control Manager of any trends or unexpected results.

8.3 Record Disposition

Maintain the documentation generated by this procedure in accordance with the project-specific QAPP.

9.0 References

Title 10, *Code of Federal Regulations*, Part 835, "Occupational Radiation Protection."
DOE 10 CFR 835 Implementation Guide, G-10 CFR 835/E2 - Rev. 1, "Workplace Air Monitoring."
Stoller Radiological Control Manual
Stoller Health and Safety Manual

Appendix B

Groundwater Sampling Procedures

Groundwater Sampling

1.0 Purpose

This procedure describes actions to be used to sample groundwater from monitoring wells and piezometers. Monitoring wells are generally sampled on a semiannual, quarterly, or monthly basis, or by special request in support for specific projects. All wells are to be sampled using this procedure unless superseded by specific site, facility, or client procedures.

This procedure describes equipment decontamination and transport, site preparation, detection and sampling of immiscible layers, water level measurements, well purging, sample collection, field and analytical parameters, quality assurance/quality control (QA/QC) requirements, and documentation that shall be used for field data collection.

2.0 Scope

This document describes acceptable methods for the sampling of wells and piezometers.

3.0 Responsibilities and Qualifications

Personnel performing groundwater sampling procedures are required to have completed the initial 40-hour OSHA classroom training that meets the Department of Labor requirements at 29 CFR 1910.120(e)(3)(i), and must maintain a current training status by completing the appropriate annual 8-hour OSHA refresher courses. Personnel must also have read the appropriate project, site, or facility Health and Safety Plan(s). Prior to engaging in groundwater sampling activities, personnel must have a complete understanding of the procedures described within this procedure and, if necessary, will be given specific training regarding these procedures by other personnel experienced in the methods described within this procedure.

4.0 Groundwater Sampling Procedures

4.1 Introduction

Many monitoring wells are constructed of either 2-inch stainless steel, or 2- or 4-inch flush threaded PVC casing. Some piezometers are completed as monitoring wells, and they are usually constructed of ¾-inch inside diameter, flush threaded PVC casing. Some wells have been constructed to incorporate a sump below the well screen. Because these vary in length, the well construction diagrams should be consulted to determine the sump lengths for specific wells. Most piezometers are constructed with a flush threaded cap at the bottom of the well screen. However, the well construction diagrams should also be consulted for information about specific piezometers.

Procedures for groundwater sampling are designed to obtain a sample that is representative of the formation water beneath the site in question. Since an analysis of the quality of formation water is desired, standing water within the well must be purged before sampling. Also, a measure of the static water elevations is important to determine the effect of seasonal horizontal and vertical flow gradient changes during site characterization activities.

Groundwater sampling procedures can be initiated after sampling personnel take the required water level measurements and purge the well in accordance with this procedure. Methods for accomplishing each of these activities are included in this procedure in the following sequence:

- Collection of immiscible layers samples, if present
- Well purging
- Groundwater sampling using a bailer

- Groundwater sampling using a peristaltic pump
- Groundwater sampling with a bladder pump

4.2 General Equipment Requirements

Down-hole sampling equipment shall be constructed of inert material such as polytetrafluoroethylene (Teflon[®]) or stainless steel. This equipment shall be assessed on an individual basis prior to use in the field.

The following is a primary list of well sampling and associated equipment:

- Bailers – Teflon[®], stainless steel, or other appropriate inert materials
- Teflon[®] coated stainless steel cable with reels
- Peristaltic pumps and tubing
- Water level measuring devices – sufficiently accurate to measure water levels to the nearest 0.01 foot
- Graduated purge water containers
- Plastic sheeting
- Distilled or deionized water
- Decontamination equipment and supplies
- Organic vapor detector (OVD)
- Gloves (nitrile)
- Calculator and watch
- Sample containers precleaned to EPA specifications
- pH paper
- Custody tape
- Coolers with sufficient blue ice to cool samples to 4°C
- Preservatives (trace metals grade)
- Disposable in-line 0.45-micron membrane filters
- Logbooks and field forms
- Black waterproof pens
- Portable laboratory equipment for measuring field parameters for pH, temperature, specific conductance, and turbidity
- Total alkalinity reagent
- Beakers and graduated cylinders

Additional equipment may be required to meet project or client health and safety standards, to perform specialized sampling, or to meet personnel and equipment decontamination requirements.

4.3 Equipment Decontamination and Transport

Equipment associated with the tasks involved in groundwater sampling shall be decontaminated upon arrival at the sampling location. All sampling equipment shall be decontaminated between

sample locations. Decontamination frequency shall be increased appropriately as field conditions dictate.

Transportation of all equipment shall be performed in a manner that eliminates any possibility of cross-contamination. Calibration solutions, fuel, decontamination solutions and wastewater, and all other sources of contamination shall be segregated from sampling equipment during transport. Purge water being transported to holding areas shall be kept in closed containers.

If the decontamination of downhole equipment is not performed at the well, used downhole equipment shall be wrapped in plastic sheeting and/or segregated from clean equipment to eliminate the possibility of cross contamination. The equipment shall then be decontaminated as soon as possible.

4.3.1 Routine Field Decontamination

Decontamination of delicate equipment and the routine decontamination of sampling equipment prior to use at each well shall consist of the following steps:

- Vigorously scrub the equipment with a brush and solution of phosphate-free laboratory grade detergent (e.g., Liquinox) and distilled water.
- Rinse the equipment thoroughly with approved distilled water.
- If the decontaminated equipment is not immediately packaged to eliminate any adhesion of airborne impurities, perform an additional final rinse, or decontamination and rinse, immediately prior to actual sampling operations.

4.3.2 Routine Decontamination of Sampling Pumps

The external surfaces of all non-dedicated pumping equipment shall be decontaminated as described in Subsection 4.3.1. Internal surfaces shall be decontaminated according to the following procedures, except under special situations where the pump(s) must be disassembled and the internal parts cleaned separately (see Subsection 4.3.3). For routine decontamination, the following procedures shall be followed.

- Pump several pump volumes of a solution of a phosphate-free laboratory grade detergent (e.g., Liquinox) and water through the equipment.
- Displace the soap solution immediately by pumping approved distilled water, equivalent to three or more volumes of the pump storage capacity, through the equipment.
- If any detergent solution remains in the pump, continue pumping distilled water through the system until the detergent is no longer visibly present. Sudsing is the common indicator used to determine incomplete rinsing.

4.3.3 Unusual Decontamination Requirements

When equipment becomes grossly contaminated, such as from the collection of immiscible layer samples (see Subsection 4.5), routine decontamination of sampling equipment is not considered sufficient and thus is not allowed. This situation and other unusual equipment decontamination problems shall be reported to the field site supervisor. Under certain circumstances, a pump can be disassembled and the parts cleaned separately using approved solvents (i.e., hexane, alcohol, etc.). If specific instructions are required, the field site supervisor shall consult with a management representative for proper decontamination procedures.

4.3.4 Disposition of Decontamination Water

All water generated during the decontamination of equipment used for the sampling of wells shall be containerized in either a satellite container or in the purge water container in the groundwater sampling vehicle. It will then be disposed of according to the procedure designated in Subsection 4.6.3 of this procedure.

4.4 Site Preparation

Sheet plastic may be used to protect clean equipment from contacting contaminated surfaces. Plastic bags and sheeting, along with the segregation of clean and dirty equipment, can be used to reduce the chances of cross contamination. If a mechanical bailer retrieval system is used, the amount of plastic appropriate for protection of sampling equipment may be lessened. The sampling crew members are responsible for determining the amount of plastic sheeting required.

Disposable nitrile gloves, or gloves made of other approved materials, shall be used at all times when handling sampling equipment. Gloves shall be changed between each site and as often as necessary to ensure the integrity of clean sampling equipment.

4.5 Collection of Immiscible Layer Samples

When specified in the project sampling plan, or when the well to be sampled contains immiscible layers, immiscible phases must be collected before purging activities begin. The method of choice for collecting light non-aqueous phase liquids (LNAPLs) is a bottom valve bailer or peristaltic pump. Dense non-aqueous phase liquids (DNAPL) or "sinkers" shall be collected with a bottom double check valve bailer or peristaltic pump.

In all cases, the bailer shall be carefully lowered into the well so that agitation of the immiscible layer is minimal. Any bailer used to collect immiscible layers shall be dedicated to the well that is sampled. Peristaltic pumps shall be equipped entirely with silicon, or other chemical compatible tubing, when sampling immiscible layers. The project manager shall be responsible for determining the type materials to be used for specific projects. Dedicated equipment used for collecting immiscible layers shall be decontaminated prior to and after use as described in Subsection 4.3 of this procedure, if removed from the well.

Immiscible layer sampling shall be performed as follows.

- Remove dedicated bailers from the well and decontaminate as specified in Subsection 4.3 of this procedure. Decontaminate dedicated pump tubing, if used, prior to use.
- For LNAPLs, carefully lower the bailer intake or sampling port to the midpoint of the immiscible layer and allow it to fill while it is held at this level. The bailer must be lowered into the immiscible layer slowly so that minimal agitation of the immiscible layer occurs. Peristaltic pump intakes must also be lowered to the midpoint of the immiscible layer.
- If a DNAPL layer is being sampled, use either the double check valve bailer or peristaltic pump. Lower the bailer into the well until bottom is encountered. Lower peristaltic pump intakes also to the well bottom. Care must be taken not to immerse the pump intake into accumulated sediments.
- Do not allow the bailer or line to touch the ground at any time or allow the ground to come in contact with other physical objects that might introduce contaminants into the well.
- Decontaminate all equipment immediately after sampling is completed. Suspend dedicated bailers in the well from the well cap above the high water level. Discard silicon tubing used with peristaltic pumps.

4.6 Well Purging

Purging stagnant water from a well is required so that the collected sample is representative of the formation groundwater. The device used (bailer or pump) depends upon aquifer properties, individual well construction, and data quality objectives. Wells that contain immiscible layers will not be purged unless specified in the site-specific work plan. Any well scheduled for purging and sampling that subsequently is found to contain immiscible layers must be reported to the site supervisor or project manager. The project manager shall be notified immediately prior to continued activities.

Before obtaining water level elevations or initiating purge activities, obtain the following information in reference to the well to be sampled, and enter the applicable information on the sample collection log.

- Location code (well number)
- Previous purge volume (information only)
- Depth to top of screen (bailed wells only)
- Well sample number
- Report Identification Number (RJN)
- Sample event number

Record the location code (well number), date, sampling team members, visitors, well condition, and any other pertinent information on the sample collection log. Enter the well number, time well is opened, and other information regarding the field activities on the Field Activity Daily Log.

The field instruments shall be standardized (to check calibration) and the results recorded on the sample collection form.

Measure the depth to the top of the water column and the total depth of the well in order to determine the height of the water column in the well. Calculate the well casing volume using the well casing inner diameter and the height of the water column in the well. The formula for calculating the volume in gallons of water in the well casing is as follows:

$$(\pi r^2 h) 7.481 = \text{gallons; where}$$

$$\pi = 3.142$$

$$r = \text{inside radius of the well pipe in feet}$$

$$h = \text{linear feet of water in well}$$

$$7.481 = \text{gallons per cubic foot of water}$$

$$1 \text{ gallon} = 3785 \text{ ml}$$

Calculations of the volume of water in typical well casings may be done as follows:

- a. 2" diameter well:

$$0.16 \text{ gal./ft} \times (\text{linear ft of water}) = \text{gallons of water}$$

- b. 4" diameter well:

$$0.65 \text{ gal./ft} \times (\text{linear ft of water}) = \text{gallons of water}$$

- c. 3/4" diameter well:

87 ml./ft x (linear ft of water) = milliliters of water

4.6.1 Purging Duration

Purging shall be considered complete if any of the following conditions are met.

1. Purging is complete if at least three casing volumes of water are removed from the well, and the last three consecutive pH, specific conductance, and temperature measurements do not deviate by more than the following: 1) pH = ± 0.1 pH units; 2) Specific Conductance = $\pm 10\%$ and; 3) temperature $\pm 0.5^\circ\text{C}$. A turbidity measurement will be taken for every other purge sample for wells that are purged using a bailer. For wells that are equipped with a dedicated bladder pump, the turbidity will be measured each time the parameters are taken. The purge rate should be such that the turbidity is maintained at 5 NTU units or less (if possible). If the readings are not stabilized after three volumes, continue purging until stabilization or until five volumes have been removed. Field parameter measurements shall be collected after every half-casing volume (approximate) is removed from the well. When casing volumes are less than 1-liter, parameter measurements will be collected after each whole casing volume is removed. If readings do not stabilize after five well volumes have been recovered, obtain additional guidance from the project manager concerning the proper course of action.
2. A well is considered dewatered when only a few milliliters of water (or none) can be recovered each time the bailer is lowered into the well. When this occurs, a 10-minute recharge rate will be calculated (linearly). If, at the end of the 10-minute period, the well has not recovered sufficiently to continue the purge in thirty minutes, the purge is considered completed. If, at the end of the 10-minute period, there is sufficient water to collect the VOA samples, the samples may be collected at that time. If the well has not recovered sufficient water during the 10 minutes, and depending upon the well history, the samplers may elect to return to the well the same day (preferably within two hours), check the water level, and collect the VOA samples (first), and other samples as feasible. If the sample team cannot return the same day, the well will be checked in 24 hours to determine if sample collection is feasible. If an extended period of time is required to collect samples, the procedures in Subsection 4.8.1 shall be followed. The well will not require an additional purge before sampling.

Wells that dewater (have a slow recharge rate as specified in 2 above) will not be restricted by parameter stabilization requirements. Sampling of these wells will follow the protocol established in Subsection 4.8.

4.6.2 Purging Methods

Wells will be purged by either bailing or pumping. When purging a well, the rate of water withdrawal during purging should not exceed the rate of withdrawal at which the well was developed (if known). All purge times (initiation and completion) and the rate of purging will be recorded on the field log sheets.

4.6.2.1 Bailing

Generalized procedures for purging a well with a bailer are as follows.

- Prepare the sampling site as discussed in Subsection 4.4. Use properly decontaminated equipment to determine the static water level of the well. Measure the total depth of the well. Use this information to determine the volume of water in the well casing.

- Decontaminate all dedicated bailers prior to initiating purging as described in Subsection 4.3 of this procedure.
- Use a mechanical reel equipped with Teflon[®] coated stainless steel cable attached to a bailer for bailing and sampling operations. Lower the bailer slowly into the well until water is encountered. Minimize agitation of the well water. Avoid lowering the bailer to the bottom of the well so sediments accumulated in the bottom do not become suspended. For wells that dewater, do not allow the bailer to strike the well bottom with force. Raise and lower the bailer carefully to limit surge energy and ensure that cable does not come in contact with any potentially contaminated surfaces. Do not allow the cable to drag along the well casing or against other objects that will cause fraying. Monitor the amount of water purged.

Wells with significant levels of contamination may have dedicated bailers installed. Dedicated bailer systems shall consist of a Teflon[®] bailer with check valve or double check valve for DNAPLS and a 5-foot leader of Teflon[®] coated stainless steel cable. Bailer sampling attachments and the stainless steel reel cable will not be dedicated to individual wells.

Dedicated bailers will be decontaminated at the conclusion of sampling activities and suspended from the well cap above the high water table. If the well interval above the high water table is not adequate to allow for storage in the casing, the dedicated bailers will be stored in labeled and sealed plastic bags at the equipment trailer.

4.6.2.2 Pumping

Pump designs that meet the following criteria are allowed for purging.

- The pump is constructed of a material that does not introduce a source of contamination to the well.
- The pump drive system does not introduce a source of contamination into the well.
- All downhole parts to the pump can be easily decontaminated.
- A return check system that does not allow pumped water to return to the well is integral in the pump design.
- The pump is easily used and does not require excessive amounts of time to install, use, remove, and decontaminate.

The pumps currently in use to purge groundwater include peristaltic pumps and dedicated submersible bladder pumps. A procedure for the use of each style of pump is specific to its applications. User manuals, which accompany each pump, shall be referenced for operating procedures.

Basic operating procedures common to all pumps are as follows.

- Prepare the sampling site as described in Subsection 4.4 regardless of the type of pump being used.
- Use properly decontaminated equipment to determine the static water level and the total depth of the well. This information is utilized to determine the volume of water in the well casing.

- For wells with dedicated pumps, calculate the minimum purge volume using the pump storage volume and the volume of the discharge tubing. A total depth of a 2-inch well cannot be taken without the removal of the pump.
- Position a dedicated pump near the bottom of the well or according to the information on the well construction form. Monitor the discharge rates and the amount of water purged during purging. The pumping rate for purging can be higher than the pumping rate for sampling, however, the water level in the well should be monitored during purging to avoid excessive water level drawdown.
- Ensure that any tubing that enters the well casing is composed of inert material. Disposable silicon tubing will be used in the drive mechanism of peristaltic pumps and discarded after each well is purged. The air supply for all air-driven pumps (dedicated bladder pumps) will be free of oil (i.e., no hydrocarbon containing substances will be added to the compressor).

4.6.3 Disposition of Purge Water

All water removed from a well during sampling operations shall be collected either in a satellite container or the purge water collection container in the groundwater sampling vehicle. The water from these containers will then be transferred to another approved collection container on the sampling or project site. When the collection container is filled, or is near capacity, it will be transported for disposition or treatment in accordance with approved project plans.

4.7 Measurement of Field Parameters

The following field parameters will be measured during groundwater purging operations unless otherwise specified by the project manager or the approved project work plans.

Parameter	Relative Precision	Minimum Calibration
pH	0.01 pH units	Daily
Conductivity	10 μ S/cm	Daily
Temperature	0.1 °C	Weekly
Total Alkalinity (unfiltered)	1 mg/l	None
Turbidity (photometric)	2 FTU (or NTU)	Specified purge samples (bailed wells) Daily (dedicated bladder pump wells)

The measuring equipment shall be stored and handled in a manner that will maintain the integrity of the equipment. Appropriate field manuals will accompany each instrument in the field. Each instrument will also be given an identification number. All logbook and field form references to individual instruments will refer to this number for ease of identification.

Field parameters will be measured at the following intervals.

- Conductivity, pH, temperature, and turbidity shall be measured from the first water removed from the well when initiating well purging procedures. For bailed wells, the initial bail of water will be carefully removed from the well and the water transferred to a sample beaker by decanting the bailer through a bottom control valve. For wells

purged with a peristaltic pump, similarly collect the first water removed in a sample beaker and then measure parameters. For wells with dedicated pumps, measure the parameters of the first recovered water that is collected in the continuous sampler.

- During purging operations, conductivity, pH, and temperature shall be measured for every half-casing volume (one half of the initial casing volume as calculated on the sample collection log form) of water removed from the well (because of the accuracy of the graduated containers for the purge water, the purge volume will be estimated as close as feasible). For wells that have half volumes less than the volume of a sample bailer (approximately 1 liter), only measure parameters after each full casing volume of water is removed from the well. Turbidity will be measured on every other sample recovered for parameters for bailed wells, or wells purged with a peristaltic pump. All parameters, including turbidity, will be measured at predetermined intervals while purging wells with dedicated pumps.
- During purging, if a well is dewatered prior to the measurement of the final required set of parameters, then conductivity, pH, temperature, and turbidity shall be measured immediately before the start of sample collection. These parameters may be delayed until sampling is completed if, at the discretion of the sampling crew, the well recharge has provided insufficient water volume to collect all the samples and also measure parameters. If there is insufficient water for samples and field parameters, the parameters will not be measured.
- Total alkalinity measurements shall be collected only once upon completion of purging. For wells that do not dewater and sample collection proceeds to completion immediately after purging, alkalinity will be measured after the completion of all other final purge field parameters. Wells that dewater and require repeated visits for the collection of samples will have alkalinity measured subsequent to the collection of the sample for inorganic water chemistry. Alkalinity will not be measured if sufficient water is not available.
- For micro purged wells, a purge is considered completed when the parameters have stabilized.
- Whenever a method used to remove well water is changed, a set of field parameters shall be recorded from water removed with the new method.

4.8 Groundwater Sampling

Techniques used to withdraw groundwater samples from a well shall be based on consideration of the parameters of interest. The order of collection, collection techniques, choice of sample containers, preservatives, and equipment are all critical to ensuring that samples are not altered or contaminated. The preferred methods for collection of groundwater samples are either bailing and/or the use of bladder pumps.

Sites shall be prepared prior to sampling as described in Subsection 4.4. All necessary and appropriate information will be recorded on the sample collection log and on the Field Activity Daily Log.

4.8.1 Sample Collection

The following discussion involves collection of groundwater samples using bailers and peristaltic or bladder pumps. Regardless of the collection method, care shall be taken not to alter the chemical nature of the sample during the collection activity by agitating the sample or allowing prolonged contact with the atmosphere. To minimize the potential for

altering the sample and to maximize the available water, the following sample collection sequence is preferred.

- Radiation Screening
- VOC
- Nitrate/Nitrite, as N
- Dissolved Metals – TAL, with Cs, Li, Sr, Sn, Mo, Si
- ^{239/240}Plutonium, ²⁴¹Americium
- ^{233/234}U, ²³⁵U, ²³⁸U
- Gross alpha and beta
- ⁸⁹Strontium
- ¹³⁷Cesium
- ^{226,228}Radium
- Tritium
- Total Metals – TAL, with Cs, Li, Sr, Sn, Mo, Si
- TDS, CL, F, SO⁴, CO₃, HCO³
- TSS
- BNA
- Pesticides/PCB
- Cyanide
- Orthophosphate

VOC samples shall be collected first and as soon as possible after the well has been purged. If a well is purged using a peristaltic pump, then all other samples shall be collected prior to removing the pump from the well. The VOC sample will then be collected using a bailer.

For wells that dewater, if a sufficient volume of water for VOC sample collection has still not accumulated within 48 hours after the completion of purging, VOCs will not be collected for that well. Other samples may be collected using a maximum of five attempts to recover sufficient sample water for analysis. This procedure is discussed in the following paragraph.

The containers used for sample collection from poor producing wells may differ from those used for high yield wells in some instances due to constraints on obtaining enough sample to fill sample containers. In some instances smaller containers may be utilized, or analyte samples normally collected in separate containers may be combined into a single container. Well histories can be used to identify which wells may require a modified sample suite and an extended sampling period. These wells will initially be sampled for a period of 48 hours after the completion of purging, with the exception of VOC sample collection, which is discussed in the previous paragraphs. The completion of purging will be considered 0 hour. At the end of 48 hours, any partial sample will be measured. The accumulated sample will be compared to the minimum volume requirement identified in Table 1 and the allowed sample holding time. If the minimum volume requirement for the target analyte has not been achieved, then sampling may continue as determined from the well recharge

history. All analyte samples that have only minimum sample volumes collected, and all uncollected samples will be documented on the sample collection log.

Table 1
Sample Containers and Preservatives for Groundwater Samples

Parameter	Minimum Container ¹	Preservative	Holding Time
Radiation Screen	120 ml poly	None	NA
VOC - CLP	3 - 40 ml amber glass	Cool to 4° C	4 Days
BNA	1 L amber glass	Cool to 4° C	7 Days
Pesticides/PCB	1 L amber glass	Cool to 4° C	7 Days
TSS	125 ml poly	Cool to 4° C	7 Days
TDS, Cl, F, SO ₄ , CO ₃ , HCO ₃	1 L poly	Cool to 4° C	7 Days
Dissolved Metals - CLP, with Cs, Li, Sr, Sn, Mo, Si	1 L poly	*Filtered, HNO ₃ to pH <2, Cool to 4° C	6 Months
TOC	125 ml poly	H ₂ SO ₄ < pH2, Cool to 4° C	28 Days
COD	125 ml poly	H ₂ SO ₄ < pH2, Cool to 4° C	28 Days
Total Metals - CLP with Cs, Li, Sr, Sn, Mo, Si	1 L poly	Unfiltered, HNO ₃ to pH <2, Cool to 4° C	6 Months
Orthophosphate	250 ml poly	Filtered, Cool to 4° C	2 Days
Nitrate / Nitrite as N	250 ml poly	H ₂ SO ₄ to pH <2, Cool to 4° C	28 Days
Cyanide	1 L poly	NaOH to pH >12, Cool to 4° C	14 Days
Gross Alpha / Beta	550 ml poly	HNO ₃ to pH <2	6 Months
^{233/234} U, ²³⁵ U, ²³⁸ U	100 ml poly	Filtered, HNO ₃ to pH <2	6 Months
^{239/240} Pu	1 L poly	HNO ₃ to pH <2	6 Months
²⁴¹ Am	1 L poly	HNO ₃ to pH <2	6 Months
^{89/90} Sr	700 ml poly	Filtered, HNO ₃ to pH <2	6 Months
^{226/228} Ra	750 ml poly	Filtered, HNO ₃ to pH <2	6 Months
¹³⁷ Cs	2.5 L poly	Filtered, HNO ₃ to pH <2	6 Months

¹ The volume listed is the minimum amount required for analysis. Actual sample volumes may be slightly higher and some parameters may be combined in a single container.

* Some samples may not require filtering if taken from a well with a dedicated pump and turbidity of 5 NTU or less.

The order of sample collection may be changed at the discretion of the sampling team. Changes in the order shall be based on the predicted volume of water that will be recovered and the priority stated in the controlling document. The sampling team shall document their sample selections on the sample collection log.

Sample containers shall be stored away from sunlight and cooled to 4°C prior to filling. Immediately after collection, samples requiring cooling shall be cooled to 4°C. A chilled cooler shall be used as the storage container. Whenever a sample bottle that requires chilling is not being physically handled, it will be placed in the cooler to prevent heating or freezing, exposure to sunlight, and possible breakage.

VOC samples shall be collected using a bailer equipped with a bottom-decanting control valve or directly from the pump discharge line on wells equipped with bladder pumps. The procedures for collecting VOC samples are discussed in Subsections 4.8.1.1 and 4.8.1.2 of this procedure.

VOC vials shall never be filled and stored below capacity because of insufficient quantities of water in the well. Except for the VOC vials, adequate air space should be left in the sample bottles to allow for expansion.

Samples shall be placed in the appropriate containers and packed with ice in coolers as soon as practical. VOC samples will be stored in the cooler in an inverted position immediately after collection. When sampling is complete, the well cap shall be replaced and locked.

Sampling tools, instruments, and equipment shall be protected from sources of contamination before use and decontaminated after use as specified in Subsection 4.3. *Liquids from decontamination operations will be handled in accordance with the procedures in Subsection 4.6.3 of this procedure.* Sample containers shall also be protected from sources of contamination. Sampling personnel shall wear chemical-resistant gloves (e.g., nitrile) when handling samples, and the gloves will be disposed of between well sites.

4.8.1.1 Groundwater Sampling Using a Bailer

This subsection describes the use of a bailer for collecting groundwater samples that may be used to obtain physical, chemical, or radiological data.

A bailer attached to a Teflon[®] coated stainless steel cable is carefully lowered into the well. After filling within the well, the bailer is withdrawn by rewinding the bailer line, and the bailer contents are drained into the appropriate containers. Certain recommendations and/or constraints should be observed when using bailers for sampling groundwater monitoring wells, as follows.

- Use only bottom-filling Teflon[®] bailers or bailers made of other inert materials.
- Ensure that bailers are attached to a Teflon[®] coated stainless steel line that is pre-wound on a reel.
- Do not use bailers constructed with adhesive joints.
- Lower the bailer slowly to the interval from which the sample is to be collected.

VOC samples shall be collected using a bailer equipped with a bottom-decanting control valve. The first water through the valve assembly will be discarded into the purge water container. Vials will be filled by dispensing water through the control valve along the inside edge of the slightly tilted sample vial. Care shall be taken to eliminate aeration of the sample water. The vials will be filled beyond capacity so the resulting meniscus will produce an airtight seal when capped. The capped vial will be checked for trapped air by lightly tapping the vial in an inverted position. If air becomes trapped in the vial, the sample water shall be discarded, and the vial refilled. If two consecutive attempts to fill a VOC vial result in trapped air bubbles, the vial shall be discarded.

The remainder of the sampling water shall be collected in a stainless steel container from which the remaining sample bottles will be filled. Samples requiring filtration shall be filtered and then containerized.

4.8.1.2 Groundwater Sampling Using a Peristaltic Pump

Use of peristaltic pumps shall generally be limited to collecting sample aliquots for radionuclides, metals, and other species that are not subject to volatilization and degassing. Peristaltic pumps shall never be used to collect VOCs or other

volatile species in routine wells, although such samples may be collected for special screening applications. All downhole tubing shall be Teflon[®] except in areas of special concern (e.g., where immiscible layers exist) where special tubing, such as stainless steel or Viton[®], may be required. If so, the project manager will make this determination. Only the portion of tubing that is inserted into the mechanical drive shall be made of silicon. This drive portion of the tubing shall be discarded after each use.

4.8.1.3 Groundwater Sampling Using a Downhole Bladder Pump

Some wells are equipped with dedicated downhole bladder pumps for purging and sampling. These are wells that will normally produce an adequate amount of water during a single visit to complete the required sampling suite. The equipment required to purge and sample a well consists of a pump control unit, a portable air compressor, a continuous sampler for measuring the field parameters, and the necessary sample containers, graduated cylinders, and container(s) to collect the purge and excess water. The following precautions should be observed during the sampling operation.

- Locate the compressor used to power the pump downwind from the well to eliminate the contamination of equipment and samples with exhaust.
- If the flow-through cell will not maintain a full sample chamber (tends to drain back), then clean the check valve on the pump if it is fouled, or replace the pump.
- Calculate the minimum purge volume using the procedure in Section 4.6. Note that a purge is considered completed only when the groundwater parameters have stabilized.
- Upon completion of purging, initiate sampling with the collection of the VOC sample(s). The pump should operate with minimum interruptions while the full sample suite is collected. Allowing the pump to stop for an extended period of time will cause the water trapped in the discharge lines to equilibrate to ambient temperatures, which is not acceptable. During sampling, the pump can be slowed to any rate that allows efficient sampling while also maintaining stable field parameters.
- Measure groundwater parameters periodically during sample collection and record them on the sample collection log to document conditions during sampling.
- Because micropurging is the method used for sampling, adjust the flow rate to limit the drawdown in the well. Also adjust the rate such that the turbidity is below 5 NTU for sampling. If this criterion is met, the samples need not be filtered.
- Operate the pump, pump control unit, and the flow-through cell according to the manufacturer's recommendations.

4.8.1.4 Groundwater Sampling Using a Push Type Sampler

This portion of this procedure describes the use of a Geoprobe[®] Screen Point 15 Groundwater Sampler, or similar type equipment, for collecting groundwater samples at predetermined depths. These samples may be used to obtain physical, chemical, or radiological analyses.

A Geoprobe® Screen Point 15 Groundwater Sampler, or equivalent tool, is driven to a predetermined depth by a push type-sampling rig. The Screen Point 15 Groundwater Sampler is equipped with a 41-inch retractable screen and expendable drive point. It can then be partially or fully withdrawn (up to 41 inches) to expose a portion or the entire deployed well screen. After groundwater enters the exposed screen, a sample is collected using either the procedures in Subsection 4.8.1.1, Groundwater Sampling Using a Bailer, or in Section 4.8.1.2, Groundwater Sampling Using a Peristaltic Pump. Note that these samples are collected only for screening purposes because the sampling tool hole has not been completed as a well.

The method for obtaining QC samples using the push type-sampling tool is provided in Subsection 4.8.4.1 for groundwater sampling. Duplicate groundwater samples shall be collected only if there is enough water to collect two full suites of analytes without dewatering the annulus. If insufficient water is available for the collection of a planned QC sample, it shall be explained and documented in the field log book, and the project manager informed. If insufficient water is available for two full suites of analytes, it may be come necessary to prioritize the analyte list. The prioritization sequence should be described in the project-specific work plan.

4.8.2 Sample Filtering and Preservation

Samples for dissolved metals, Gross Alpha/Beta, ^{233/234}Uranium, ²³⁵Uranium, ²³⁸Uranium, ^{89/90}Strontium, ¹³⁷Cesium, ²²⁶Radium, ²²⁸Radium, and orthophosphate shall be filtered in the field at the well location during the sampling event through a disposable 0.45-micrometer membrane filter. If a peristaltic or bladder pump is used, a disposable filter may be attached directly to the sample delivery line so that the sample is filtered directly into the sample container as it exits the delivery line. Discharge pressure shall be gauged so it does not exceed 50 psi. Alternatively, sample water may be collected in a stainless steel container and filtered with a peristaltic pump. Before sample collection, 100 to 200 milliliters of sample water shall be passed through the filter in order to rinse the filter and filtration apparatus of possible contaminating substances.

Preservatives shall be added to the sample bottles prior to the introduction of the filtered sample water. The preservative shall be added in aliquots appropriate to the size of the bottle.

After sample collection has been completed, the pH of preserved samples shall be checked as follows.

- Pour a small amount of sample from the sample bottle directly onto approved pH paper. Use care so that the threaded neck of the bottle does not contact the pH paper. Do not, under any circumstances, insert the pH paper into the sample bottle.
- Check the pH paper against the supplied color chart. If the appropriate pH has not been achieved, add additional preservative to the sample in 5 ml aliquots and repeat the pH test after each addition.

4.8.3 QA/QC Samples

The frequency and types of field QA/QC samples collected during groundwater sampling are described in project-specific work plans or quality assurance plan documents. These documents detail the applicable criteria for collecting QA/QC samples.

4.8.3.1 Duplicates

Duplicate samples shall be collected only from wells that produce enough water to collect two full suites of analytes without dewatering. Wells that produce sufficient water shall be incorporated into the sampling program such that the required duplicate frequency can be maintained.

Wells scheduled for duplicate sample collection shall be sampled as described in Subsection 4.8 of this procedure, and in relevant sections of project-specific work plans and/or quality assurance documents. Field duplicates are collected following the same sampling procedures used to obtain the real samples. With the exception of VOCs, the typical procedure for a location is to collect the real and duplicate of each sample at the same time, in two equal portions, with each portion going to the laboratory in separate containers. This is accomplished by alternately filling two sample bottles one half at a time to minimize heterogeneity. Note that real and duplicate VOC samples shall be collected independently to reduce the possibility of volatilization of the sample.

When a well with a dedicated pump is being used for sample collection, all samples shall be collected in the normal order, with duplicate VOC samples being collected first. The remaining samples will be sampled as described above.

If a well is being used for matrix spike (MS) and matrix spike duplicate (MSD) samples, the duplicate shall be collected after collection of the MS and MSD.

All duplicate samples shall be given a sample number different from the original sample and the information recorded on the sample collection log and/or the field QC sample collection log.

4.8.3.2 Matrix Spike and Matrix Spike Duplicate

MS and MSD samples shall be collected only from wells that produce enough water to collect the required suites of analytes without dewatering. MS and MSD samples are not collected on a routine basis, but will be collected if so designated in a site-specific sampling plans, or if requested by the project manager.

MS and MSD samples shall be collected as follows.

- Purge the well as described in Subsection 4.6 of this procedure..
- After completion of purging, collect VOC samples. Collect the real sample followed by the MS and MSD. Collect these samples in immediate succession.
- Collect the remaining samples not requiring filtering. For each sample parameter, collect the original sample, MS, and MSD concurrently. Fill the original sample bottle one-third full followed by the MS and MSD sample bottles, which are also filled one-third full. Rotate each bottle in the sequence, filling in one-third full until all three bottles are full. For analytes not requiring an MSD, collect only the original sample and the MS.
- After the real sample, MS, and MSD (where appropriate) are collected for one parameter, repeat the process for the next parameter.
- Similarly, collect samples requiring filtering. When a bailer is used, fill a stainless steel bucket with sample water. As samples are collected and the reservoir of water in the bucket is depleted, add more water with discretion. When a pump is used, attach the filter directly to the discharge line. Fill

sample bottles as described above, partially filling the original sample, MS, and MSD in rotating sequence until each parameter bottle is full.

- Radiochemistry samples may have more than one bottle for each parameter group. In this case, include all required bottles in the rotating sequence.
- Field parameter measurements are not be required for MS and MSD samples.
- Retain the original sample number for MS and MSD samples. However, add a suffix of MS or MSD to the sample number to correspond with each QA/QC sample. Record all information on the field QC groundwater sample collection log.

4.8.3.3 Replicates and Splits

Replicate and split samples shall be collected in the same manner as described for the MS and MSD. Seek instruction from the project manager for replicates and splits exceeding three samples. Record all information will be recorded on the groundwater sample collection logs.

4.8.3.4 Field Equipment Rinses

Wells scheduled for equipment rinsate samples shall be sampled as described in Subsection 4.8 of this procedure, and field equipment rinses shall be collected as described in this Subsection and in relevant portions of project-specific QC documents and work plans. Field equipment rinses shall be collected in a manner designed to reflect sampling techniques. All equipment used during sampling will be fully decontaminated as described in Subsection 4.3, then rinsed with distilled or deionized water. The rinse water will then be collected in bottles identical to those used for the original sample, and assigned a separate sample number. Analytes requiring filtration will be filtered using a new filter and tubing as required for the real sample. All information will be recorded on groundwater sample collection logs.

4.8.3.4.1 Bailed Wells

After completion of sampling, all equipment shall be decontaminated. Prior to leaving the well location, the equipment rinse will then be collected as follows.

- Fill the bailer with distilled or deionized water by pouring the water into the top opening.
- Decant the rinse water to the VOC vials through the bottom valve just as was done during sample collection.
- For the remaining unfiltered samples, fill the bailer with distilled or deionized water each time additional rinsate is needed. Transfer the rinsate to sample bottles or to a stainless steel bucket and then to sample containers in the same manner used during collection.
- Collect filtered samples in an identical manner as the real samples. Fill the bailer with distilled or deionized water. Then transfer the rinse water to a stainless steel bucket. Filter the rinse water in the bucket through a new disposable filter.

- Preserve rinse samples in the same manner as the real samples.

4.8.3.4.2 Pumped Wells

Rinsate samples are not routinely collected from wells that are equipped with dedicated bladder pumps because the samples from these wells are collected directly from the pump discharge line. However, wells sampled using peristaltic pumps for sampling may be selected for rinsate sampling, with equipment used in sample collection (down hole tubing, filter tubing and the stainless steel bucket used for sample water collection, etc.) being decontaminated prior to rinsate sampling. The tubing at the pump head will be replaced, and a new filter used for filtered analytes. To collect the samples, distilled or deionized water will be poured into the decontaminated stainless steel bucket and pumped, using the decontaminated tubing, into the sample containers. The equipment used to collect the real VOC samples will also be decontaminated, rinsed, and used to collect the VOC rinse samples. All samples will be preserved at the same pH levels as the real samples.

4.8.3.5 Distilled Water Blanks

Distilled water sample blanks are not submitted on a routine basis, but will be made up if so designated in a site-specific sampling plan. Samples of the distilled or deionized water used for the final decontamination of equipment will be transferred directly to sample bottles to determine any baseline contamination the water may have introduced into the samples. Five-gallon bottles of the distilled or deionized water will be opened in a controlled area, such as the bottle storage room, and then poured directly into the appropriate sample bottle. A Teflon[®], glass, or stainless steel funnel may be used to help control flows into small mouth bottles. Blank samples will be preserved to the appropriate pH required for each analyte. All information will be recorded on groundwater sample collection logs.

4.9 Sample Handling and Control

Pre-cleaned sample containers will be obtained from a contract analytical sample container source. Preserving solution will be added to the bottles by a laboratory, the sample manager or qualified sampling personnel. The bottles will be labeled to indicate the preservative added.

The sampling containers, preservation requirements, and holding times for the various types of analyses are shown in Table 1. Groundwater samples will be properly labeled so that they can be easily identified. The sample numbering system will be assigned by project-specific sampling plan documents. A sample identification (ID) number will be assigned to each sample suite. The sample ID number will contain the following information as part of a nine to twelve character, alpha-numeric code:

Character(s)	Description	Code
1 and 2	Project ID	GW
3 through 7	Sample Number	00001 to 99999
8 and 9	Subcontractor ID	Alpha (e.g. TE = Tierra Environmental Consultants)
10, 11, and 12	QA/QC	MS for matrix spike, MSD for matrix spike duplicate

In addition to a sample number, each well sampled will be assigned a current Record Identification Number (RIN), an event number (specific to the RIN), and bottle numbers that are specific to the RIN and event number.

5.0 Records

All field activities shall be recorded on a Field Activity Daily Log or Groundwater Sample Collection Log. Additional logs may be required to record QC samples and for recording well status. Refer to specific project, site, or facility work plans for further information. Summary information of the day's activities or other pertinent information should always be recorded on the field forms. Under some circumstances, the project manager may assign a bound field logbook to the field personnel that will remain in their custody during all sampling activities. The cover of each logbook shall contain the following information at a minimum:

- Name of the organization to which the book is assigned
- Book number
- Project name
- Start and end dates

Logbook pages shall be sequentially numbered and marked with the book number before any data are recorded. All data and information pertinent to field sampling shall be recorded in the logbook or on the field forms that identify all required data entries. Enough detail must be included in the documentation to reconstruct the sampling event. Field form entries shall include the following minimum information:

- Date and time
- Names of field personnel
- Names of all visitors
- Location of field activities
- Description of sampling sites including weather conditions
- All field observations and comments
- Field parameters
- Sample identification information
- References to all prepared field activity forms and chain-of-custody records

Field logbooks, when required on specific projects, shall normally be kept only by the field sampling team leaders and the site supervisor and shall typically be used only to summarize field activities and to document project information not required by the procedure field forms.

Permanent ink shall be used for all entries in the logbooks and on the field forms. Mistakes shall be crossed out with a single line, initialed, and dated. Unused pages or partial pages shall be voided by drawing a line through the blank sections and initialing and dating the mark. Any deviation from this procedure shall require documentation in the site supervisor's logbook.

The field activity daily log narrative should create a chronological record of the sampling team's activities, including the time and location of each activity. Descriptions of problems encountered, personnel contacted, deviations from the procedure, and visitors on site shall also be included. The weather conditions, date, signature of the person responsible for entries, and the number of field activity daily log sheets used to record media team activities for a given day shall also be included.

The Groundwater Levels Measurement/Calculations Form and the Chain of Custody Record (see *Containing, Preserving, Handling, and Shipping Soil and Water Samples*) shall also be completed for each site. All blank fields on the forms must be completed or voided.

6.0 References

- Environmental Protection Agency, 1982, Test Methods for Evaluating Solid Waste, SW-846, Volume II. Field Methods, 2nd edition.
- Environmental Protection Agency, 1986a, Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, EPA Region IV Environmental Service Division.
- Environmental Protection Agency, September 1986b, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1.
- Environmental Protection Agency, 1987a, A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001. 1987.
- Environmental Protection Agency, 1987b, Data Quality Objectives for Remedial Activities, Development Process, EPA/540/G-87/003.
- Environmental Protection Agency, December 1988, User's Guide to the Contract Laboratory Program.

APPENDIX A
STANDARD GROUNDWATER FORMS

Appendix C
Sample Collection Forms

SM Stoller Corp.

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>	Sample location: <i>CSEMRI-2</i>		
Project Number: <i>4060-510</i>	Date: <i>3/8/07</i>		
Sample Type: GW SW Rinse	Sampler: <i>Nick Malczyk</i>		
Duplicate Other:			

Purge Volume Calculations		Sample Collection				
Measured TD =	(+.28) <i>45.10</i> (ft)	Analysis	Container	Preservative	Date	Time
Total Depth =	<i>95.38</i> (ft)	<i>Dissolved Metals</i>	<i>500ml plastic</i>	<i>F/HNO₃ 40%</i>	<i>3/8/07</i>	<i>1620</i>
Depth to Water =	<i>55.95</i> (ft)	<i>Nitrate Nitrite</i>	<i>1L plastic</i>	<i>F/H₂SO₄ 40%</i>	<i>3/8/07</i>	<i>1625</i>
Initial Water Column =	<i>39.43</i> (ft)	<i>Anions</i>	<i>1L plastic</i>	<i>F/40%</i>	<i>3/8/07</i>	<i>1630</i>
Initial Water Volume =	<i>6.30</i> (gal)	<i>Barium Thorium Uranium</i>	<i>1.5L cube</i>	<i>F/HNO₃ 40%</i>	<i>3/8/07</i>	<i>1635</i>
3X Water Volume =	<i>18.90</i> (gal)	Lab: <i>Pargen - Fort Collins</i>				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>0925</i>	<i>3.15</i>	<i>54.3</i>	<i>7.42</i>	<i>641</i>	<i>236</i>	-	-	<i>brown</i>
<i>0934</i>	<i>6.30</i>	<i>54.3</i>	<i>7.39</i>	<i>647</i>	<i>357</i>	-	-	
<i>0943</i>	<i>4.45</i>	<i>54.6</i>	<i>7.11</i>	<i>725</i>	<i>465</i>	-	-	<i>↓</i>
	<i>12.60</i>							
	<i>15.75</i>							
	<i>18.90</i>							
Volume purged: <i>11.45</i>				Alkalinity: pH = <i>Over range</i> pH = <i>NEA</i>				
				Total Alkalinity = _____ ppm				

Comments: *Purged 11.45 gal, sampled later in the afternoon*

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Sample Collection Log			
Project Name: <i>Cedeno School of Mines</i>		Sample location: <i>CSMRI-4</i>	
Project Number: <i>4060-510</i>		Date: <i>3/8/07</i>	
Sample Type: <input checked="" type="radio"/> SW SW Rinse Duplicate Other:		Sampler: <i>Nick Malczyk</i>	

Purge Volume Calculations		Sample Collection				
Measured TD =	<i>17.25</i> (ft)	Analysis	Container	Preservative	Date	Time
	(+28)	Dissolved	500 mL	F/HNO ₃	<i>3/8/07</i>	<i>1145</i>
Total Depth =	<i>17.53</i> (ft)	Metals	Plastic	40% F/40%		
Depth to Water =	<i>7.23</i> (ft)	Ammonia	1L	Plastic	<i>3/8/07</i>	<i>1150</i>
Initial Water Column =	<i>10.30</i> (ft)	Nitrate	1L	F/H ₂ SO ₄	<i>3/8/07</i>	<i>1155</i>
Initial Water Volume =	<i>1.64</i> (gal)	Nitrite	Plastic	40%		
3X Water Volume =	<i>4.92</i> (gal)	Radium	1 gal	F/HNO ₃	<i>3/8/07</i>	<i>1200</i>
		Thorium	case	40%		
		Uranium				
		Lab: Pargen - Fort Collins				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1130</i>	<i>0.8</i>	<i>44.4</i>	<i>7.21</i>	<i>1196</i>	<i>25</i>	—	—	<i>clear</i>
<i>1132</i>	<i>1.64</i>	<i>42.7</i>	<i>7.09</i>	<i>1162</i>	<i>29</i>	—	—	
<i>1134</i>	<i>2.46</i>	<i>42.4</i>	<i>7.08</i>	<i>1159</i>	<i>37</i>	—	—	
<i>1136</i>	<i>3.28</i>	<i>42.2</i>	<i>7.06</i>	<i>1156</i>	<i>42</i>	—	—	
<i>1138</i>	<i>4.10</i>	<i>41.8</i>	<i>7.06</i>	<i>1164</i>	<i>48</i>	—	—	
<i>1143</i>	<i>4.92</i>	<i>41.6</i>	<i>7.03</i>	<i>1186</i>	<i>57</i>	—	—	
Volume purged: <i>4.92 gal</i>				Alkalinity pH = Over range pH = <i>NM</i> Total Alkalinity = ppm				

Comments:

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>	Sample location: <i>CSMRI-5</i>		
Project Number: <i>4060-510</i>	Date: <i>3/8/07</i>		
Sample Type: <i>GW</i> SW Rinse Duplicate Other:	Sampler: <i>Nick Malczyk</i>		

Purge Volume Calculations		Sample Collection				
Measured TD =	<i>10.97</i> (ft)	Analysis	Container	Preservative	Date	Time
Total Depth =	<i>11.25</i> (ft)	<i>Dissolved Metals</i>	<i>500ml Plastic</i>	<i>F/HNO₃ 40C</i>	<i>3/8/07</i>	<i>1245</i>
Depth to Water =	<i>6.63</i> (ft)	<i>Ammon</i>	<i>1L Plastic</i>	<i>F/40C</i>	<i>3/8/07</i>	<i>1250</i>
Initial Water Column =	<i>4.62</i> (ft)	<i>Nitrate Nitrite</i>	<i>1L Plastic</i>	<i>F/H₂SO₄ 40C</i>	<i>3/8/07</i>	<i>1255</i>
Initial Water Volume =	<i>1.74</i> (gal)	<i>Barium Chromium Uranium</i>	<i>1 gal 6L</i>	<i>F/HNO₃ 40C</i>	<i>3/8/07</i>	<i>1300</i>
3X Water Volume =	<i>2.22</i> (gal)	Lab: <i>Pargen - Fort Collins</i>				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1240</i>	<i>Initial</i>	<i>47.1</i>	<i>7.12</i>	<i>826</i>	<i>57</i>	<i>-</i>	<i>-</i>	<i>clear</i>
<i>1242</i>	<i>1.48</i>	<i>45.3</i>	<i>7.09</i>	<i>798</i>	<i>165</i>	<i>-</i>	<i>-</i>	<i>cloudy</i>
<i>1244</i>	<i>2.22</i>	<i>44.8</i>	<i>7.07</i>	<i>797</i>	<i>231</i>	<i>-</i>	<i>-</i>	<i>↓</i>
Volume purged: <i>2.22 gal</i>				Alkalinity pH = <i>Over range</i> pH = Total Alkalinity = <i>ppm</i>				

Comments:

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>		Sample location: <i>C. SMRI-8</i>	
Project Number: <i>4060-510</i>		Date: <i>3/8/07</i>	
Sample Type: <input checked="" type="checkbox"/> SW <input type="checkbox"/> SW <input type="checkbox"/> Rinse Duplicate Other:		Sampler: <i>Nick Malczyk</i>	

Purge Volume Calculations		Sample Collection				
Measured TD =	(+28) <i>17.05</i> (ft)	Analysis	Container	Preservative	Date	Time
Total Depth =	<i>17.32</i> (ft)	Dissolved Metals	500ml Plastic	F/HNO ₃ 40% 40%	3/8/07	1300
Depth to Water =	<i>8.04</i> (ft)	Anions	1L Plastic	F/40%	3/8/07	1305
Initial Water Column =	<i>9.28</i> (ft)	Nitrate Nitrite	250ml Plastic	F/H ₂ SO ₄ 40%	3/8/07	1310
Initial Water Volume =	<i>1.48</i> (gal)	Redox Uranium Thorium	1 gal cube	F/HNO ₃ 40%	3/8/07	1315
3X Water Volume =	<i>4.44</i> (gal)	Lab: Pargen - Fort Collins				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1040</i>	<i>0.1 Initial</i>	<i>47.1</i>	<i>7.36</i>	<i>1793</i>	<i>1000+</i>	—	—	<i>brown</i>
<i>1044</i>	<i>1.48</i>	<i>43.0</i>	<i>7.40</i>	<i>1752</i>	↓	—	—	↓
<i>1048</i>	<i>2.22</i>	<i>43.2</i>	<i>7.48</i>	<i>1764</i>	↓	—	—	↓
<i>1052</i>	<i>2.96</i>	<i>43.7</i>	<i>7.57</i>	<i>1764</i>	↓	—	—	↓
<i>1054</i>	<i>3.70</i>	<i>44.4</i>	<i>7.65</i>	<i>1735</i>	↓	—	—	↓
<i>1101</i>	<i>4.44</i>	<i>45.6</i>	<i>7.77</i>	<i>1736</i>	↓	—	—	↓
Volume purged: <i>4.44 gal</i>		Alkalinity pH = <i>Over range</i> pH = <i>nm</i> Total Alkalinity = _____ ppm						

Comments: *well does not recharge well*

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>	Sample location: <i>CSMRD-9</i>		
Project Number: <i>4060-510</i>	Date: <i>2/27/07</i>		
Sample Type: <i>SW</i> SW Rinse Duplicate Other:	Sampler: <i>Nick Malczyk</i>		

Purge Volume Calculations		Sample Collection				
Measured TD =	<i>32.40</i> (ft)	Analysis	Container	Preservative	Date	Time
Total Depth =	<i>32.68</i> (ft)	<i>Ammonia</i>	<i>1L Plastic</i>	<i>F/402</i>	<i>1425</i>	<i>2/27/07</i>
Depth to Water =	<i>26.14</i> (ft)	<i>nitrate nitric</i>	<i>1L Plastic</i>	<i>H2SO4/F/402</i>	<i>1430</i>	<i>2/27/07</i>
Initial Water Column =	<i>6.54</i> (ft)	<i>Dissolved Metals</i>	<i>500ml Plastic</i>	<i>F/HNO3 402</i>	<i>1640</i>	<i>2/27/07</i>
Initial Water Volume =	<i>1.05</i> (gal)	<i>Radium Thorium Uranium</i>	<i>1gal cube</i>	<i>F/HNO3 402</i>	<i>1650</i>	<i>2/27/07</i>
3X Water Volume =	<i>3.15</i> (gal)	Lab: <i>Pargen - Fort Collins</i>				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1337</i>	<i>1.05</i>	<i>55.7</i>	<i>7.41</i>	<i>856</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>brown</i>
<i>1342</i>	<i>2.10</i>	<i>53.6</i>	<i>7.51</i>	<i>333</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>↓</i>
<i>1347</i>	<i>3.15</i>	<i>52.5</i>	<i>7.48</i>	<i>425</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>↓</i>
<i>1358</i>	<i>4.20</i>	<i>53.7</i>	<i>7.46</i>	<i>678</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>↓</i>
Volume purged: <i>4.20 gal</i>				Alkalinity pH = <i>Over range</i> pH = Total Alkalinity = <i>ppm</i>				

Comments: *Filtered samples had to settle prior to filtering/sampling*

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>		Sample location: <i>CSMR-10</i>	
Project Number: <i>4060-510</i>		Date: <i>2/27/07, 3/1/07</i>	
Sample Type: <input checked="" type="checkbox"/> GW <input type="checkbox"/> SW <input type="checkbox"/> Rinse Duplicate Other:		Sampler: <i>Nick Melczyk</i>	

Purge Volume Calculations		Sample Collection				
Measured TD =	<i>27.54</i> (ft)	Analysis	Container	Preservative	Date	Time
	(+28)	<i>Arsenic</i>	<i>1 L Plastic</i>	<i>F/402</i>	<i>2/27/07</i>	<i>1520</i>
Total Depth =	<i>27.82</i> (ft)	<i>Nitrate</i>	<i>1 L Plastic</i>	<i>F/H₂SO₄</i>	<i>2/27/07</i>	<i>1525</i>
Depth to Water =	<i>23.74</i> (ft)	<i>Nitrite</i>	<i>1 L Plastic</i>	<i>402</i>	<i>2/27/07</i>	<i>1525</i>
Initial Water Column =	<i>4.08</i> (ft)	<i>Dissolved Metals</i>	<i>500mL Plastic</i>	<i>F/HNO₃</i>	<i>3/1/07</i>	<i>1220</i>
Initial Water Volume =	<i>.65</i> (gal)	<i>Radium</i>	<i>1 gal</i>	<i>F/HNO₃</i>	<i>3/1/07</i>	<i>1225</i>
3X Water Volume =	<i>1.95</i> (gal)	<i>Thorium</i>	<i>1 gal</i>	<i>402</i>	<i>2/28/07</i>	<i>1225</i>
		<i>Uranium</i>	<i>1 gal</i>		<i>2/28/07</i>	<i>1225</i>
Lab: <i>Pargen - Fort Collins</i>						

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (°F)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1458</i>	<i>.65</i>	<i>53.6</i>	<i>7.57</i>	<i>807</i>	<i>1000+</i>	<i>—</i>	<i>—</i>	<i>brown</i>
<i>1501</i>	<i>1.30</i>	<i>52.3</i>	<i>7.59</i>	<i>776</i>	<i>1000+</i>	<i>—</i>	<i>—</i>	<i>↓</i>
<i>1504</i>	<i>1.95</i>	<i>52.0</i>	<i>7.48</i>	<i>759</i>	<i>1000+</i>	<i>—</i>	<i>—</i>	<i>↓</i>
<i>1508</i>	<i>2.60</i>	<i>52.5</i>	<i>7.37</i>	<i>758</i>	<i>1000+</i>	<i>—</i>	<i>—</i>	<i>↓</i>
<i>1513</i>	<i>3.25</i>	<i>52.1</i>	<i>7.28</i>	<i>740</i>	<i>1000+</i>	<i>—</i>	<i>—</i>	<i>↓</i>
Volume purged: <i>3.25 gal</i>				Alkalinity pH = <i>Over range</i> pH = Total Alkalinity = <i>ppm</i>				

Comments: *All samples collected 2/27 but filtered samples had to settle overnight prior to being filtered*

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>		Sample location: <i>CSMR-I-11</i>	
Project Number: <i>4060-510</i>		Date: <i>2/27/07</i>	
Sample Type: <input checked="" type="radio"/> SW <input type="radio"/> Rinse Duplicate Other:		Sampler: <i>Nick Malczyk</i>	

Purge Volume Calculations		Sample Collection				
Measured TD =	<i>36.13</i> (ft)	Analysis	Container	Preservative	Date	Time
	(+28)	<i>Arsons</i>	<i>1 L Plastic</i>	<i>None / 4oz</i>	<i>2/27/07</i>	<i>1040</i>
Total Depth =	<i>36.41</i> (ft)	<i>Nitrate</i>	<i>1 L Plastic</i>	<i>H₂SO₄ / 4oz</i>	<i>2/27/07</i>	<i>1045</i>
Depth to Water =	<i>31.11</i> (ft)	<i>Nitrite</i>	<i>500mL Plastic</i>	<i>F/HNO₃ / 4oz</i>	<i>2/27/07</i>	<i>1545</i>
Initial Water Column =	<i>5.3</i> (ft)	<i>Reduced Metals</i>	<i>1 Gal Cube</i>	<i>F/HNO₃ / 4oz</i>	<i>2/27/07</i>	<i>1555</i>
Initial Water Volume =	<i>0.85</i> (gal)	Lab: <i>Pargen - Fort Collins</i>				
3X Water Volume =	<i>2.55</i> (gal)					

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (°F)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>1019</i>	<i>0.85 Initial</i>	<i>57.9</i>	<i>7.24</i>	<i>1172</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>Brown</i>
<i>1024</i>	<i>1.7</i>	<i>54.9</i>	<i>7.25</i>	<i>755</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>Brown</i>
<i>1028</i>	<i>2.55</i>	<i>53.9</i>	<i>7.17</i>	<i>728</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>Brown</i>
<i>1032</i>	<i>3.4</i>	<i>54.4</i>	<i>7.28</i>	<i>714</i>	<i>1000+</i>	<i>-</i>	<i>-</i>	<i>Brown</i>
<i>NEA</i>								
Volume purged: <i>3.5 gallons</i>				Alkalinity pH = _____ Over range pH = _____ Total Alkalinity = _____ ppm <i>NEA</i>				

Comments: *Filtered samples had to settle before filtering*

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Sample Collection Log			
Project Name: <i>Colorado School of Mines</i>		Sample location: <i>Equipment Blank</i>	
Project Number: <i>4060-510</i>		Date: <i>3/8/07</i>	
Sample Type: GW SW <u>Rinse</u>		Sampler: <i>Nick Malczyk</i>	
Duplicate Other:			

Purge Volume Calculations			Sample Collection				
Measured TD =	(+28)	(ft)	Analysis	Container	Preservative	Date	Time
Total Depth =		(ft)	<i>Dissolved Metals</i>	<i>500mL Plastic</i>	<i>F/HNO₃ 40%</i>	<i>3/8/07</i>	<i>1225</i>
Depth to Water =		(ft)	<i>Uranium Thorium Radon</i>	<i>1 gal Plastic</i>	<i>F/HNO₃ 40%</i>	<i>3/8/07</i>	<i>1230</i>
Initial Water Column =		(ft)					
Initial Water Volume =		(gal)					
3X Water Volume =		(gal)					
			Lab: <i>Pargen - Fort Collins</i>				

Purge Volumes and Field Water Quality Measurements								
Time	Volume (gal)	Temp (C)	pH (SU)	Conductivity (uS/cm)	Turbidity (NTU)	ORP (mV)	DO (mg/L)	Appearance
<i>Initial</i>								
Volume purged: <i>—</i>				Alkalinity				
				pH = <i>Over range</i> pH = <i>NEM</i>				
				Total Alkalinity = ppm				

Comments:

sample
ID

Sample ID	Collection Start Date	Collection Start Time	Starting Flow Rate (L/min.)	Collection Stop Date	Collection Stop Time	Ending Flow Rate (L/min.)	Count Date	Time at Start of Count	Alpha Counts	Counting Time (min.)	Background Count Rate (cpm)	Scaler S/N	Prol. S/N
1204	AS- East	10/22/06	1205	57	11/15/06	1515	50						
-	AS- West	↓	-	-	-	-							
1516	AS- East	11/15/06	1517	59	12/13/06	1513	42						
-	AS- West	↓	-	-	-	-							
1515	AS- East	12/13/06	1516	60	1/18/07	1047	45						
-	AS- West	12/26/06 to m	1230	65	↓	1042	60						
1049	AS- East	1/18/07	1050	60	2/17/07	1531	42						
1044	AS- West	↓	1048	70	↓	1537	430						

mm

Appendix D
Surface Water Sampling Procedures

Surface Water Sampling

1.0 Scope and Objective

1.1 Scope

This procedure provides instructions and establishes requirements for the collection and documentation of surface water samples by Stoller personnel. This procedure applies to the collection of surface water samples from streams, rivers, ponds, lakes, seeps, impoundments, and other surface sources.

1.2 Objective

The objective of this procedure is to establish a uniform method for the collection of surface water samples that provides representative samples in a safe and responsible manner.

2.0 Definitions

Composite Sample – A sample that is comprised of roughly equal amounts of water collected from a set of sample locations known as a sample group.

Grab Sample – A single sample collected at one sampling point over a short period of time. Grab sample results are representative of the sample location at the time of sample collection. Also called a catch sample.

Peristaltic Pump – A self-priming, low volume pump consisting of a rotor and ball bearing rollers. Tubing placed around the rotors is squeezed by the rotors as they revolve. The squeezing produces a wavelike contractual movement which causes water to be drawn through the tubing. The peristaltic pump is limited to sampling at depths of less than 25 feet.

3.0 Responsibilities and Qualifications

3.1 Project Manager

The Project Manager is responsible for ensuring that surface water samples are properly and safely collected. This will be accomplished through staff training and by maintaining quality control (QC). At a minimum, project management shall:

- 3.1.1 Verify that personnel have reviewed, and are familiar with, site-specific work plans which address surface water sampling, this procedure, and any associated procedures.
- 3.1.2 Ensure that hazards are identified and analyzed with respect to collecting surface water samples, and develop and implement controls to minimize hazards.
- 3.1.3 Provide personnel with training in the operation of surface water sampling equipment and the requirements of this procedure.
- 3.1.4 Periodically review field generated documentation associated with surface water sampling to ensure compliance with project requirements and implement corrective action if necessary.
- 3.1.5 Receive feedback from field sampling personnel in order to continually improve surface water sampling process.

3.2 Site Supervisor

The Site Supervisor is responsible for directing and overseeing all field activities, including sampling, to ensure that site-specific plan requirements are met in a safe and efficient manner within the established safety envelope.

3.3 Field Sampling Personnel

Field sampling personnel are responsible for the proper sample collection and documentation of the sampling event in accordance with this procedure. At a minimum, field sampling personnel have the responsibility to:

- 3.3.1 Familiarize themselves with site-specific work plans, surface water sampling procedures, potential hazards, and health and safety plan.
- 3.3.2 Implement the controls to minimize hazards.
- 3.3.3 Be familiar with sampling equipment and its proper use.
- 3.3.4 Properly complete field documentation.
- 3.3.5 Provide feedback to project manager in order to improve sampling process.

4.0 Equipment/Materials and Calibration

4.1 Equipment/Materials

A number of devices are available for the collection of surface water samples. These devices are constructed of a number of materials including, but not limited to: stainless steel, glass, Teflon®, Tygon®. The sampling and analytical requirements, as well as site characteristics, must be taken into account when determining the proper surface water sampling equipment to use. The site-specific work plans should identify the specific equipment to be used, and methods for safely using equipment.

4.2 Calibration

Equipment shall be calibrated in accordance with manufacturer's recommendations and calibration documentation shall be maintained in project files.

5.0 Method

5.1 Field Preparation

Field preparation requires the organization of sample containers, sample labels, and documentation in an orderly, systematic manner to promote consistency and traceability of all data.

- 5.1.1 General sampling areas will be predetermined to ensure coverage of the various impact scenarios and should be described in project-specific work plans. The location of each sampling point shall be surveyed or mapped and staked as described in Section 5.1.6 prior to sampling.
- 5.1.2 In flowing water, surface water sampling shall be conducted from downstream locations first, then proceed to upstream locations to avoid potential cross contamination from disturbing the substrate.
- 5.1.3 Prior to sampling and between sampling locations, sampling equipment shall be decontaminated.
- 5.1.4 Appropriate personal protective equipment shall be used, as specified in the project-specific health and safety plan.
- 5.1.5 All pertinent information (date, site name, identification number, and location) shall be recorded on a Field Activity Daily Log (FADL) and a Sample Collection Log, as appropriate. Field conditions, unusual circumstances, and weather conditions shall be noted.

5.1.6 Due to the nature of sampling an aqueous environment, additional steps are required to verify and mark sample locations. Depending on the project needs, it may be useful to use a Global Positioning System (GPS) to verify and mark the sample locations. Refer to *Field Mapping with a Global Positioning System* for details. The following steps shall be followed by the sampler in addition to the field preparation requirements described in Section 5.1.1.

5.1.6.1 Place a marker (stake) on the shore approximately perpendicular to the sampling location and mark the sample number on the stake.

5.1.6.2 If the sample location is accessible by foot, use a measuring tape to measure the distance between the marked point and the sample location station. Record the compass bearing from the sample location to the shore marker.

5.1.6.3 If the sample location is accessible only by boat, use a rangefinder to estimate the distance to the shore marker to obtain the most accurate measurement. Record the compass bearing from the sample location to the shore marker. It is recommended that the boat's position on the water be stabilized to prevent drifting.

5.1.6.4 Determine and record the distance and direction of each shore marker from a reference point shown on the topographic map and mark all points on a map or use a GPS, if available.

5.1.7 Quality Control samples, including field and source blanks, shall be collected in accordance with the project-specific work plan.

5.2 Surface Water Sample Collection Using a Transfer Container

The device most commonly used to collect grab surface water samples is a transfer container (beaker, flask, etc.) made of inert material such as glass, stainless steel or Teflon*. When sampling with a transfer container, the procedure is as follows:

5.2.1 Survey and clearly map sampling points as described in Section 5.1.6 prior to sampling. The sample should be collected as close to the mapped location as possible. If the collection point must be moved, the new location must be approved and documented.

5.2.2 Dip the transfer container into the surface water. Always use a clean, properly decontaminated transfer container at each sample location.

5.2.3 Filter the sample if required.

5.2.4 Fill the sample bottle, allowing the sample stream to flow gently down the inside of the bottle with minimal turbulence.

5.2.5 Cap the bottle and handle the sample according to the procedures outlined in Project *Sample Shipping*.

5.2.6 Label the sample and document the sampling event.

5.3 Surface Water Sample Collection Using a Peristaltic Pump

A device used to collect composite surface water samples is a peristaltic pump. Samples to be analyzed for volatile organic analysis cannot be composited. When sampling with a peristaltic pump, the procedure is as follows:

5.3.1 Survey and clearly map sampling points as described in Section 5.1.6 prior to sampling. The sample should be collected as close to the mapped location as possible. If a collection point must be moved, the new location must be approved and documented.

- 5.3.2 Attach the appropriate tubing to the peristaltic pump. Always use new tubing at each sample location. Do not try to decontaminate and reuse tubing.
- 5.3.3 If filtering is required, attach the filtering device to the discharge end of the tubing.
- 5.3.4 Lower the intake end of the tubing into the water and begin pumping. If the pump is computerized, program the pump to collect the sample at the desired intervals and flow rate. If the pump is not programmable, record the discharge rate (compute discharge rate by dividing an amount of water collected by the time it took to collect it). Collect the sample at the desired interval.
- 5.3.5 Fill the sample bottle, allowing the sample stream to flow gently down the inside of the bottle with minimal turbulence. The programmable pump will perform this automatically.
- 5.3.6 Cap the bottle and handle the sample according to the procedures outlined in Project *Sample and Shipping*.
- 5.3.7 Label the sample and document the sampling event.

6.0 Required Inspection/Acceptance Criteria

None.

7.0 Records

The following records generated as a result of implementation of this procedure shall be maintained in a safe manner and submitted to project central files for storage and disposition.

Field Activity Daily Log

Sample Collection Log

Chain of Custody

8.0 References

8.1 Others

U.S. Environmental Protection Agency. 1987. *EPA Compendium of Superfund Field Operations Methods*, EPA 540/P-87/001a, OSWER 9355.0-14. Washington, DC.

U.S. Environmental Protection Agency. 1988. *EPA Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA*, Interim Final OSWER Directive 9355.3-01. Washington, DC.

American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1985. *Standard Methods for the Examination of Water and Wastewater*, 16th Edition, American Public Health Association, Washington, DC.

Appendix E

Data Validation Reports

DATA VALIDATION REPORT

To: Robert Hill
From: John Garrett
Date: March 30, 2007
Project/Site: CO School of Mines
Project No.: 4060
SDG No.: 0703015

This report presents the radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the radiological results that were obtained by Paragon Procedure PA SOP 714R10 for Isotopic/Total Uranium and Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation Counting, PA SOP 724R9 for Gross Alpha and Gross Beta by gas proportional counting, for SDG 0703015 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists of 4 filter samples for the CSMRI/ 4060 project collected on January 18, 2007 and February 17, 2007. The filter samples were analyzed for Isotopic/Total Uranium and Isotopic Thorium on March 14, 2007 by alpha spectrometry, Radium-226 by Radon Emanation Counting on March 20, 2007, and Gross Alpha and Gross Beta by gas proportional counting on March 8, 2007. All analyses were conducted by Paragon Analytics, Inc. The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703015-1	AS-East	Filter
0703015-2	AS-East	Filter
0703015-3	AS-West	Filter
0703015-4	AS-West	Filter

Data validation was conducted in accordance with the Analytical Services Statement of Work for the following modules: the Determination of Radionuclides by Alpha Spectrometry, Module RC01-v2, October 1, 2002, and the Determination of Gross Alpha and Beta by Gas Proportional Counting, Module RC04-v2, October 1, 2002, and U.S. DOE Quality Systems for Analytical Services rev 2.2 (QSAS).

The radiological data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Instrument Initial Calibrations
- * Instrument Performance Checks
- * Preparation Blanks
- * Duplicate Sample Results
- * Laboratory Control Samples (LCS) Results
- * Laboratory Control Samples Duplicate (LCSD) Results
- * Compound Quantitation and Reporting Limits (full validation only)

Data Completeness

The data package was complete as per Paragon Procedure PA SOP 714R10 for Isotopic/Total Uranium and Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation counting, PA SOP 724R9 for Gross Alpha and Gross Beta by gas proportional counting, for SDG 0703015.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

The Method Blank analyzed with QC batch AS070312-1 alpha spectroscopy for the analysis of Isotopic Uranium and Total Uranium had a failed chemical tracer recovery of 9.19%. Thus all results were below the MDC are qualified as rejected "R".

The Method Blank analyzed with QC batch AS070312-3 alpha spectroscopy for the analysis of Isotopic Thorium had a failed chemical tracer recovery of 15.1%. Thus all results were below the MDC are qualified as rejected "R" except for Thorium-230 in sample AS-West. 0703015-3 collected on February 17, 2007 which the result was above the MDC at 1.37 pCi/sample and is qualified due to the Method Blank as estimated "J".

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation except for Gross alpha and Gross beta that were detected above their MDCs but below the RDL. Since all sample activities for the analysis of Gross alpha greatly exceeded at least by 5X the RDL no action was necessary.

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, a duplicate LCS was analyzed for isotopic uranium and thorium by alpha spectrometry, Radium-226 by radon emanation, and a duplicate analysis of sample 0703015-1 AS-EAST was performed in lieu of a prepared duplicate for the analysis of Gross Alpha and Gross Beta by gas proportional counting. All isotopic activities for LCS and LCS duplicate and for original and duplicate analysis were within the limits of the statistical test for equivalency. No action was required.

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates were not performed for the samples in this SDG, nor were any required.

Laboratory Control Samples

The LCS analyzed with QC batch AS070312-1 alpha spectroscopy for the analysis of Isotopic Uranium and Total Uranium had a failed chemical tracer recovery of 12.97%, thus all results are qualified as rejected "R".

The LCS analyzed with QC batch AS070312-3 alpha spectroscopy for the analysis of Isotopic Thorium had a failed chemical tracer recovery of 12.4%, thus all results are qualified as rejected "R".

The laboratory analyzed laboratory control samples for Radium-226 by radon emanation, and Gross Alpha and Gross Beta by gas proportional counting. All recoveries were

within 75-125% limits.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

Isotopic Uranium, Total Uranium and Isotopic Thorium results are qualified as rejected due to failed low tracer recoveries achieved in the associated Laboratory Control Samples and the associated Method Blanks.

The laboratory reports that measurable amounts of Uranium-234 in the samples may cause a small amount of characteristic activity in the Uranium-235 region of interest due to poorly resolved alpha activity at the boundary between the 2 regions. To minimize the potential for high bias in the Uranium-235 analytical results, the Uranium-235 ROI has been narrowed and limited to a lower energy region. An 85.1% abundance correction has been made to the final Uranium-235 results. The laboratory reports Total Uranium and no action is necessary.

The laboratory provided a calculated value (in pCi/sample) for total uranium in each filter sample based on the measured values by alpha spectrometry of the individual uranium isotopic activities. No action was required.

The Gross Alpha and Gross Beta activity was observed above three times (3X) the MDCs in all filter samples and considered detected.

Overall Comments

All Isotopic Uranium, Total Uranium and Isotopic Thorium results are qualified as rejected "R" due to failed batch QC. The Gross Alpha and Gross Beta activities were observed above three times (3X) their MDC in all filter samples and considered detected. No Radium-226 activities were detected above the MDCs.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Robert Hill/Steve Brinkman
From: John Garrett
Date: April 18, 2007
Project/Site: CSMRI
Project No.: CO School of Mines
SDG No.: 0703016

This report presents the inorganic metals data validation for the data obtained for six CSMRI water samples collected on February 27 and March 1, 2007 and submitted to Paragon Analytics, Inc on March 1, 2007 for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the inorganic metals results that were obtained by SW-846, 5th edition, Methods 6010B and 6020A and Paragon Procedure PA SOP 827R5 for trace metals by Inductively Coupled Plasma (ICP) atomic emission spectrophotometry analysis, and mercury results that were obtained by SW-846, 3rd Edition, Method 7470A and PA SOP 812 Rev 13 for mercury by Cold Vapor Atomic Absorption (CVAA) analysis for SDG 0703016 from Paragon Analytics, Inc. (Fort Collins, CO). The water samples were analyzed for dissolved ICP trace metals on March 8, 2007 and dissolved mercury by CVAA on March 5, 2007. Additionally 5 water samples were analyzed wet chemistry parameters using MCAWW methods 310.1, 340.2, 353.5, 300.0 and EMSL Rev 2.1. All analyses were conducted by Paragon Analytics, Inc. The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703016-1	CSMRI-1B	Water
0703016-2	CSMRI-1	Water
0703016-3	CSMRI-9	Water
0703016-4	CSMRI-10	Water
0703016-5	CSMRI-11	Water
0703016-6	SW-1	Water

Data validation was conducted in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review.

The metals and mercury data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Initial and Continuing Calibration Verification
- * Contract Required Detection Limit (CRDL)
Preparation/ Initial (ICB)/ and Continuing (CCB) Calibration Blanks
- * Interference Check Sample (ICSA) Results
- * Matrix Spike Results
- * Duplicate Sample Results
- * Laboratory Control Samples (LCS) Results
Serial Dilution Sample Results
- * Compound Quantitation and Reporting Limits (full validation only)

- * **All criteria were met for this parameter**

Data Completeness

The data package was complete except for the missing CRDL (2B) and IDL (10) QC Summary Forms. No results were qualified as a result of the missing data.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met.

The water samples were all found to be field filtered, preserved in nitric acid, and 4.6 and 4.8 degrees centigrade. The laboratory reports that the samples had a pH of less than 2 upon receipt. No action was necessary.

Initial and Continuing Calibration Verification

Initial and Continuing Calibration Verification standards were analyzed at the required frequency and all were within the required 90-110% limits for ICP trace metals and within 80-120% for mercury by CVAA. No action was necessary.

Contract Required Detection Limit (CRDL)

No CRDL or CRI standard recovery summary forms (EPA Form 2b) were included in the data package. The reviewer obtained the %Rs from the instrument raw data. All CRDL %Rs for ICP and CRI %Rs for mercury were within 80-120% limits. No action was necessary.

Preparation and Initial/ Continuing Calibration Blanks

Preparation and Initial/ Continuing Calibration Blanks are evaluated to assess the level of contamination in the preparation and analytical processes.

Preparation and Initial/ Continuing Calibration Blanks were prepared and analyzed at the required frequencies.

All of the blanks that were analyzed had concentrations that were below their respective Reporting Limits (RLs).

However, if blank results were above the Instrument Detection Limits (IDLs) and below the RLs, it caused the associated sample results to be qualified for contamination as estimated and non-detected [UJ 107]. If blank results were below the negate IDL and above the negate RL, it caused the associated sample results to be qualified for negative contamination as estimated [J 107]. No sample results were qualified due to blank contamination:

Interference Check Sample (ICSA) Results

Interference Check Samples were prepared and analyzed at the required frequencies.

No aqueous concentrations of aluminum, calcium, iron, or magnesium exceeded the ICSA values in any of the samples. No action was necessary.

Matrix Spike/Matrix Spike Duplicate Results

All ICP and Mercury MS/MSD percent recoveries were within 75-125% limits. No action was necessary.

Duplicate Sample Analysis

All ICP and Mercury original sample/duplicate sample and MS/MSD differences were less than 20% RPD or less than the RDL for results less than (5X)(RDL). No actions were necessary.

The RPD reported for ICP-MS are:

Target Analyte	% D (RPD)
Aluminum	3
Arsenic	4
Barium	3
Cadmium	3
Calcium	1
Chromium	3
Iron	4
Lead	4
Magnesium	1
Manganese	2
Molybdenum	4
Potassium	0
Selenium	4
Silver	0
Sodium	0
Vanadium	3
Zinc	4
Uranium	1

The RPD reported for Wet Chemistry are:

Target Analyte	% D (RPD)
Fluoride	0

Laboratory Control Samples

The laboratory analyzed laboratory control samples for all metals and mercury. All recoveries were within 80-120% limits. No action was necessary.

Serial Dilution Results

The laboratory used dilutions as standard PA practice for ICP-MS analysis. All %Ds were less than 10% for all ICP metals.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

Overall Comments

No CRDL or CRI standard recovery summary forms (EPA Form 2b) were included in the data package. The reviewer obtained the results from the raw data. No action was necessary.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Robert Hill/Steve Brinkman
From: John Garrett
Date: November 15, 2006
Project/Site: CSMRI
Project No.: CO School of Mines
SDG No.: 0703016

This report presents the radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the radiological results that were obtained by Paragon Procedure PA SOP 714R9 for Isotopic Thorium by alpha spectrometry, PA SOP 783R5 for Radium-226 by Radon Emanation counting, Radium-228, for SDG 0703016 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists six water samples for the CSMRI project collected on February 27 and March 1, 2007. The laboratory received the samples on March 1, 2007. The six water samples were analyzed for Isotopic Thorium on March 10, 2007 by alpha spectrometry. Six water samples were analyzed Radium-226 by Radon Emanation Counting on March 10, 2007. Six water samples were analyzed Radium-228 by Radon Emanation Method on March 8, 2007. All analyses were conducted by Paragon Analytics, Inc. The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703016-1	CSMRI-1B	Water
0703016-2	CSMRI-1	Water
0703016-3	CSMRI-9	Water
0703016-4	CSMRI-10	Water
0703016-5	CSMRI-11	Water
0703016-6	SW-1	Water

Data validation was conducted in accordance with the Analytical Services Division of the Statement of Work for the following modules: the Determination of Radionuclides by

Alpha Spectrometry, Module RC01-v2, October 1, 2002, and the Determination of Radium-228, and ICPT BOA and U.S. DOE Quality Systems for Analytical Services rev 2.2 (QSAS).

The radiological data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Instrument Initial Calibrations
- * Instrument Performance Checks
- * Preparation Blanks
- * Duplicate Sample Results
- * Laboratory Control Samples (LCS) Results
- * Laboratory Control Samples Duplicate (LCSD) Results
- * Compound Quantitation and Reporting Limits (full validation only)

Data Completeness

The data package was complete as per Paragon Procedure PA SOP 714R10 for Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation counting, PA SOP 724R9 for Radium-228 by Radon Emanation, for SDG 0703016.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation blanks.

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, a duplicate LCS was analyzed for isotopic thorium by alpha spectrometry, Radium-228 by GPC, Radium-226 by radon emanation. All isotopic activities for LCS and LCS duplicate and for original and duplicate analysis were within the limits of the statistical test for equivalency. No action was required.

The Relative Error Ratio are:

Target Analyte	RER
Thorium-230	0.15
Radium-228	0.05
Radium-226	0.02

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates were not performed for the samples in this SDG, nor were any required.

Laboratory Control Samples

All recoveries were within 75-125% limits. No calculation errors or transcription errors were found.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

Overall Comments

No Radium-226 activities were detected above their MDCs. Radium-228 activity was detected above the MDC in samples all samples except for SW-1. No Thorium-232 activities were detected above their MDCs. The data were found to acceptable as

reported.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Robert Hill/Steve Brinkman
 From: John Garrett
 Date: April 18, 2007
 Project/Site: CSMRI
 Project No.: CO School of Mines
 SDG No.: 0703076

This report presents the inorganic metals data validation for the data obtained for seven CSMRI water samples collected on March 8, 2007 and submitted to Paragon Analytics, Inc on March 9, 2007 for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the inorganic metals results that were obtained by SW-846, 5th edition, Methods 6010B and 6020A and Paragon Procedure PA SOP 827R5 for trace metals by Inductively Coupled Plasma (ICP) atomic emission spectrophotometry analysis, and mercury results that were obtained by SW-846, 3rd Edition, Method 7470A and PA SOP 812 Rev 13 for mercury by Cold Vapor Atomic Absorption (CVAA) analysis for SDG 0703076 from Paragon Analytics, Inc. (Fort Collins, CO). The water samples were analyzed for dissolved ICP trace metals on March 15, 2007 and dissolved mercury by CVAA on March 13, 2007. Additionally 5 water samples were analyzed wet chemistry parameters using MCAWW methods 310.1, 340.2, 353.5, 300.0 and EMSL Rev 2.1. All analyses were conducted by Paragon Analytics, Inc. The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703076-1	CSMRI-2	Water
0703076-2	CSMRI-4	Water
0703076-3	CSMRI-5	Water
0703076-4	SW-2	Water
0703076-5	CSMRI-8	Water
0703076-6	EQUIPMENT BLANK	Water
0703076-7	CSMRI-1B	Water

Data validation was conducted in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review.

The metals and mercury data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Initial and Continuing Calibration Verification
- * Contract Required Detection Limit (CRDL)
Preparation/ Initial (ICB)/ and Continuing (CCB) Calibration Blanks
- * Interference Check Sample (ICSA) Results
- * Matrix Spike Results
- * Duplicate Sample Results
- * Laboratory Control Samples (LCS) Results
Serial Dilution Sample Results
- * Compound Quantitation and Reporting Limits (full validation only)

- * **All criteria were met for this parameter**

Data Completeness

The data package was complete except for the missing CRDL (2B) and IDL (10) QC Summary Forms. No results were qualified as a result of the missing data.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met.

The water samples were all found to be field filtered, preserved in nitric acid, and 4.4 and 3.8 degrees centigrade. The laboratory reports that the samples had a pH of less than 2 upon receipt. No action was necessary.

Initial and Continuing Calibration Verification

Initial and Continuing Calibration Verification standards were analyzed at the required frequency and all were within the required 90-110% limits for ICP trace metals and within 80-120% for mercury by CVAA. No action was necessary.

Contract Required Detection Limit (CRDL)

No CRDL or CRI standard recovery summary forms (EPA Form 2b) were included in the data package. The reviewer obtained the %Rs from the instrument raw data. All CRDL %Rs for ICP and CRI %Rs for mercury were within 80-120% limits. No action was necessary.

Preparation and Initial/ Continuing Calibration Blanks

Preparation and Initial/ Continuing Calibration Blanks are evaluated to assess the level of contamination in the preparation and analytical processes.

Preparation and Initial/ Continuing Calibration Blanks were prepared and analyzed at the required frequencies.

All of the blanks that were analyzed had concentrations that were below their respective Reporting Limits (RLs).

However, if blank results were above the Instrument Detection Limits (IDLs) and below the RLs, it caused the associated sample results to be qualified for contamination as estimated and non-detected [UJ 107]. If blank results were below the negate IDL and above the negate RL, it caused the associated sample results to be qualified for negative contamination as estimated [J 107]. No sample results were qualified due to blank contamination:

Interference Check Sample (ICSA) Results

Interference Check Samples were prepared and analyzed at the required frequencies.

No aqueous concentrations of aluminum, calcium, iron, or magnesium exceeded the ICSA values in any of the samples. No action was necessary.

Matrix Spike/Matrix Spike Duplicate Results

All ICP and Mercury MS/MSD percent recoveries were within 75-125% limits except for molybdenum. No action was necessary.

Duplicate Sample Analysis

All ICP and Mercury original sample/duplicate sample and MS/MSD differences were less than 20% RPD or less than the RDL for results less than (5X)(RDL). No actions were necessary.

The RPD reported for ICP-MS are:

Target Analyte	% D (RPD)
Aluminum	3
Arsenic	0
Barium	2
Cadmium	3
Calcium	1
Chromium	3
Iron	7
Lead	2
Magnesium	1
Manganese	2
Molybdenum	14
Potassium	4
Selenium	1
Silver	2
Sodium	4
Vanadium	2
Zinc	6
Uranium	1
Mercury	1

Laboratory Control Samples

The laboratory analyzed laboratory control samples for all metals and mercury. All recoveries were within 80-120% limits. No action was necessary.

Serial Dilution Results

The laboratory used dilutions as standard PA practice for ICP-MS analysis. All %Ds were less than 10% for all ICP metals.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

Overall Comments

No CRDL or CRI standard recovery summary forms (EPA Form 2b) were included in the data package. The reviewer obtained the results from the raw data. No action was necessary.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Robert Hill/Steve Brinkman
 From: John Garrett
 Date: November 15, 2006
 Project/Site: CSMRI
 Project No.: CO School of Mines
 SDG No.: 0703076

This report presents the radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the radiological results that were obtained by Paragon Procedure PA SOP 714R9 for Isotopic Thorium by alpha spectrometry, PA SOP 783R5 for Radium-226 by Radon Emanation counting, Radium-228, for SDG 0703076 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists seven water samples for the CSMRI project collected on March 8, 2007. The laboratory received the samples on March 9, 2007. The seven water samples were analyzed for Isotopic Thorium on March 26, 2007 by alpha spectrometry. Seven water samples were analyzed Radium-226 by Radon Emanation Counting on March 27, 2007. Seven water samples were analyzed Radium-228 by Radon Emanation Method on March 16, 2007. All analyses were conducted by Paragon Analytics, Inc. The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703076-1	CSMRI-2	Water
0703076-2	CSMRI-4	Water
0703076-3	CSMRI-5	Water
0703076-4	SW-2	Water
0703076-5	CSMRI-8	Water
0703076-6	EQUIPMENT BLANK	Water
0703076-7	CSMRI-1B	Water

Data validation was conducted in accordance with the Analytical Services Division of the

Statement of Work for the following modules: the Determination of Radionuclides by Alpha Spectrometry, Module RC01-v2, October 1, 2002, and the Determination of Radium-228, and ICPT BOA and U.S. DOE Quality Systems for Analytical Services rev 2.2 (QSAS).

The radiological data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Instrument Initial Calibrations
- * Instrument Performance Checks
- * Preparation Blanks
- * Duplicate Sample Results
- * Laboratory Control Samples (LCS) Results
- * Laboratory Control Samples Duplicate (LCSD) Results
- * Compound Quantitation and Reporting Limits (full validation only)

Data Completeness

The data package was complete as per Paragon Procedure PA SOP 714R10 for Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation counting, PA SOP 724R9 for Radium-228 by Radon Emanation, for SDG 0703076.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation blanks except for Radium-228.

Radium-228 was reported in the method blank above the MDC but below the RDL. Sample results for CSMRI-4, CSMRI-5, SW-2, and the Equipment Blank are qualified as Estimated (J).

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, a duplicate LCS was analyzed for isotopic thorium by alpha spectrometry, Radium-228 by GPC, Radium-226 by radon emanation. All isotopic activities for LCS and LCS duplicate and for original and duplicate analysis were within the limits of the statistical test for equivalency. No action was required.

The Relative Error Ratio are:

Target Analyte	RER
Thorium-230	0.23
Radium-228	0.12
Radium-226	0.50

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates were not performed for the samples in this SDG, nor were any required.

Laboratory Control Samples

All recoveries were within 75-125% limits. No calculation errors or transcription errors were found.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

Overall Comments

Radium-226 activities were detected above their MDCs in samples CSMRI-2, CSMRI-5, CSMRI-8. Radium-228 activity was detected above the MDC in samples CSMRI-2, SW-2, and CSMRI-8. No Thorium-232 activities were detected above their MDCs. The data were found to be acceptable as reported.

Due to limited sample volume a reduced aliquot was analyzed for sample CSMRI-1B and the MDC was greater than the RDL. Since a reduced aliquot was used no action was taken.

Radium-228 was reported in the method blank above the MDC but below the RDL. Sample results for CSMRI-4, CSMRI-5, SW-2, and the Equipment Blank are qualified as Estimated (J).

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Robert Hill/Steve Brinkman
From: John Garrett
Date: April 26, 2007
Project/Site: CO School of Mines
Project No.: 4107-540
SDG No.: 0703207

This report presents the radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical evaluation of the radiological results that was obtained by Paragon Procedure PA SOP 714R10 for Isotopic/Total Uranium and Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation Counting, PA SOP 724R9 for Gross Alpha and Gross Beta by gas proportional counting, for SDG 0703207 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists of 2 filter samples for the CSMRI/ 4107-540 project collected on March 16, 2007 and received by the laboratory on March 29, 2007. The filter samples were analyzed for Isotopic/Total Uranium and Isotopic Thorium on April 12, 2007 by alpha spectrometry, Radium-226 by Radon Emanation Counting on April 17, 2007, and Gross Alpha and Gross Beta by gas proportional counting on April 4, 2007. All analyses were conducted by Paragon Analytics, Inc. The field sample number and corresponding laboratory number are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0703207-1	AS-EAST	Filter
0703207-2	AS-WEST	Filter

Data validation was conducted in accordance with the Analytical Services Statement of Work for the following modules: the Determination of Radionuclides by Alpha Spectrometry, Module RC01-v2, October 1, 2002, and the Determination of Gross Alpha and Beta by Gas Proportional Counting, Module RC04-v2, October 1, 2002, and U.S. DOE ICPT BOA and Quality Systems for Analytical Services rev 2.2 (QSAS).

The radiological data was evaluated based on the following parameters:

- * Data Completeness
- * Holding Times and Preservation
- * Instrument Initial Calibrations
- * Instrument Performance Checks
- * Preparation Blanks
- * Duplicate Sample Results
- * Laboratory Control Sample (LCS) Results
- * Laboratory Control Sample Duplicate (LCSD) Results
- * Compound Quantitation and Reporting Limits (full validation only)

Data Completeness

The data package was complete as per Paragon Procedure PA SOP 714R10 for Isotopic/Total Uranium and Isotopic Thorium by alpha spectrometry, PA SOP 783R7 for Radium-226 by Radon Emanation counting, PA SOP 724R9 for Gross Alpha and Gross Beta by gas proportional counting, for SDG 0703207.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation. No action was necessary.

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, a duplicate LCS was analyzed for isotopic uranium and thorium by alpha spectrometry, Radium-226 by radon emanation. Sample 0703207-2 AS-WEST was used in lieu of a prepared duplicate for Gross Alpha and Gross Beta by gas proportional counting. All isotopic activities for LCS and LCS duplicate and for original and duplicate analysis were within the limits of the statistical test for equivalency Relative Error Ratio (RER). No action was required.

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates was not performed for the sample in this SDG, nor was any required.

Laboratory Control Sample

The laboratory analyzed laboratory control sample for Uranium-238, Uranium-234, and Thorium-230 for alpha spectrometry, Radium-226 by radon emanation, and Gross Alpha and Gross Beta by gas proportional counting. All recoveries were within 75-125% limits.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits was correctly reported.

Total Uranium activity was detected above the MDC and below the RDL in sample AS-WEST. Uranium-238 was detected above the MDC and below the RDL in sample AS-WEST. No Isotopic Thorium or Radium-226 was reported above their respective MDCs. Gross alpha was reported greater than 5x the MDCs in both samples but below the RDL. Gross beta was detected above the RDL in both samples.

The laboratory reports that measurable amounts of Uranium-234 in the sample may cause a small amount of characteristic activity in the Uranium-235 region of interest due to poorly resolved alpha activity at the boundary between the 2 regions. To minimize the

potential for high bias in the Uranium-235 analytical results, the Uranium-235 ROI has been narrowed and limited to a lower energy region. An 85.1% abundance correction has been made to the final Uranium-235 results. The laboratory reports Total Uranium and no action is necessary.

The laboratory provided a calculated value (in pCi/sample) for total uranium in each filter sample based on the measured values by alpha spectrometry of the individual uranium isotopic activities. No action was required.

The Gross Beta activity was observed above three times (5X) the MDC in both filter samples. No action was taken.

Overall Comments

The data were found to be accurate as reported by the laboratory and the data are acceptable as reported.

The data reports that Total Uranium activity was detected above the MDC and below the RDL in sample AS-WEST. Uranium- 238 was detected above the MDC and below the RDL in sample AS-WEST. No Isotopic Thorium or Radium-226 was reported above their respective MDCs. Gross alpha was reported greater than 5x the MDCs in both samples but below the RDL. Gross beta was detected above the RDL in both samples.

DATA QUALIFIER DEFINITIONS

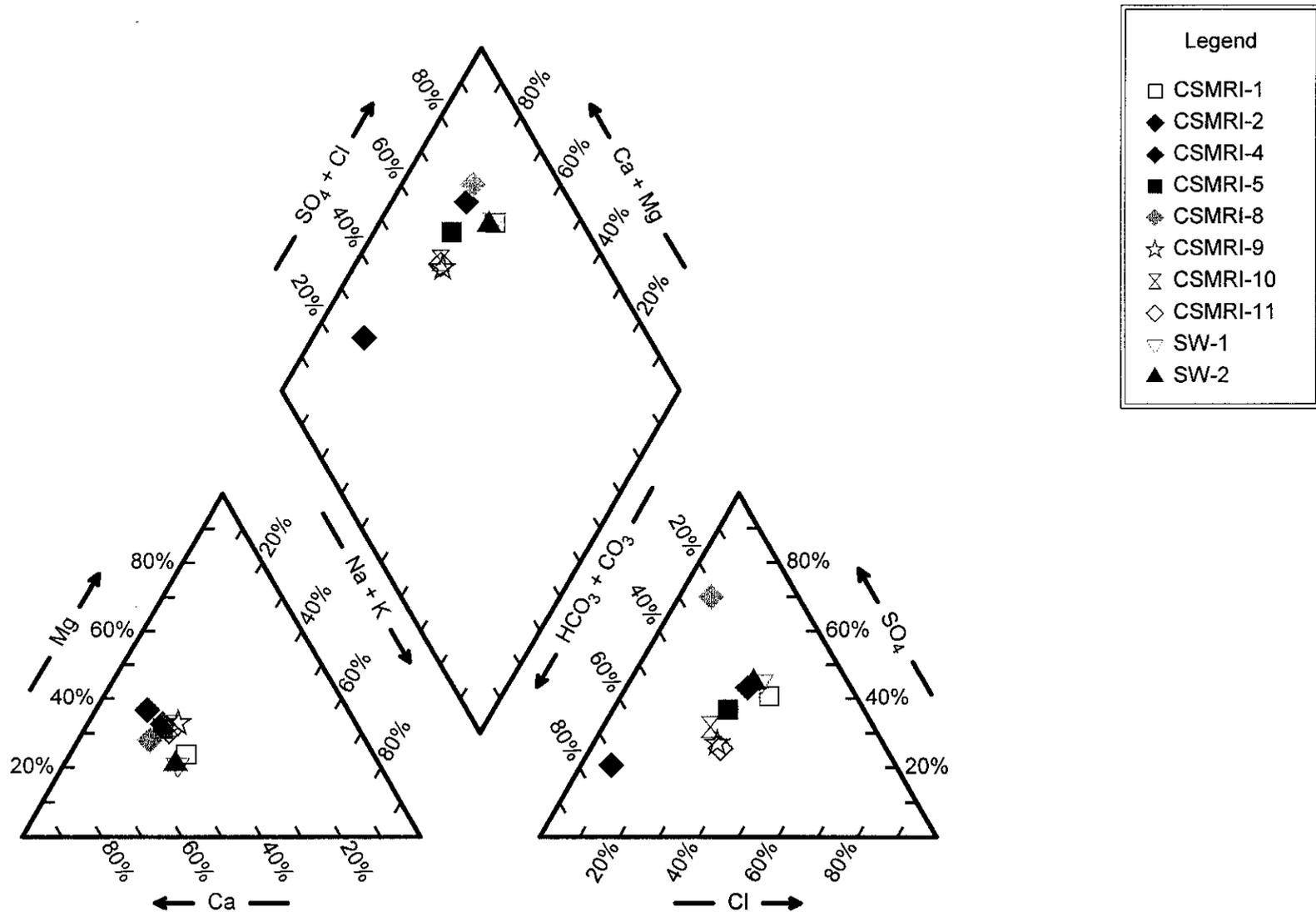
For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

- R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.
- J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.
- U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.
- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
- NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

Appendix F
Results of Analyses CD

Appendix G
Anion – Cation Data Results

CSMRI - Piper Trilinear Diagram



Name	Unit	CSMRI-1	CSMRI-1B	CSMRI-2	CSMRI-4	CSMRI-5	CSMRI-8	CSMRI-9	CSMRI-10	CSMRI-11	SW-1	SW-2
Date	Date	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007	3/1/2007
Sample ID	text	CSMRI-1	CSMRI-1B	CSMRI-2	CSMRI-4	CSMRI-5	CSMRI-8	CSMRI-9	CSMRI-10	CSMRI-11	SW-1	SW-2
Aluminum	mg/L	0.049	0.051	0.0056	0.0056	0.0056	0.0056	0.045	0.049	0.073	0.076	0.025
Bicarbonate	mg/L	55		310	200	160	240	170	180	160	54	49
Calcium	mg/L	39	130	88	120	80	230	69	79	75	44	39
Carbonate	mg/L	5		50	10	20	20	20	20	20	5	5
Chloride	mg/L	52		19	120	75	54	77	69	74	51	41
Fluoride	mg/L	0.59		1.3	0.65	0.5	1.2	0.5	0.5	0.5	0.63	0.68
Iron	mg/L	0.005	0.004	0.011	0.011	0.011	0.011	0.012	0.0029	0.047	0.0029	0.011
Magnesium	mg/L	12	47	39	49	31	72	31	33	29	11	9.8
Manganese	mg/L	0.0037	0.71	0.023	0.28	0.0029	0.88	1.4	0.93	1.5	0.25	0.25
Nitrogen	mg/L	0.72		0.079	0.073	2.1	0.83	1.5	2.7	2.3	0.53	0.51
Potassium	mg/L	3	52	8.3	11	4.5	23	12	7.3	9.7	4.3	4.2
Sodium	mg/L	26	91	21	47	34	74	33	36	33	26	22
Sulfate	mg/L	77		71	230	130	640	91	110	79	94	80
pH	pH	7.17		7.11	7.03	7.07	7.77	7.46	7.28	7.28	7.76	8.09
Alkalinity	mg CaCO ₃ /l	55		310	200	160	240	170	180	160	54	49
Conductivity	µmho/cm	424		725	1186	797	1736	678	740	714	515	549

Anion / Cation Summary Report

Lab ID: 0703016-2
Field ID: CSMRI-1

QC Type: SMP

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	55	MG/L	1.10
CHLORIDE	52	MG/L	1.47
FLUORIDE	0.59	MG/L	0.03
NITRATE/NITRITE AS N	0.72	MG/L	0.05
SULFATE	77	MG/L	1.60
Anion Result Sum	185.31		

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.049	MG/L	0.01
CALCIUM	39	MG/L	1.95
IRON	0.005	MG/L	0.00
MAGNESIUM	12	MG/L	0.99
MANGANESE	0.0037	MG/L	0.00
POTASSIUM	3	MG/L	0.08
SODIUM	26	MG/L	1.13
Cation Result Sum	80.06		

Total Result: 265.37 MG/L
TDS Result:
RPD:

Anion mEq Sum: 4.25
Cation mEq Sum: 4.15
RPD: 2.49%

Lab ID: 0703016-3
Field ID: CSMRI-9

QC Type: SMP

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	170	MG/L	3.40
CHLORIDE	77	MG/L	2.17
FLUORIDE	0.5	MG/L	0.00
NITRATE/NITRITE AS N	1.5	MG/L	0.11
SULFATE	91	MG/L	1.89
Anion Result Sum	340.00		

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.045	MG/L	0.01
CALCIUM	69	MG/L	3.44
IRON	0.012	MG/L	0.00
MAGNESIUM	31	MG/L	2.55
MANGANESE	1.4	MG/L	0.05
POTASSIUM	12	MG/L	0.31
SODIUM	33	MG/L	1.44
Cation Result Sum	146.46		

Total Result: 486.46 MG/L
TDS Result:
RPD:

Anion mEq Sum: 7.57
Cation mEq Sum: 7.79
RPD: 2.88%

Lab ID: 0703016-4
Field ID: CSMRI-10

QC Type: SMP

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	180	MG/L	3.60
CHLORIDE	69	MG/L	1.95
FLUORIDE	0.5	MG/L	0.00
NITRATE/NITRITE AS N	2.7	MG/L	0.19
SULFATE	110	MG/L	2.29

Anion / Cation Summary Report

Anion Result Sum 362.20

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.049	MG/L	0.01
CALCIUM	79	MG/L	3.94
IRON	0.0029	MG/L	0.00
MAGNESIUM	33	MG/L	2.71
MANGANESE	0.93	MG/L	0.03
POTASSIUM	7.3	MG/L	0.19
SODIUM	36	MG/L	1.57

Cation Result Sum 156.28

Total Result: **518.48** MG/L
TDS Result:
RPD:

Anion mEq Sum: **8.03**
Cation mEq Sum: **8.45**
RPD: **5.13%**

Lab ID: **0703016-5** QC Type: SMP
Field ID: CSMRI-11

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	160	MG/L	3.20
CHLORIDE	74	MG/L	2.09
FLUORIDE	0.5	MG/L	0.00
NITRATE/NITRITE AS N	2.3	MG/L	0.16
SULFATE	79	MG/L	1.64

Anion Result Sum 315.80

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.073	MG/L	0.01
CALCIUM	75	MG/L	3.74
IRON	0.047	MG/L	0.00
MAGNESIUM	29	MG/L	2.39
MANGANESE	1.5	MG/L	0.05
POTASSIUM	9.7	MG/L	0.25
SODIUM	33	MG/L	1.44

Cation Result Sum 148.32

Total Result: **464.12** MG/L
TDS Result:
RPD:

Anion mEq Sum: **7.09**
Cation mEq Sum: **7.88**
RPD: **10.46%**

Lab ID: **0703016-6** QC Type: SMP
Field ID: SW-1

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	54	MG/L	1.08
CHLORIDE	51	MG/L	1.44
FLUORIDE	0.63	MG/L	0.03
NITRATE/NITRITE AS N	0.53	MG/L	0.04
SULFATE	94	MG/L	1.96

Anion Result Sum 200.16

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.076	MG/L	0.01
CALCIUM	44	MG/L	2.20
IRON	0.0029	MG/L	0.00
MAGNESIUM	11	MG/L	0.90
MANGANESE	0.25	MG/L	0.01
POTASSIUM	4.3	MG/L	0.11

Anion / Cation Summary Report

SODIUM	26	MG/L	1.13
Cation Result Sum	85.63		

Total Result	285.79	MG/L
TDS Result		
RPD		

Anion mEq Sum	4.55
Cation mEq Sum	4.36
RPD	4.19%

Below is a list of Lab IDs for this Order Number that were logged in for metals analyses. Note: if this area is empty then either no metals analyses were requested or the cations of interest were not requested.

0703016-1	0703016-2	0703016-3	0703016-4	0703016-5	0703016-6
-----------	-----------	-----------	-----------	-----------	-----------

Anion / Cation Summary Report

Lab ID: **0703076-1**

QC Type: SMP

Field ID: CSMRI-2

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	310	MG/L	6.20
CHLORIDE	19	MG/L	0.54
FLUORIDE	1.3	MG/L	0.07
NITRATE/NITRITE AS N	0.079	MG/L	0.01
SULFATE	71	MG/L	1.48
Anion Result Sum	401.38		

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.0056	MG/L	0.00
CALCIUM	88	MG/L	4.39
IRON	0.011	MG/L	0.00
MAGNESIUM	39	MG/L	3.21
MANGANESE	0.023	MG/L	0.00
POTASSIUM	8.3	MG/L	0.21
SODIUM	21	MG/L	0.91
Cation Result Sum	156.34		

Total Result: **557.72** MG/L
 TDS Result:
 RPD:

Anion mEq Sum: **8.28**
 Cation mEq Sum: **8.73**
 RPD: **5.21%**

Lab ID: **0703076-2**

QC Type: SMP

Field ID: CSMRI-4

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	200	MG/L	4.00
CHLORIDE	120	MG/L	3.38
FLUORIDE	0.65	MG/L	0.03
NITRATE/NITRITE AS N	0.073	MG/L	0.01
SULFATE	230	MG/L	4.79
Anion Result Sum	550.72		

Analyte	Final Result	Report Units	mEq
ALUMINUM	0.0056	MG/L	0.00
CALCIUM	120	MG/L	5.99
IRON	0.011	MG/L	0.00
MAGNESIUM	49	MG/L	4.03
MANGANESE	0.28	MG/L	0.01
POTASSIUM	11	MG/L	0.28
SODIUM	47	MG/L	2.04
Cation Result Sum	227.30		

Total Result: **778.02** MG/L
 TDS Result:
 RPD:

Anion mEq Sum: **12.21**
 Cation mEq Sum: **12.35**
 RPD: **1.18%**

Lab ID: **0703076-3**

QC Type: SMP

Field ID: CSMRI-5

Analyte	Final Result	Report Units	mEq
BICARBONATE AS CaCO3	160	MG/L	3.20
CHLORIDE	75	MG/L	2.12
FLUORIDE	0.5	MG/L	0.00
NITRATE/NITRITE AS N	2.1	MG/L	0.15
SULFATE	130	MG/L	2.71

Appendix H
Chain-of-Custody Documentation



Paragon Analytics

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 805.
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody Date 3/4/07 Page 1 of 3

Originator: Retain pink copy!

Project Name/No.: CO School Farms Sampler(s): N.M. 16.24K Turnaround (circle one): Standard or Rush (Due _____) Dispose: Date _____ or Return to Client

Report To: Steve Brinkman
Phone: (303) 994-1883
Fax: (303) 443-1408
E-mail: sbrinkman@stoller.com
Company: S.M. Stoller
Address: 105 Technology Dr, Suite 190
Broomfield, CO 80021

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs	BTEX (only)	SVOCs	OC Pesticides	PCBs	Herbicides	Explosives	TCLP Organics SW1311	TCLP Metals SW1311	Total Metals by ICP	Dissolved Metals by ICP	Total Metals by ICP/MS	Dissolved Metals by ICP/MS	Hexavalent Chromium	Inorganic Anions	Solids:	pH	TPH	Gross Alpha / Beta	Actinides by Paragon SOP	Tritium	Total Alpha-Emitting Radium	Radium 226 E903.1	Strontium 89 D5911-00	Gamma Isotopes	Asims	Write/White	ISO Th, U, Totl -u		
CSMRI-2	3/5/07	1620		W	F/HNO3	1											X																			
		1630																																		
		1625			A2S4																															
		1635			HNO3																							X								
CSMRI-4		1145			HNO3												X																			
		1150																																		
		1155			A2S4																															
		1200			HNO3																							X								
CSMRI-5		1245			HNO3												X																			
		1250																																		
		1255			H2SO4																															

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments: All samples were filtered

Relinquished By: (1) Signature: [Signature] Printed Name: Nick Maloyk Date: 3/4/07 Time: 1255 Company: Stoller

Relinquished By: (2) Signature: _____ Printed Name: _____ Date: _____ Time: _____ Company: _____

Received By: (1) Signature: [Signature] Printed Name: Sheri Lafferty Date: 3-9-07 Time: 1255 Company: paragon

Received By: (2) Signature: _____ Printed Name: _____ Date: _____ Time: _____ Company: _____



Paragon Analytics

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 805.
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody Date 3/9/07 Page 2 of 3

Originator: Retain pink copy!

Project Name/No.: 10 School of Mines Sampler(s): N Malczyk Turnaround (circle one): Standard or Rush (Due _____) Dispose: Date _____ or Return to Client

Report To:
Phone:
Fax:
E-mail:
Company:
Address:

see page 1

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs	BTEX (only)	SVOCs	OC Pesticides	PCBs	Herbicides	Explosives	TCLP Organics SW1311	TCLP Metals SW1311	Total Metals by ICP	Dissolved Metals by ICP	Total Metals by ICP/MS	Dissolved Metals by ICP/MS	Hexavalent Chromium	Inorganic Anions	Solids:	pH	TPH	Gross Alpha / Beta	Actinides by Paragon SOP	Tritium	Total Alpha-Emitting Radium	Radium 226 E903.1	Strontium 89 D5811-00	Gamma Isotopes	Other			
CSMRI-5	3/8/07	1300		W	HNO ₃	1																													
SW-2		1005			HNO ₃												X																		
		1010			-																														
		1015			H ₂ SO ₄																														
		1020			HNO ₃																														
CSMRI-8	3/8/07	1300			HNO ₃												X																		
		1305			-																														
		1310			H ₂ SO ₄	4																													
		1315			HNO ₃	1																													
Equipment Blank	3/9/07	1225			HNO ₃												X																		
		1230			HNO ₃																														

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:
All samples were filtered
CSMRI-8 has 4x 250ml bottles instead of 1x 1L bottle

Relinquished By: (1) Signature: [Signature] Printed Name: Nick Malczyk Date: 3/9/07 Time: 1235 Company: Stoller

Relinquished By: (2) Signature: _____ Printed Name: _____ Date: _____ Time: _____ Company: _____

Received By: (1) Signature: [Signature] Printed Name: Sheri Lafferty Date: 3-9-07 Time: 1255 Company: Paragon

Received By: (2) Signature: _____ Printed Name: _____ Date: _____ Time: _____ Company: _____



Paragon Analyticals

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 8052
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody Date 3/1/07 Page 1 of 2

Originator: Retain 1 copy!

Project Name/No.: CO School of Mines Sampler(s): N Malczyk Turnaround (circle one): Standard or Rush (Due _____) Dispose: Date _____ or Return to Client

Report To: Steve Brinkman
Phone: (303) 994-1883
Fax: (303) 443-1408
E-mail: sbrinkman@stoller.com
Company: SM Stoller
Address: 105 Technology Dr, Suite 190
Broomfield, CO 80021

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs	BTEX (only)	SVOCS	OC Pesticides	PCBs	Herbicides	Explosives	TCLP Organics SW1311	TCLP Metals SW1311	Total Metals by ICP	Dissolved Metals by ICP	Total Metals by ICP/MS	Dissolved Metals by ICP/MS	Hexavalent Chromium	Inorganic Anions	Solids:	pH	TPH	Gross Alpha / Beta	Actinides by Paragon SOP	Tritium	Total Alpha-Emitting Radium	Radium 226 E903.1	Strontium 89 D5011-00	Gamma Isotopes	Amionas	Nitrate / Nitrite	F ₂₀ Th, U, Total-U	
CSMRI-1B	3/1/07	0830		W	HNO ₃	1											X																		
CSMRI-1	3/1/07	1100																															X		
		1105			H ₂ SO ₄																												X		
		1110			HNO ₃												X																		
		1120			HNO ₃																						X							X	
CSMRI-9	2/27/07	1425																														X			
		1430			H ₂ SO ₄																												X		
		1640			HNO ₃												X																		
		1650			HNO ₃																						X							X	
CSMRI-10	2/27/07	1520																														X			
		1525			H ₂ SO ₄																												X		

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments: All samples were filtered

Relinquished By: (1) Signature [Signature] (2) Signature _____
 Printed Name Vick Malczyk Printed Name _____
 Date 3/1/07 Time 1555 Date _____ Time _____
 Company Stoller Company _____

Received By: (1) Signature [Signature] (2) Signature _____
 Printed Name Shari Lafferty Printed Name _____
 Date 3-1-07 Time 1555 Date _____ Time _____
 Company paragon Company _____



Paragon Analytics

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 805
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody Date 3/1/07 Page 2 of 2 Originator: Retain pink copy!

Project Name/No.: CO School of Mines Sampler(s): N. Malczyk Turnaround (circle one): Standard or Rush (Due _____) Dispose: Date _____ or Return to Client

Report To:
Phone:
Fax:
E-mail:
Company: see page 1
Address:

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs	BTEX (only)	SVOCs	OC Pesticides	PCBs	Herbicides	Explosives	TCLP Organics SW1311	TCLP Metals SW1311	Total Metals by ICP	Dissolved Metals by ICP	Total Metals by ICP/MS	Dissolved Metals by ICP/MS	Hexavalent Chromium	Inorganic Anions	Solids: Total E100.3 TDS E100.1 TSS E100.2	pH	TPH	Gross Alpha / Beta	Actinides by Paragon SOP	Tritium	Total Alpha-Emitting Radium	Radium 226 E903.1	Strontium 90 D5911-00	Gamma Isotopes	Anions: Nitrate / Nitrite Iso Th, U, Total-H				
CS.MRI-10	3/1/07	1220		W	HNO ₃	1											X																			
↓	↓	1225			HNO ₃																							X					X			
CS.MRI-11	2/27/07	1040			-																												X			
↓	↓	1045			H ₂ SO ₄																													X		
↓	↓	1545			HNO ₃												X																			
↓	↓	1555			HNO ₃																							X						X		
SW-7	3/1/07	1130			-																												X			
↓	↓	1135			H ₂ SO ₄																														X	
↓	↓	1140			HNO ₃												X																			
↓	↓	1145			HNO ₃																							X							X	

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:
ALL samples were filtered

Relinquished By: (1)
Signature: [Signature]
Printed Name: Nick Malczyk
Date: 3/1/07 Time: 1555
Company: Stoller

Relinquished By: (2)
Signature: _____
Printed Name: _____
Date: _____ Time: _____
Company: _____

Received By: (1)
Signature: [Signature]
Printed Name: Shari Lafferty
Date: 3-1-07 Time: 1555
Company: Paragon

Received By: (2)
Signature: _____
Printed Name: _____
Date: _____ Time: _____
Company: _____



Paragon Analyticals

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 8052
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody

Date 2/21/07 Page 1 of 1

Originator: Retain pink copy

Project Name / No.: CSMRI / 4060 Sampler(s): CHICKS Turnaround (circle one): Standard or Rush (Due _____) Dispose: Date _____ or Return to Client _____

Report To: Steve Brinkman
Phone: 303 546-4388
Fax: 303 443 1408
E-mail: sbrinkman@stoller.com
Company: SM Stoller Corp
Address: 105 Technology Dr.
Suite 190
Broomfield CO 80021

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs	BTEX (only)	SVOCs	OC Pesticides	PCBs	Herbicides	Explosives	TCLP Organics SW131	TCLP Metals SW1311	Total Metals by ICP	Dissolved Metals by ICP	Total Metals by ICP/MS	Dissolved Metals by ICP/MS	Hexavalent Chromium	Inorganic Anions	Solids:	pH	TPH	Gross Alpha / Beta	Actinides by Paragon SOP	Tritium	Total Alpha-Emitting Radium	Radium 226 E903.1	Strontium 89 05811-00	Gamma Isotopes	Other					
022107-1237	2/21/07	0930		soil	NA	1																															
022107-1238	2/21/07	0940		soil	NA	1																															
AS - East	2/17/07	1538		F	-	1																		X													
+	1/15/07	1049			-																			X													
AS - West	2/17/07	1532			-																			X													
+	1/15/07	1044			-																			X													

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:
Ra 226 by EPA 901.0 M, 21 day ingrowth

Relinquished By: _____ (1) Relinquished By: _____ (2)
Signature _____ Signature _____
Printed Name Nick Maloney Printed Name _____
Date 3/1/07 Time _____ Date _____ Time _____
Company Stoller Company _____

Received By: _____ (1) Received By: _____ (2)
Signature _____ Signature _____
Printed Name Shari Lefferty Printed Name _____
Date 3-1-07 Time 1555 Date _____ Time _____
Company Paragon Company _____



Paragon Analytics

A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 805
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID)

Chain-of-Custody Date 3/28/07 Page 1 of 1

Originator: Retain pink copy!

Project Name/No.: CO School of Mines Sampler(s): N Malczyk Turnaround (circle one): Standard or Rush (Due) Dispose: Date or Return to Client

Report To: Steve Brinkman
Phone: (303) 944-1883
Fax: (303) 443-1408
E-mail: sbrinkman@stoller.com
Company: SA Stoller
Address: 105 Technology Dr Site 190
Broomfield, CO 80021

Circle method (right); provide additional information as needed (comments).

Table with columns: Sample ID, Date, Time, Lab ID, Matrix, Preservative, No. of Containers, and various analytical methods (VOCs, BTEX, SVOCs, etc.). Includes handwritten entries for AS-East and AS-West samples.

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter
Comments:

Relinquished By: (1) Signature, Printed Name, Date, Company
Received By: (1) Signature, Printed Name, Date, Company
Relinquished By: (2) Signature, Printed Name, Date, Company
Received By: (2) Signature, Printed Name, Date, Company

Appendix I
Monitor Well Top of Casing
Coordinates and Elevation

Appendix I
CSMRI Monitor Well Survey Results
Top of Casing Coordinates and Elevation

WELL FEATURE DESCRIPTION	NORTHING UTM Zone 13 Grid NAD 83 (Meters)	EASTING UTM Zone 13 Grid NAD 83 (Meters)	ELEVATION (Meters) NAVD 88	ELEVATION (FEET) NAVD 88
WELL 6B N PVC	4,400,301.1	480,289.1	1,745.1	5,725.46
WELL 11 N PVC	4,400,359.5	480,403.0	1,741.8	5,714.40
WELL 9 N PVC	4,400,408.8	480,361.3	1,739.7	5,707.71
WELL 7B N PVC	4,400,397.6	480,281.0	1,738.3	5,703.08
WELL 4 N PVC	4,400,475.8	480,405.8	1,730.7	5,678.25
WELL 10 N PVC	4,400,419.6	480,433.3	1,738.7	5,704.30
WELL 1B N PVC	4,400,354.1	480,232.1	1,741.1	5,712.14
WELL 1 N PVC	4,400,351.6	479,925.5	1,735.7	5,694.42
WELL 5 N PVC	4,400,468.2	480,458.4	1,730.2	5,676.61
WELL 8 N PVC	4,400,424.7	480,285.1	1,732.4	5,683.60
MW2TOC	4,400,032.6	480,648.0	1,773.8	5,819.55

CSMRI-1B

Colorado School of Mines

Colorado School of Mines Research Institute Site

Golden, Colorado

Project Number: 4060 - 720

Client: Colorado School of Mines

Geologist: N. Malczyk

Northing: 4,400,354.1 Easting: 480,232.1

Drilling Contractor: Prosonic Corporation, B. Owens

Total Depth of Borehole: 21.5 feet bgs

Dates Drilled: 02/11/07 - 02/15/07

Depth to Water: Dry

Borehole Type: 6-inch dia. Resonant Sonic Casing Advance

Well Type: 2-inch Sch 40 PVC GW Monitoring Well

Ground Elevation: 5,709.02 feet

Top of Casing Elevation: 5,712.14 feet

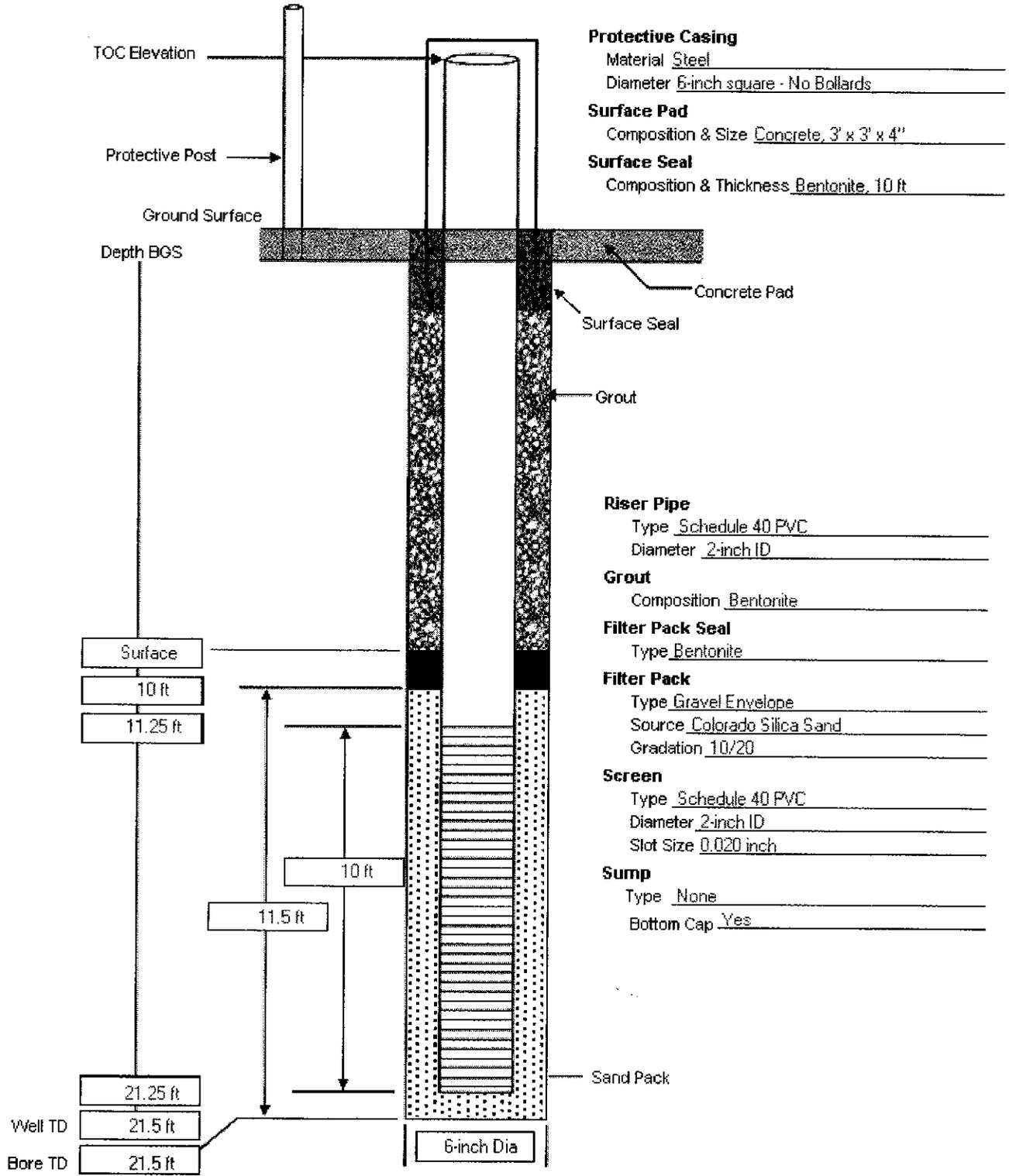
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 17,000 cpm
			ML	0' - 1' Silt, clayey, some pebbles, dark yellowish brown (10YR 4/4), moist		
			SP	1' - 3' Sand, fine grain, few pebbles, dark yellowish brown (10YR 4/4), dry		
	5		SM	3' - 7' Sand, silty, light yellowish brown (10YR 6/4), dry		15,600
			SP	7' - 8' Sand, fine grain, some cobbles, yellowish red (5YR 4/6), dry		
	10		SW	8' - 13' Sand, gravelly, alluvial material, light gray (5YR 7/1), loose, dry		16,800
	15		SW	13' - 16.5' Sand, medium to coarse grain, some pebbles and gravel, dark gray (5YR 4/1), loose, damp, becoming moist from 15 ft to 16.5 ft		17,500
	20		SH	16.5' - 21.5' Pierre Shale, black (2.5YR 2.5/0), dry		16,700
	25			Total Depth of Borehole 21.5 feet bgs No Water Encountered Total Depth of Well 21.5 feet bgs 2" Sch. 40 PVC Blank Casing +3.12' ags to 11.25' bgs 2" Sch. 40 PVC 0.020" Slot Screen 11.25' to 21.25' bgs 2" Sch. 40 PVC End Cap 21.25' to 21.5' bgs 10/20 Colorado Silica Sand 10' to 21.5' bgs Hydrated Bentonite Surface Seal 0' to 10' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.81' ags		

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoffer Corporation
 Driller: B. Dwens, Prosonic Corp, Lic # 1350
 Well Coordinates: N 4,400,354.1 m E 480,232.1 m
 TOC Elevation: 1,741.06 m (5,712.14 ft)
 Surface Elevation: 1,740.11 m (5,709.02 ft)

Well No: CSMRI-1B
 Well Type: GW Monitoring Well
 Date Constructed: 02/15/07
 Observed By: N. Malczyk
 Sheet 1 of 1



CSMRI-6B

Colorado School of Mines	Colorado School of Mines Research Institute Site	Golden, Colorado
Project Number: 4060 - 720	Client: Colorado School of Mines	
Geologist: N. Malczyk	Northing: 4,400,301.1 Easting: 480,289.1	
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 40 feet bgs	
Dates Drilled: 02/16/07 - 02/16/07	Depth to Water: Dry	
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well	
Ground Elevation: 5,722.24 feet	Top of Casing Elevation: 5725.46 feet	

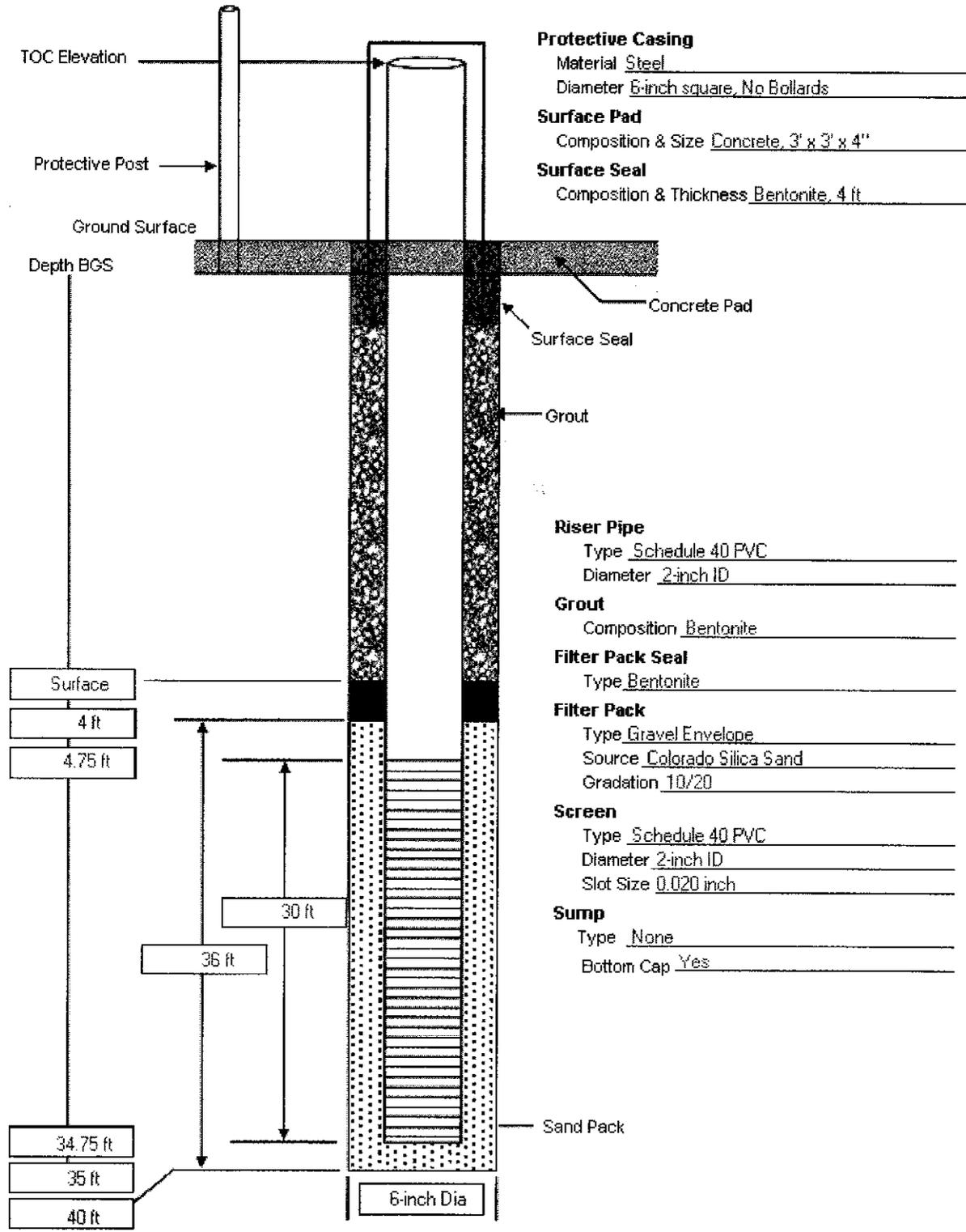
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 12,500 cpm
			CL/ML	0' - 2' Clay, silty, dark yellowish brown (10YR 4/2), moist		
	5		CL/ML	2' - 8' Clay, silty, some pebbles, dark yellowish brown (10YR 4/2), moist		13,200
	10		CL	8' - 11' Clay, dark yellowish brown (10YR 4/2), hard, saturated		13,300
			CL/ML	11' - 13' Clay, silty, grayish red (10R 4/2), soft, moist		
	15			13' - 23' Sand, dark reddish brown (10R 3/4), fine grain, loose, dry		12,400
	20		SP			14,200
	25			23' - 32' Sand, some cobbles, pinkish gray (5YR 8/1), fine grain, little medium grain		16,400
	30		SP			15,700
	35		SH	32' - 40' Pierre Shale, black (2.5YR 2.5/0), dry		13,700
	40			Total Depth of Borehole 40 feet bgs Vadose Water 8' - 11' bgs		13,600
	45			Total Depth of Well 35 feet bgs 2" Sch. 40 PVC Blank Casing +3.22' ags to 4.75' bgs 2" Sch. 40 PVC 0.020" Slot Screen 4.75' to 34.75' bgs 2" Sch. 40 PVC End Cap 34.75' to 35' bgs 10/20 Colorado Silica Sand 4' to 40' bgs Hydrated Bentonite Surface Seal 0' to 4' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.88' ags		
	50					
	55					

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,301.1 m E 480,289.1 m
 TOC Elevation: 1,745.12 m (5,725.46 ft)
 Surface Elevation: 1,744.14 m (5,722.24 ft)

Well No: CSMRI-6B
 Well Type: GW Monitoring Well
 Date Constructed: 02/16/07
 Observed By: N. Malczyk
 Sheet 1 of 1



CSMRI-7B

Colorado School of Mines	Colorado School of Mines Research Institute Site	Golden, Colorado
Project Number: 4060 - 720	Client: Colorado School of Mines	
Geologist: R. Hill	Northing: 4,400,397.6 Easting: 480,281.0	
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 20 feet bgs	
Dates Drilled: 02/10/07 - 02/10/07	Depth to Water: Dry	
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well	
Ground Elevation: 5,700.07 feet	Top of Casing Elevation: 5,703.08 feet	

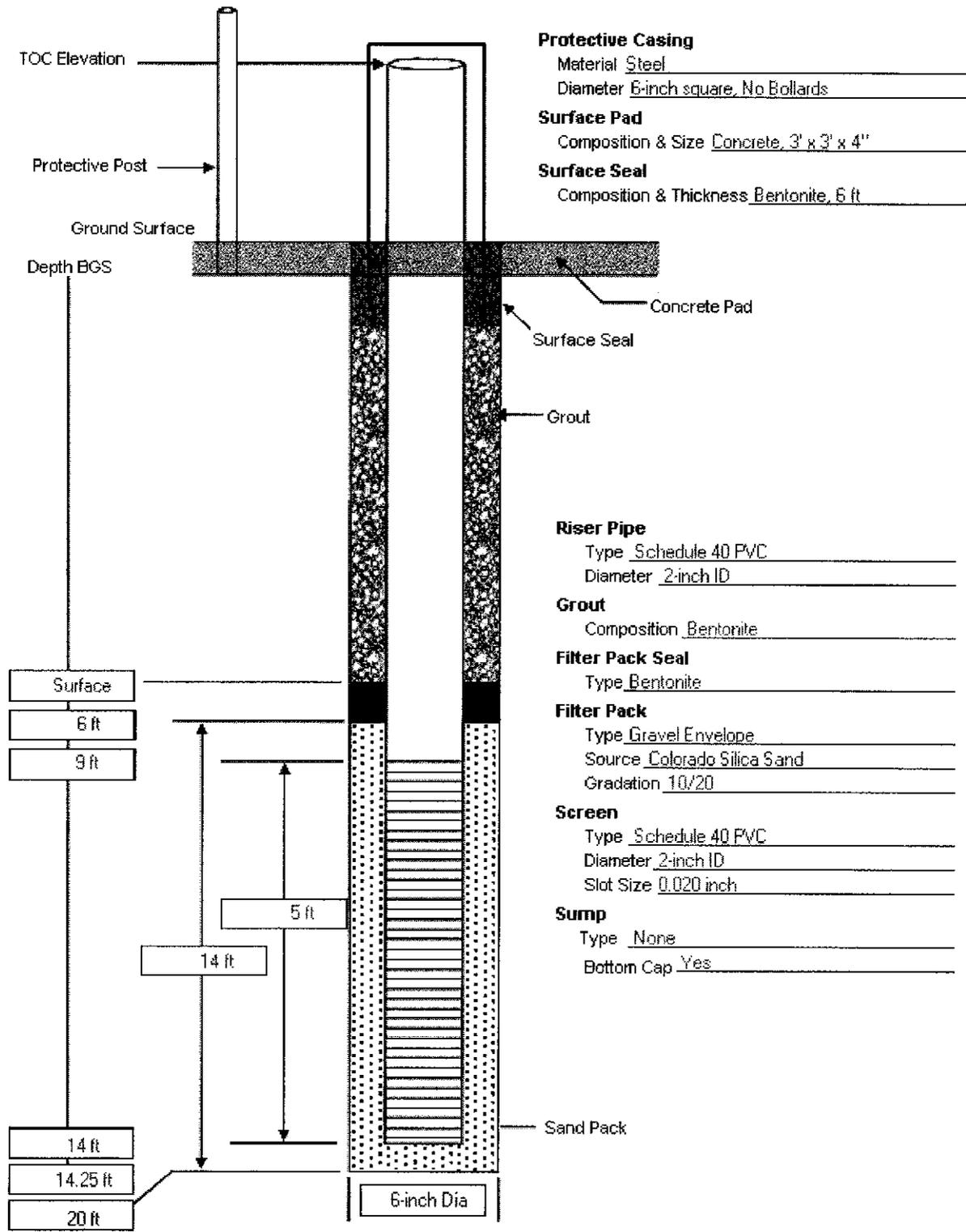
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 21,000 cpm
	5	[Dotted Pattern]	SW/GW	0' - 10.5' Sand, clayey, abundant gravel and cobbles, moderate brown (SYR 4/4), poor sorting, fine to very coarse grain, loose, damp		21,500
	10	[Diagonal Lines]	CL	10.5' - 12.3' Clay, sandy, medium light gray (N6), soft, moist to wet		21,700
	15	[Horizontal Lines]	CL	12.3' - 14' Clay, trace silt, medium light gray (N6), mottled with rust colored streaks in fractures, stiff, dry, weathered shale		22,300
	20	[Vertical Lines]	SH	14' - 20' Pierre Shale, clay, trace silt, medium light gray (N6), no mottling, stiff, dry		22,100
	25			Total Depth of Borehole 20 feet bgs Vadose Water 10' - 11' bgs Total Depth of Well 14.24 feet bgs 2" Sch. 40 PVC Casing +3.01' ags to 9' bgs 2" Sch. 40 PVC 0.020" Slot Screen 9' to 14' bgs 2" Sch. 40 PVC End Cap 14' to 14.25' bgs 10/20 Colorado Silica Sand 6' to 20' bgs Hydrated Bentonite Surface Seal 0' to 6' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.60' ags		

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,397.6 m E 480,281.0 m
 TOC Elevation: 1,738.30 m (5,703.08 ft)
 Surface Elevation: 1,737.38 m (5,700.07 ft)

Well No: CSMRI-7B
 Well Type: GW Monitoring Well
 Date Constructed: 02/10/07
 Observed By: B. Hill
 Sheet 1 of 1



CSMRI-8

Colorado School of Mines	Colorado School of Mines Research Institute Site	Golden, Colorado
Project Number: 4060 - 720	Client: Colorado School of Mines	
Geologist: N. Malczyk	Northing: 4,400424.7	Easting: 480,285.1
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 15 feet bgs	
Dates Drilled: 02/11/07 - 02/11/07	Depth to Water: 4.95 feet bgs	
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well	
Ground Elevation: 5,680.51 feet	Top of Casing Elevation: 5,683.60 feet	

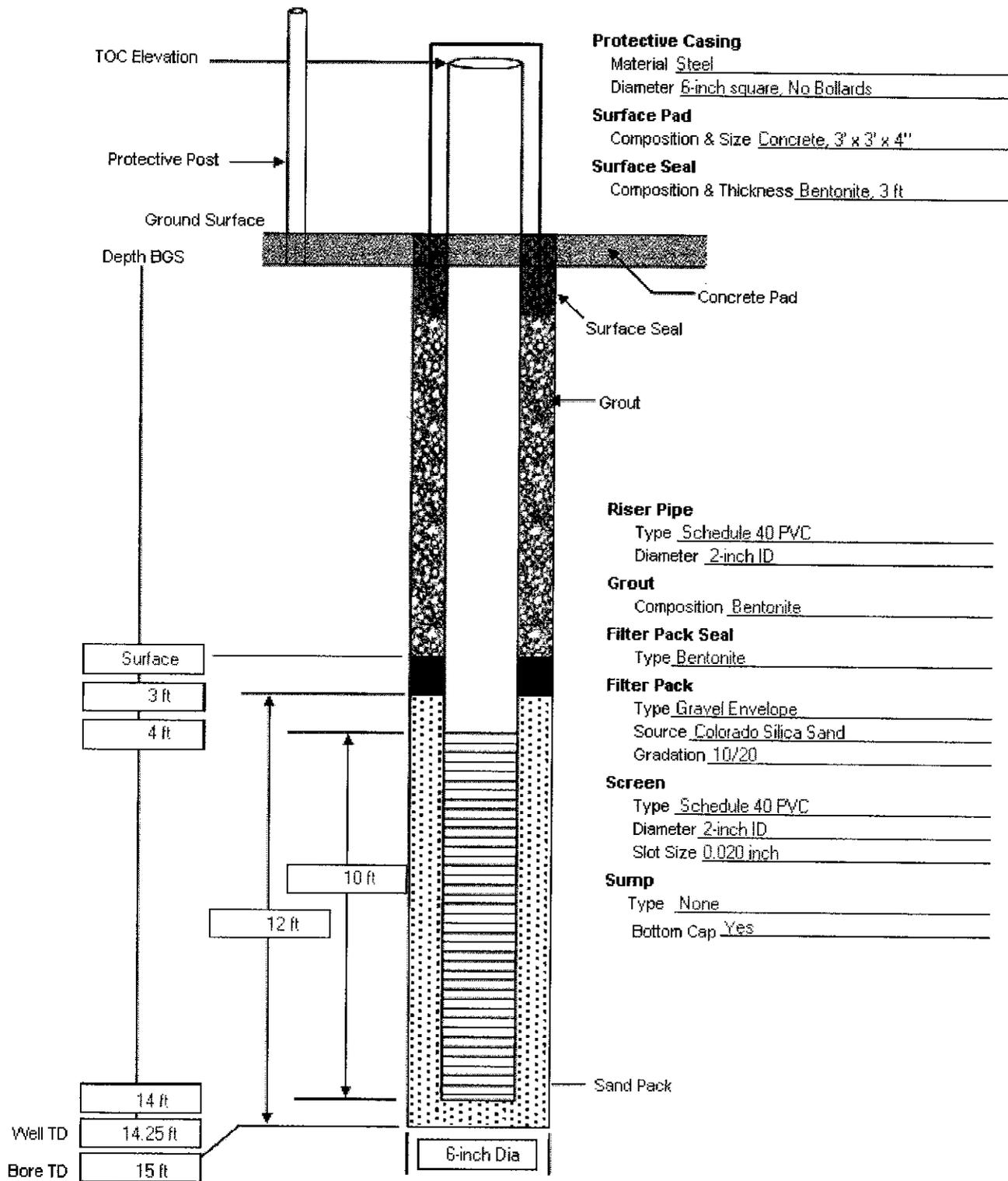
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 18,500 cpm
				0' - 7' Post-Piney Creek Alluvium, Sand, silty, some gravel and cobbles, very dark brown (10YR 2/2), moist to 4 feet, saturated at 5 feet, 67% recovery		
	5	SW/GW		Static Water Level 4.95' bgs measured 03/08/07		18,200
	10	SH		7' - 15' Pierre Shale, dark gray (2.5YR 4/0), damp grading to dry		18,000
	15			Total Depth of Borehole 15 feet bgs Depth to Water 4.95 feet bgs		18,300
	20			Total Depth of Well 14.25 feet bgs 2" Sch. 40 PVC Blank Casing +3.09' ags to 4' bgs 2" Sch. 40 PVC 0.020" Slot Screen 4' to 14' bgs 2" Sch. 40 PVC End Cap 14' to 14.25' bgs 10/20 Colorado Silica Sand 3' to 15' bgs Hydrated Bentonite Surface Seal 0' to 3' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.64' ags		
	25					

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,424.7 m E 480,285.1 m
 TOC Elevation: 1,732.36 m (5,683.60 ft)
 Surface Elevation: 1,731.42 m (5,680.51 ft)

Well No: CSMRI-8
 Well Type: GW Monitoring Well
 Date Constructed: 02/11/07
 Observed By: N. Malczyk
 Sheet 1 of 1



Protective Casing

Material Steel
 Diameter 6-inch square, No Bollards

Surface Pad

Composition & Size Concrete, 3' x 3' x 4"

Surface Seal

Composition & Thickness Bentonite, 3 ft

Riser Pipe

Type Schedule 40 PVC
 Diameter 2-inch ID

Grout

Composition Bentonite

Filter Pack Seal

Type Bentonite

Filter Pack

Type Gravel Envelope
 Source Colorado Silica Sand
 Gradation 10/20

Screen

Type Schedule 40 PVC
 Diameter 2-inch ID
 Slot Size 0.020 inch

Sump

Type None
 Bottom Cap Yes

CSMRI-9

Colorado School of Mines

Colorado School of Mines Research Institute Site

Golden, Colorado

Project Number: 4060 - 720

Client: Colorado School of Mines

Geologist: N. Malczyk

Northing: 4,400408.8 Easting: 480,361.3

Drilling Contractor: Prosonic Corporation, B. Owens

Total Depth of Borehole: 30 feet bgs

Dates Drilled: 02/19/07 - 02/19/07

Depth to Water: 22.99 feet bgs

Borehole Type: 6-inch dia. Resonant Sonic Casing Advance

Well Type: 2-inch Sch 40 PVC GW Monitoring Well

Ground Elevation: 5,704.56 feet

Top of Casing Elevation: 5,707.71 feet

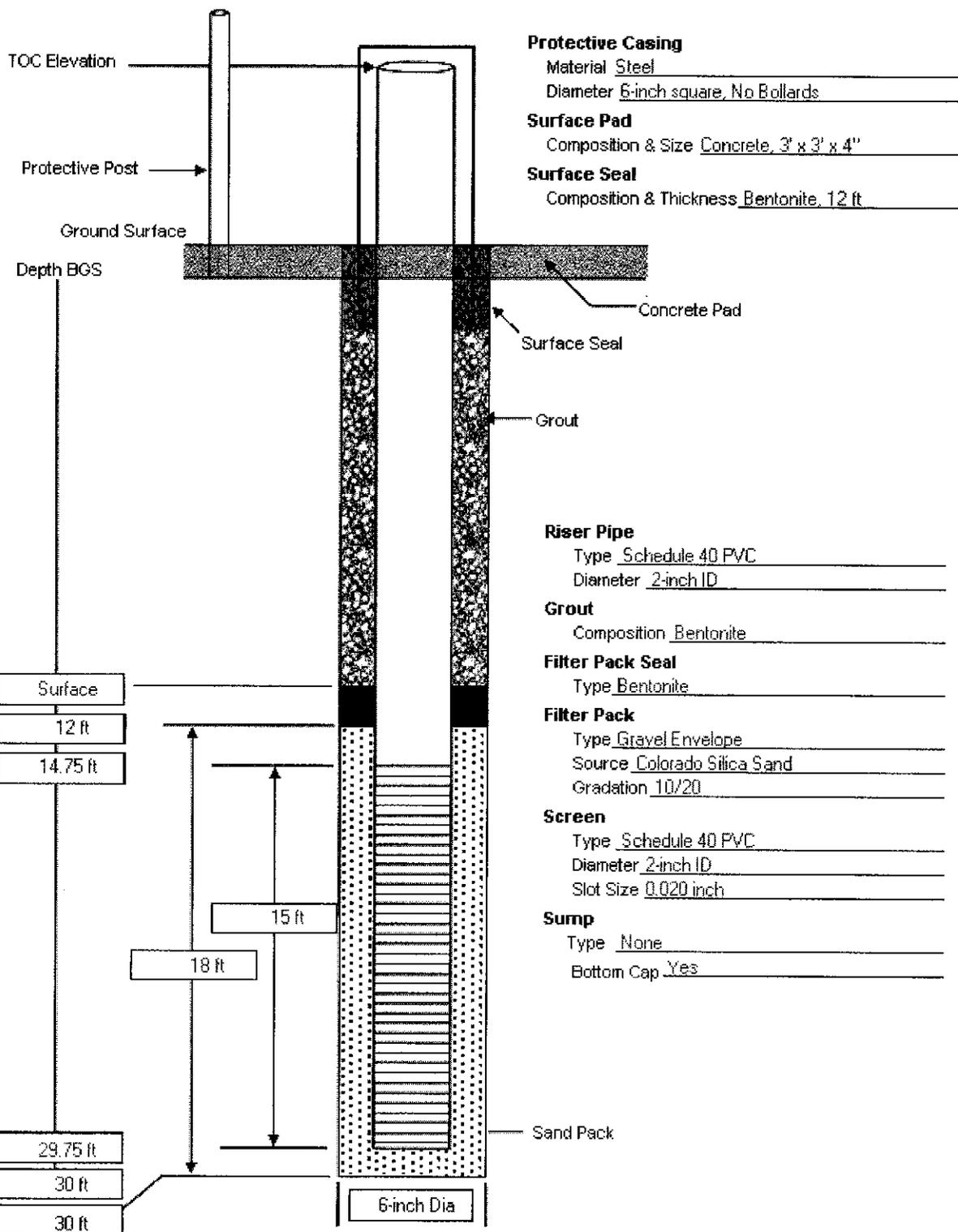
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 15,000 cpm
			Fill	0' - 2' Fill, fine grain sand, silt, clay, some cobbles, dark yellowish brown (10YR 4/2), moist		
			Fill	2' - 4' Fill, silt, some fine sand, dark yellowish orange (10YR 6/6), dry		
	5		Fill	4' - 10' Fill, fine and medium grain sand, some cobbles, pieces of wood, moderate brown (5YR 4/4)		18,400
	10			10' - 19' Similar material as above with color change to greenish gray (5GY 6/1), probable Louviers Alluvium		20,300
	15		SW			18,300
	20			19' - 30' Fox Hills Sandstone, fine grain sand, dark yellowish orange (10YR 6/6), moist		15,500
	25		SP	Static Water Level 22.99' bgs measured 02/27/07 @ 25' - 26' becomes moist to wet		16,600
	30			Total Depth of Borehole 30 feet bgs Depth to Water 22.99 feet bgs		14,300
	35			Total Depth of Well 30 feet bgs 2" Sch. 40 PVC Blank Casing +3.15' ags to 14.75' bgs 2" Sch. 40 PVC 0.020" Slot Screen 14.75' to 29.75' bgs 2" Sch. 40 PVC End Cap 29.75' to 30' bgs 10/20 Colorado Silica Sand 12' to 30' bgs Hydrated Bentonite Surface Seal 0' to 12' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.67' ags		

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,408.8 m E 480,361.3 m
 TOC Elevation: 1,739.71 m (5,707.71 ft)
 Surface Elevation: 1,738.75 m (5,704.56 ft)

Well No: CSMRI-9
 Well Type: GW Monitoring Well
 Date Constructed: 02/17/07
 Observed By: N. Malczyk
 Sheet 1 of 1



CSMRI-10

Colorado School of Mines

Colorado School of Mines Research Institute Site

Golden, Colorado

Project Number: 4060 - 720	Client: Colorado School of Mines
Geologist: N. Malczyk	Northing: 4,400,419.6 Easting: 480,433.3
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 26 feet bgs
Dates Drilled: 02/19/07 - 02/20/07	Depth to Water: 20.69 feet bgs
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well
Ground Elevation: 5,701.25 feet	Top of Casing Elevation: 5,704.30 feet

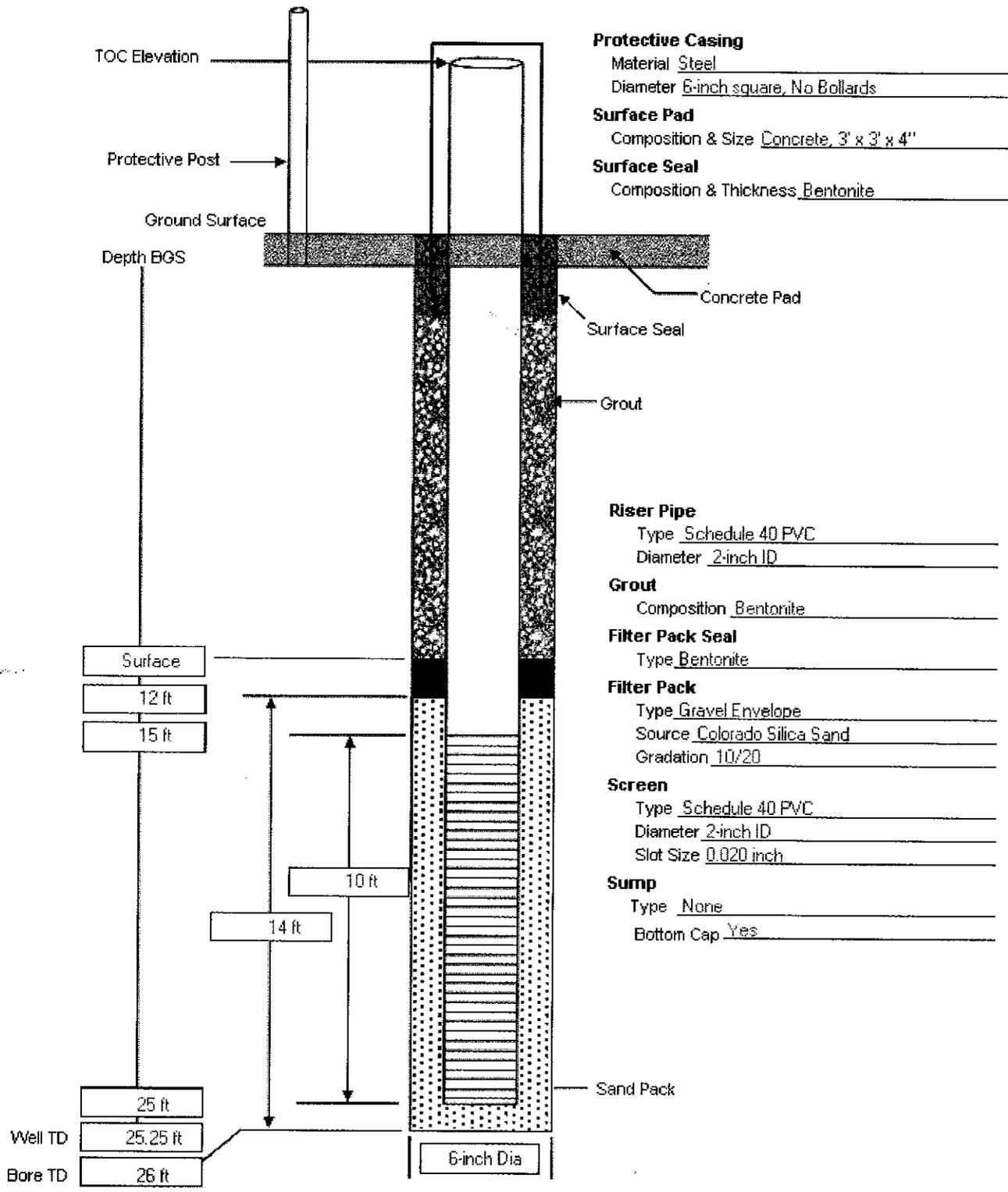
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 21,000 cpm
		ML		0' - 4' Louviers Alluvium, clay and silt, dark yellowish brown (10YR 4/2), moist		
	5			4' - 23' Louviers Alluvium, fine and medium sand, some cobbles, from 4' to 5' moderate yellowish brown (5YR 4/4), from 5' to 23' pale yellowish brown (10YR 6/2)		23,300
	10					24,000
	15	SW				23,400
	20			Static Water Level 20.69 feet bgs measured 02/27/07 @ 21' becomes wet during drilling		21,400
	25	SC		23' - 26' Laramie Formation, medium gray (N5), sandstone/claystone		19,200
	30			Total Depth of Borehole 26 feet bgs Depth to Water 20.69 feet bgs		
	35			Total Depth of Well 25.25 feet bgs 2" Sch. 40 PVC Blank Casing +3.05' ags to 15' bgs 2" Sch. 40 PVC 0.020" Slot Screen 15' to 25' bgs 2" SCH. 40 PVC End Cap 25' to 25.25' bgs 10/20 Colorado Silica Sand 12' to 26' bgs Hydrated Bentonite Surface Seal 0' to 12' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.74' ags		

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,419.6 m E 480,433.3 m
 TOC Elevation: 1,738.67 m (5,704.30 ft)
 Surface Elevation: 1,737.74 m (5,701.25 ft)

Well No: CSMRI-10
 Well Type: GW Monitoring Well
 Date Constructed: 02/20/07
 Observed By: N. Malczyk
 Sheet 1 of 1



CSMRI-11

Colorado School of Mines	Colorado School of Mines Research Institute Site	Golden, Colorado
Project Number: 4060 - 720	Client: Colorado School of Mines	
Geologist: N. Malczyk	Northing: 4,400,359.5 Easting: 480,403.0	
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 35 feet bgs	
Dates Drilled: 02/16/07 - 02/18/07	Depth to Water: 27.83 feet bgs	
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well	
Ground Elevation: 5,711.12 feet	Top of Casing Elevation: 5,714.40 feet	

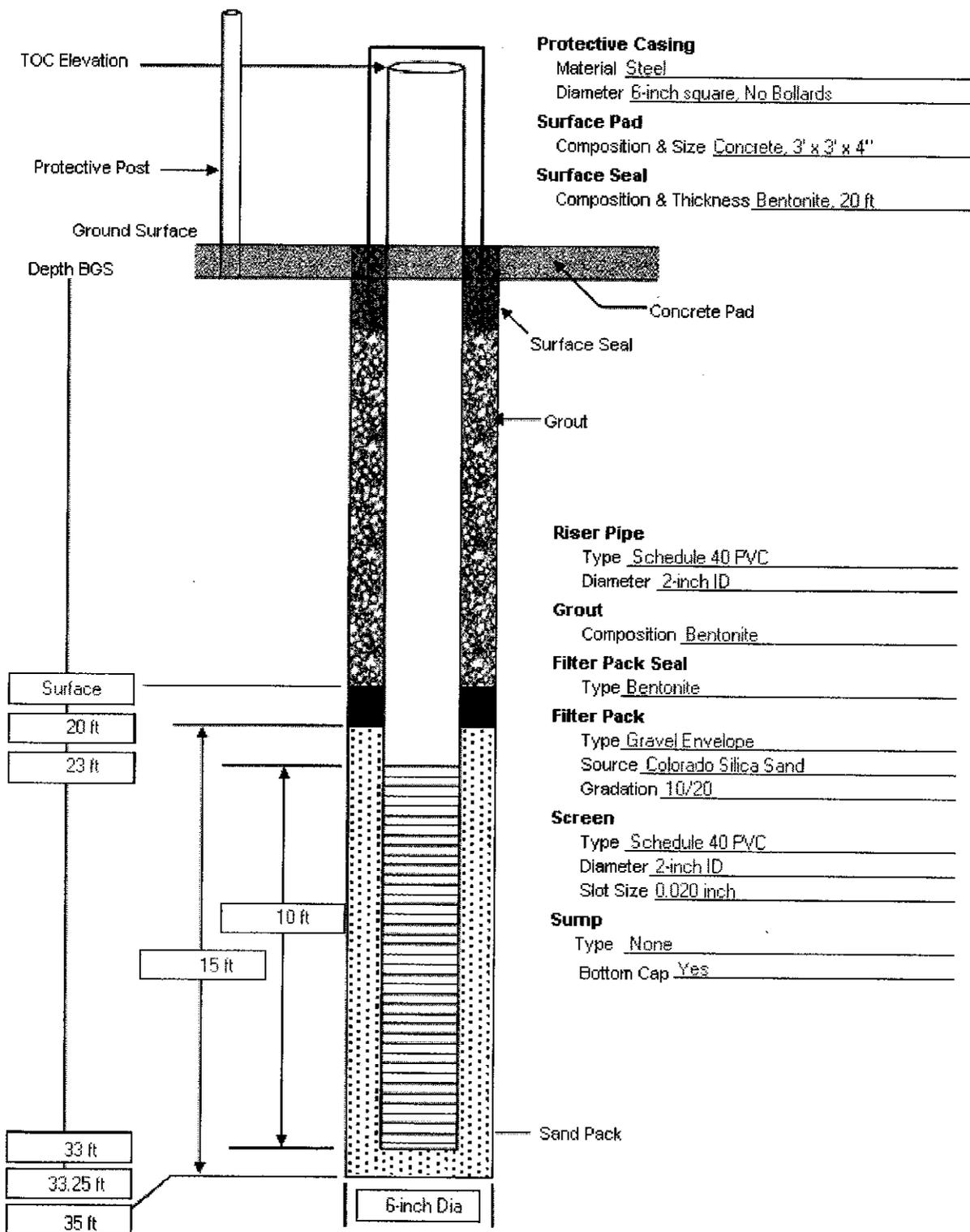
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 16,500 cpm
	0		SP	0' - 1' Louviers Alluvium, Sand, medium and fine grain, few pebbles, dark yellowish brown (10YR 4/2)		
	1		CL	1' - 8' Louviers Alluvium, clay and silt, dark yellowish brown (10YR 4/2), stiff, dry		15,500
	8		ML	8' - 9' Louviers Alluvium, silt and very fine sand, few pebbles, dark yellowish brown (10YR 4/2), soft, very moist		16,300
	9		SC	9' - 12' Louviers Alluvium, clay and silt, some very fine sand, dark yellowish brown (10YR 4/2), dry		
	12		SP	12' - 14' Louviers Alluvium, fine sand, some pebbles and cobbles, moderate brown (10YR 4/4), loose, dry		17,200
	14			14' - 27' Louviers Alluvium, fine sand, little medium sand, some cobbles, pinkish gray (5YR 8/1)		19,700
	20		SP			17,100
	25					
	27		SP	27' - 29' Louviers Alluvium, medium sand, some cobbles, dark yellowish brown (10YR 4/2), wet		19,000
	29			Static Water Level 27.83 feet bgs measured 02/27/07		
	29		SH	29' - 35' Fox Hills Sandstone, interbedded sandstone and shale, weathered from 29' to 31', moderate brown (5YR 4/4), medium gray (N5) below 31'		16,400
	35			Total Depth of Borehole 35 feet bgs Depth to Water 27.83 feet bgs		
	40			Total Depth of Well 33.25 feet bgs 2" Sch. 40 PVC Blank Casing +3.28' ags to 23' bgs 2" Sch. 40 PVC 0.020" Slot Screen 23' to 33' bgs 2" Sch. 40 PVC End Cap 33' to 33.25' bgs 10/20 Colorado Silica Sand 20' to 35' bgs Hydrated Bentonite Surface Seal 0' to 20' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +4.00' ags		

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Well Installation Diagram

Project: CSMRI #4060-720
 Location: CSM, Golden, Colorado 80401
 Contractor: S.M. Stoller Corporation
 Driller: B. Owens, Prosonic Corp, Lic #1350
 Well Coordinates: N 4,400,359.5 m E 480,403.0 m
 TOC Elevation: 1,741.75 m (5,714.40 ft)
 Surface Elevation: 1,740.75 m (5,711.12 ft)

Well No: CSMRI-11
 Well Type: GW Monitoring Well
 Date Constructed: 02/18/07
 Observed By: N. Malczyk
 Sheet 1 of 1



Appendix I
CSMRI Monitor Well Survey Results
Top of Casing Coordinates and Elevation

WELL FEATURE DESCRIPTION	NORTHING UTM Zone 13 Grid NAD 83 (Meters)	EASTING UTM Zone 13 Grid NAD 83 (Meters)	ELEVATION (Meters) NAVD 88	ELEVATION (FEET) NAVD 88
WELL 6B N PVC	4,400,301.1	480,289.1	1,745.1	5,725.46
WELL 11 N PVC	4,400,359.5	480,403.0	1,741.8	5,714.40
WELL 9 N PVC	4,400,408.8	480,361.3	1,739.7	5,707.71
WELL 7B N PVC	4,400,397.6	480,281.0	1,738.3	5,703.08
WELL 4 N PVC	4,400,475.8	480,405.8	1,730.7	5,678.25
WELL 10 N PVC	4,400,419.6	480,433.3	1,738.7	5,704.30
WELL 1B N PVC	4,400,354.1	480,232.1	1,741.1	5,712.14
WELL 1 N PVC	4,400,351.6	479,925.5	1,735.7	5,694.42
WELL 5 N PVC	4,400,468.2	480,458.4	1,730.2	5,676.61
WELL 8 N PVC	4,400,424.7	480,285.1	1,732.4	5,683.60
MW2TOC	4,400,032.6	480,648.0	1,773.8	5,819.55

CSMRI-1B

Colorado School of Mines		Colorado School of Mines Research Institute Site		Golden, Colorado
Project Number: 4060 - 720		Client: Colorado School of Mines		
Geologist: N. Malczyk		Northing: 4,400,354.1 Easting: 480,232.1		
Drilling Contractor: Prosonic Corporation, B. Owens		Total Depth of Borehole: 21.5 feet bgs		
Dates Drilled: 02/11/07 - 02/15/07		Depth to Water: Dry		
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance		Well Type: 2-inch Sch 40 PVC GW Monitoring Well		
Ground Elevation: 5,709.02 feet		Top of Casing Elevation: 5,712.14 feet		

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 17,000 cpm
			ML	0' - 1' Silt, clayey, some pebbles, dark yellowish brown (10YR 4/4), moist		
			SP	1' - 3' Sand, fine grain, few pebbles, dark yellowish brown (10YR 4/4), dry		
	5		SM	3' - 7' Sand, silty, light yellowish brown (10YR 6/4), dry		15,600
			SP	7' - 8' Sand, fine grain, some cobbles, yellowish red (5YR 4/6), dry		
	10		SW	8' - 13' Sand, gravelly, alluvial material, light gray (5YR 7/1), loose, dry		16,800
	15		SW	13' - 16.5' Sand, medium to coarse grain, some pebbles and gravel, dark gray (5YR 4/1), loose, damp, becoming moist from 15 ft to 16.5 ft		17,500
	20		SH	16.5' - 21.5' Pierre Shale, black (2.5YR 2.5/0), dry		16,700
	25			Total Depth of Borehole 21.5 feet bgs No Water Encountered Total Depth of Well 21.5 feet bgs 2" Sch. 40 PVC Blank Casing +3.12' ags to 11.25' bgs 2" Sch. 40 PVC 0.020" Slot Screen 11.25' to 21.25' bgs 2" Sch. 40 PVC End Cap 21.25' to 21.5' bgs 10/20 Colorado Silica Sand 10' to 21.5' bgs Hydrated Bentonite Surface Seal 0' to 10' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.81' ags		

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CSMRI-6B

Colorado School of Mines

Colorado School of Mines Research Institute Site

Golden, Colorado

Project Number: 4060 - 720	Client: Colorado School of Mines
Geologist: N. Malczyk	Northing: 4,400,301.1 Easting: 480,289.1
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 40 feet bgs
Dates Drilled: 02/16/07 - 02/16/07	Depth to Water: Dry
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well
Ground Elevation: 5,722.24 feet	Top of Casing Elevation: 5725.46 feet

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 12,500 cpm
			CL/ML	0' - 2' Clay, silty, dark yellowish brown (10YR 4/2), moist		
	5		CL/ML	2' - 8' Clay, silty, some pebbles, dark yellowish brown (10YR 4/2), moist		13,200
	10		CL	8' - 11' Clay, dark yellowish brown (10YR 4/2), hard, saturated		13,300
	15		CL/ML	11' - 13' Clay, silty, grayish red (10R 4/2), soft, moist		
	20		SP	13' - 23' Sand, dark reddish brown (10R 3/4), fine grain, loose, dry		12,400
	25		SP	23' - 32' Sand, some cobbles, pinkish gray (5YR 8/1), fine grain, little medium grain		14,200
	30		SP			16,400
	35		SH	32' - 40' Pierre Shale, black (2.5YR 2.5/0), dry		15,700
	40			Total Depth of Borehole 40 feet bgs Vadose Water 8' - 11' bgs		13,700
	45			Total Depth of Well 35 feet bgs 2" Sch. 40 PVC Blank Casing +3.22' ags to 4.75' bgs 2" Sch. 40 PVC 0.020" Slot Screen 4.75' to 34.75' bgs 2" Sch. 40 PVC End Cap 34.75' to 35' bgs 10/20 Colorado Silica Sand 4' to 40' bgs Hydrated Bentonite Surface Seal 0' to 4' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.88' ags		13,600
	50					
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CSMRI-7B

Colorado School of Mines	Colorado School of Mines Research Institute Site	Golden, Colorado
Project Number: 4060 - 720	Client: Colorado School of Mines	
Geologist: R. Hill	Northing: 4,400,397.6 Easting: 480,281.0	
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 20 feet bgs	
Dates Drilled: 02/10/07 - 02/10/07	Depth to Water: Dry	
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well	
Ground Elevation: 5,700.07 feet	Top of Casing Elevation: 5,703.08 feet	

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 21,000 cpm
	5	[Dotted Pattern]	SW/GW	0' - 10.5' Sand, clayey, abundant gravel and cobbles, moderate brown (SYR 4/4), poor sorting, fine to very coarse grain, loose, damp		21,500
	10	[Diagonal Lines]	CL	10.5' - 12.3' Clay, sandy, medium light gray (N6), soft, moist to wet		21,700
	15	[Horizontal Lines]	CL	12.3' - 14' Clay, trace silt, medium light gray (N6), mottled with rust colored streaks in fractures, stiff, dry, weathered shale		22,300
	20	[Vertical Lines]	SH	14' - 20' Pierre Shale, clay, trace silt, medium light gray (N6), no mottling, stiff, dry		22,100
	25			Total Depth of Borehole 20 feet bgs Vadose Water 10' - 11' bgs Total Depth of Well 14.24 feet bgs 2" Sch. 40 PVC Casing +3.01' ags to 9' bgs 2" Sch. 40 PVC 0.020" Slot Screen 9' to 14' bgs 2" Sch. 40 PVC End Cap 14' to 14.25' bgs 10/20 Colorado Silica Sand 6' to 20' bgs Hydrated Bentonite Surface Seal 0' to 6' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.60' ags		

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CSMRI-8

Colorado School of Mines		Colorado School of Mines Research Institute Site		Golden, Colorado	
Project Number: 4060 - 720			Client: Colorado School of Mines		
Geologist: N. Malczyk			Northing: 4,400424.7 Easting: 480,285.1		
Drilling Contractor: Prosonic Corporation, B. Owens			Total Depth of Borehole: 15 feet bgs		
Dates Drilled: 02/11/07 - 02/11/07			Depth to Water: 4.95 feet bgs		
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance			Well Type: 2-inch Sch 40 PVC GW Monitoring Well		
Ground Elevation: 5,680.51 feet			Top of Casing Elevation: 5,683.60 feet		

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 18,500 cpm
				0' - 7' Post-Piney Creek Alluvium, Sand, silty, some gravel and cobbles, very dark brown (10YR 2/2), moist to 4 feet, saturated at 5 feet, 67% recovery		
	5	SW/GW		Static Water Level 4.95' bgs measured 03/08/07		18,200
	10	SH		7' - 15' Pierre Shale, dark gray (2.5YR 4/0), damp grading to dry		18,000
	15			Total Depth of Borehole 15 feet bgs Depth to Water 4.95 feet bgs		18,300
	20			Total Depth of Well 14.25 feet bgs 2" Sch. 40 PVC Blank Casing +3.09' ags to 4' bgs 2" Sch. 40 PVC 0.020" Slot Screen 4' to 14' bgs 2" Sch. 40 PVC End Cap 14' to 14.25' bgs 10/20 Colorado Silica Sand 3' to 15' bgs Hydrated Bentonite Surface Seal 0' to 3' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.64' ags		
	25					

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CSMRI-9

Colorado School of Mines		Colorado School of Mines Research Institute Site		Golden, Colorado
Project Number: 4060 - 720		Client: Colorado School of Mines		
Geologist: N. Malczyk		Northing: 4,400408.8 Easting: 480,361.3		
Drilling Contractor: Prosonic Corporation, B. Owens		Total Depth of Borehole: 30 feet bgs		
Dates Drilled: 02/19/07 - 02/19/07		Depth to Water: 22.99 feet bgs		
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance		Well Type: 2-inch Sch 40 PVC GW Monitoring Well		
Ground Elevation: 5,704.56 feet		Top of Casing Elevation: 5,707.71 feet		

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 15,000 cpm
			Fill	0' - 2' Fill, fine grain sand, silt, clay, some cobbles, dark yellowish brown (10YR 4/2), moist		
			Fill	2' - 4' Fill, silt, some fine sand, dark yellowish orange (10YR 6/6), dry		
	5		Fill	4' - 10' Fill, fine and medium grain sand, some cobbles, pieces of wood, moderate brown (5YR 4/4)		18,400
	10			10' - 19' Similar material as above with color change to greenish gray (5GY 6/1), probable Louviers Alluvium		20,300
	15		SW			18,300
	20			19' - 30' Fox Hills Sandstone, fine grain sand, dark yellowish orange (10YR 6/6), moist		15,500
	25		SP	Static Water Level 22.99' bgs measured 02/27/07 @ 25' - 26' becomes moist to wet		16,600
	30			Total Depth of Borehole 30 feet bgs Depth to Water 22.99 feet bgs		14,300
	35			Total Depth of Well 30 feet bgs 2" Sch. 40 PVC Blank Casing +3.15' ags to 14.75' bgs 2" Sch. 40 PVC 0.020" Slot Screen 14.75' to 29.75' bgs 2" Sch. 40 PVC End Cap 29.75' to 30' bgs 10/20 Colorado Silica Sand 12' to 30' bgs Hydrated Bentonite Surface Seal 0' to 12' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +3.67' ags		

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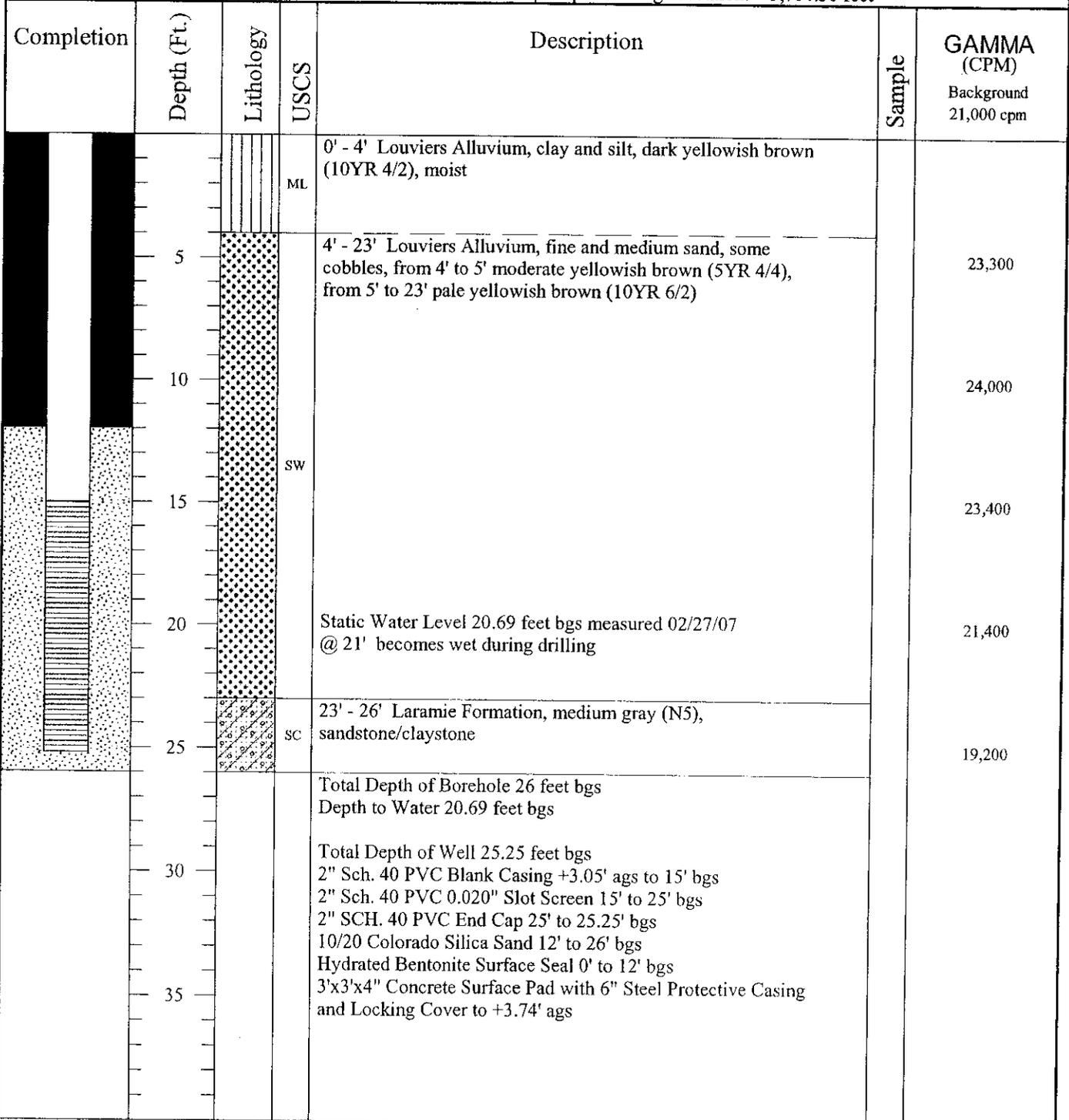
CSMRI-10

Colorado School of Mines

Colorado School of Mines Research Institute Site

Golden, Colorado

Project Number: 4060 - 720	Client: Colorado School of Mines
Geologist: N. Malczyk	Northing: 4,400,419.6 Easting: 480,433.3
Drilling Contractor: Prosonic Corporation, B. Owens	Total Depth of Borehole: 26 feet bgs
Dates Drilled: 02/19/07 - 02/20/07	Depth to Water: 20.69 feet bgs
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance	Well Type: 2-inch Sch 40 PVC GW Monitoring Well
Ground Elevation: 5,701.25 feet	Top of Casing Elevation: 5,704.30 feet



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S.M. STOLLER CORPORATION

CSMRI-11

Colorado School of Mines		Colorado School of Mines Research Institute Site		Golden, Colorado
Project Number: 4060 - 720		Client: Colorado School of Mines		
Geologist: N. Malczyk		Northing: 4,400,359.5 Easting: 480,403.0		
Drilling Contractor: Prosonic Corporation, B. Owens		Total Depth of Borehole: 35 feet bgs		
Dates Drilled: 02/16/07 - 02/18/07		Depth to Water: 27.83 feet bgs		
Borehole Type: 6-inch dia. Resonant Sonic Casing Advance		Well Type: 2-inch Sch 40 PVC GW Monitoring Well		
Ground Elevation: 5,711.12 feet		Top of Casing Elevation: 5,714.40 feet		

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	GAMMA (CPM) Background 16,500 cpm
	0		SP	0' - 1' Louviers Alluvium, Sand, medium and fine grain, few pebbles, dark yellowish brown (10YR 4/2)		
	1		CL	1' - 8' Louviers Alluvium, clay and silt, dark yellowish brown (10YR 4/2), stiff, dry		15,500
	8		ML	8' - 9' Louviers Alluvium, silt and very fine sand, few pebbles, dark yellowish brown (10YR 4/2), soft, very moist		16,300
	9		SC	9' - 12' Louviers Alluvium, clay and silt, some very fine sand, dark yellowish brown (10YR 4/2), dry		
	12		SP	12' - 14' Louviers Alluvium, fine sand, some pebbles and cobbles, moderate brown (10YR 4/4), loose, dry		17,200
	14			14' - 27' Louviers Alluvium, fine sand, little medium sand, some cobbles, pinkish gray (5YR 8/1)		
	20		SP			19,700
	25					17,100
	27		SP	27' - 29' Louviers Alluvium, medium sand, some cobbles, dark yellowish brown (10YR 4/2), wet		
	27.83			Static Water Level 27.83 feet bgs measured 02/27/07		19,000
	29		SH	29' - 35' Fox Hills Sandstone, interbedded sandstone and shale, weathered from 29' to 31', moderate brown (5YR 4/4), medium gray (N5) below 31'		
	35			Total Depth of Borehole 35 feet bgs Depth to Water 27.83 feet bgs		16,400
	40			Total Depth of Well 33.25 feet bgs 2" Sch. 40 PVC Blank Casing +3.28' ags to 23' bgs 2" Sch. 40 PVC 0.020" Slot Screen 23' to 33' bgs 2" Sch. 40 PVC End Cap 33' to 33.25' bgs 10/20 Colorado Silica Sand 20' to 35' bgs Hydrated Bentonite Surface Seal 0' to 20' bgs 3'x3'x4" Concrete Surface Pad with 6" Steel Protective Casing and Locking Cover to +4.00' ags		

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Appendix J
Anion/Cation Data Package