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November 10, 2009

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Mr. John Buckley, NRC Project Manager
U.S. Nuclear Regulatory Commission
Decommissioning and Uranium Recovery Licensing Directorate
Division of Waste Management and Environmental Protection
Mail Stop T-8F5
Washington, DC 20555

RE: Evaluation of Alluvial aquifer background concentrations for Contaminants of Concern for the Homestake Mining Company Superfund Site (CERCLIS ID NMD007860935), Cibola County, New Mexico

Dear Sai and John:

Earlier this year, the New Mexico Environment Department ("NMED") received the attached paper entitled "Statistical evaluation of alluvial groundwater (*sic*) quality upgradient of the Homestake Mining Company ("HMC") uranium mill Superfund Site near Grants, New Mexico: Molybdenum, selenium, uranium" by Dr. Richard Abitz, who is the EPA-funded Technical Advisor to the Bluewater Valley Downstream Alliance ("BVDA"). This paper presents a statistical critique of both the spatial well placement and hydrochemical data analytical methodologies that were used by the regulatory agencies to establish the current Alluvial aquifer regulatory remedial standards for the HMC site.

Both BVDA and other interested parties have long questioned the validity of the HMC Site regulatory remedial standards; however, the paper from Dr. Abitz presents the first quantitative treatment of these questions. The general issue of background hydrochemical conditions within the Grants Mineral Belt—both pre-mining/pre-milling for the legacy uranium mines, and pre-milling for millsites—has, and will continue to be, very significant to the determination and characterization of both possible site-specific and regional ground water impacts from legacy uranium sites, as is proposed under the draft EPA Region 6 interagency "5-year plan." NMED recently has received a copy of

Mr. Sairam Appaji, EPA and Mr. John Buckley, NRC

RE: Evaluation of Alluvial aquifer background concentrations for Contaminants of Concern for the Homestake Mining Company Superfund Site (CERCLIS ID NMD007860935), Cibola County, New Mexico

November 10, 2009

an EPA proposal to investigate possible differentiation of contaminant sources commonly associated with legacy uranium sites within the San Mateo Creek basin that was developed by the EPA Office of Research and Development, at the request of John Meyer, Chief of EPA Region 6 Risk and Site Assessment Section (attached). NMED believes that possible joint review of, and response to, Dr. Abitz' critique by EPA and NRC staff could serve dual objectives of more rigorously documenting the technical basis for the Homestake Site Alluvial remedial standards, as well as contributing to the proposed EPA effort to discriminate regional impacts to ground water hydrochemistry from legacy uranium sites throughout the Grants Mineral Belt in accordance with the interagency "5-year plan."

Jerry Schoeppner and I would welcome the opportunity to discuss these issues further with your agencies. Please contact me at (505) 476-3777 or Jerry Schoeppner at (505) 827-0652 for further information on this matter.

Sincerely,



David L. Mayerson
Superfund Oversight Section

Attachments:

Dr. Richard Abitz, April 2009. "Statistical evaluation of alluvial groundwater (*sic*) quality upgradient of the Homestake Mining Company uranium mill Superfund Site near Grants, New Mexico: Molybdenum, selenium, uranium."

EPA, 2009. "Assessing Pre-Mining Water Chemistry for Ground Water within the Grants Mineral Belt, New Mexico." FY2010 RARE proposal.

Copies without attachments:

Ms. Dana Bahar, NMED
Mr. John Meyer, EPA
Mr. Jerry Schoeppner, NMED

NMED/GWQB/SOS November 2009 read file

Statistical Evaluation of Alluvial Groundwater Quality Upgradient of the Homestake Site Near Grants, New Mexico: Molybdenum, Selenium, Uranium

Prepared by:
Environmental Restoration Group, Inc. (ERG)
December 2001

Reviewed by:
Richard J. Abitz
Geochemical Consulting Services, LLC
April 2009

This statistical evaluation (the ERG report) purports to characterize upgradient concentrations of molybdenum, selenium and uranium to determine background levels of the constituents in upgradient wells and to assess the impact of contamination generated from the Homestake Mining Company (HMC) tailings piles on downgradient wells. The results and conclusions presented in the report are invalid for the following reasons:

- 1) The upgradient groundwater in the alluvial deposits has been contaminated by uranium mining waters discharged over decades of past underground operations; and this is the primary source of contamination, rather than the unsupported conclusion that natural outcrops of uranium ore provided a sufficient mass of contaminants to contribute to the observed elevated concentrations.
- 2) Upgradient wells placed in the alluvial aquifer have not been located using a valid statistical approach (e.g., systematic grid or random locations on a grid).
- 3) There is no discussion of laboratory quality control and quality assurance practices to address the significant differences in analytical results between laboratories for samples collected on or near the same date.
- 4) Results from all laboratories for a given well were grouped together to perform the statistical calculations, yet sample splits analyzed by different labs on the same date show significantly different results, which precludes averaging the grouping the labs together.
- 5) All near upgradient (or far upgradient) wells were grouped together to determine a single background value for the parameter of interest, yet samples from different wells show significantly different means (based on the t test for sample sets with a normal distribution), which precludes grouping the wells together.

Upgradient Groundwater

Millions of gallons of contaminated water have been discharged to the San Mateo alluvial system from decades of past mining operations (New Mexico HED, EID & WPCB; 1980). These operations are located upgradient of the HMC site. Therefore, the impacted area upgradient of the HMC site cannot be used to assess background water quality in the alluvial aquifer. The best representation of pre-mining conditions in the San Mateo alluvial system is groundwater that is downgradient of the present contamination plumes south of the HMC site.

Writers of the ERG report state that natural exposures of uranium ore in the upgradient reaches of the alluvial system influence natural background water quality. However, they present no

scientific data to show that this is a significant source of contamination, relative to the millions of gallons of contaminated water discharged from the mines. For example:

What is the surface area of exposed uranium ore relative to the surface area of the drainage system?

What calculations have been performed to estimate the mass of molybdenum, selenium and uranium released from the outcrops?

What is the mass of molybdenum, selenium and uranium discharged from the mines?

What are the assumed hydrological and geochemical properties for the transport of molybdenum, selenium and uranium in the alluvial system?

Location of Upgradient Wells

As noted above, upgradient wells cannot be used to determine background water quality because the alluvial aquifer has been contaminated by past mining operations. However, if the upgradient alluvial system were uncontaminated, background wells would have to be located using a systematic grid or random locations on a grid. This valid statistical approach should also be followed to determine the location of background wells downgradient of the HMC plumes.

Figure 1 illustrates the location of HMC's near upgradient wells in Sections 23 and 24, relative to wells that are located on a systematic grid or as random points on a grid. Assuming that the nine HMC wells are the proper density over the given area, nine locations on a systematic ½ by ½ mile grid (open diamond symbols) or nine random locations selected from the nodes of a ¼ by ¼ mile grid (filled triangles) illustrate the proper statistical methods for locating background wells. There is no statistical justification for the location of the present HMC wells used in this study.

Laboratory QA/QC

Six different analytical laboratories reported results for groundwater samples. In many cases, the results for sample splits analyzed by two laboratories are significantly different (i.e., outside +/- 20 percent), yet there is no discussion on laboratory QA/QC to determine which laboratory may have been out of control. Table 74 of the ERG report (page 161) tabulates uranium results and there are significant differences for the splits from wells:

DD (9May84, 13Dec88, 11Jan89, 15Feb89);

P (16Apr80, 16Jul80, 7Jan81, 15Apr81, 28Dec81, 18Nov82, 9May84, 16Sep87, 24Feb88);

P2 (4May93);

Q (13Jun77, 23Oct78, 30Apr79, 16Apr80, 16Jul80, 7Jan81, 15Apr81, 28Dec81, 28Jun83, 9May84, 15Dec86, 11Jan89);

R (28Jun83, 9May84, 11Mar85, 5Sep85, 10Mar86, 15Sep86, 15Dec86, 19Mar87, 13Dec88, 16Sep92).

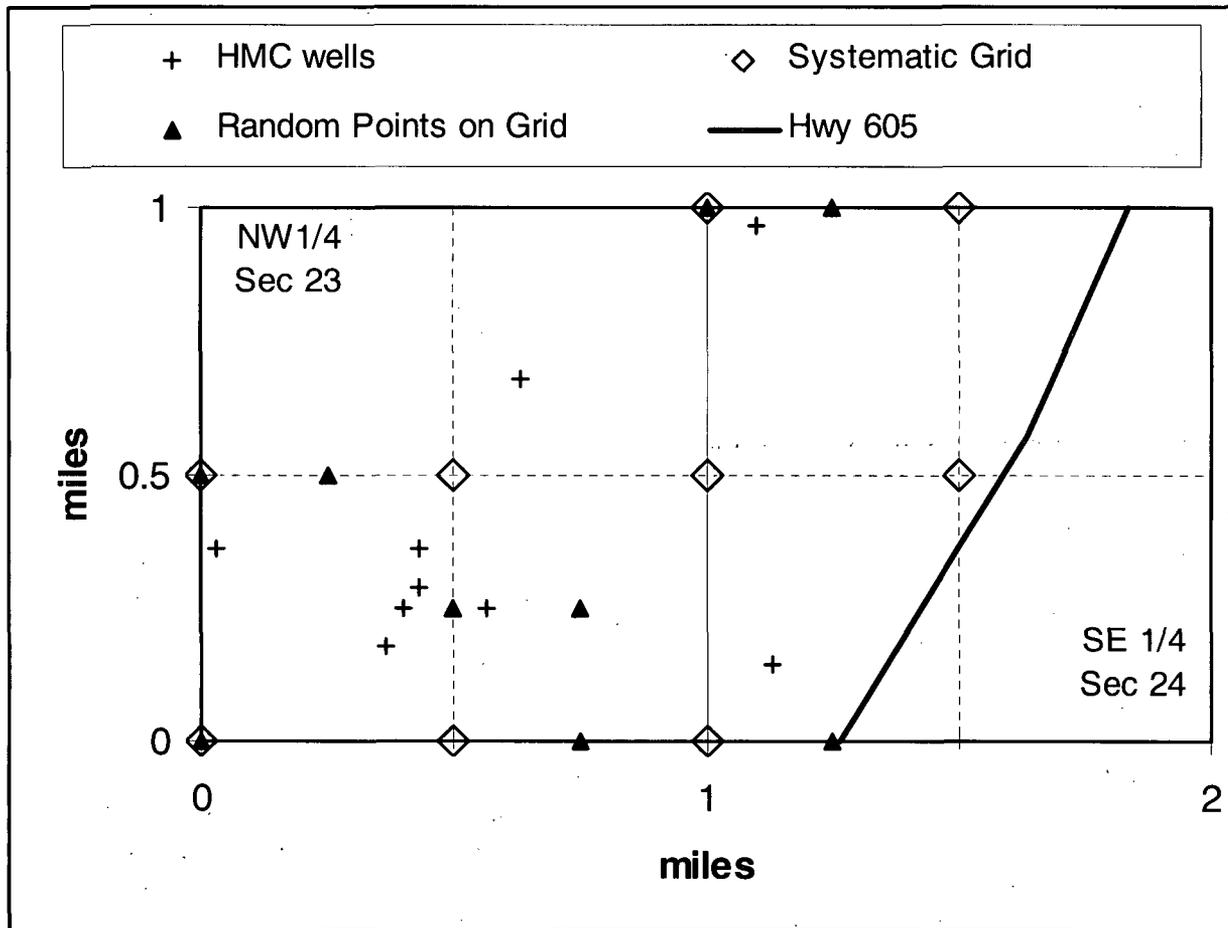


Figure 1. Systematic grid and random points on a grid are the statistically valid methods for locating background wells.

The authors of this report note on page 3, second paragraph, "...the on-site and any verification lab results for a sampling round were averaged together to produce one value for the concentration of a constituent in each well on that date." This is an unacceptable practice because the independent laboratory results do not agree within the established QA/QC guidelines for commercial laboratories, and the averaging of values with significant differences can produce a high bias in the result.

For example, at well DD, the 08Dec88 result for uranium is 0.102 mg/L, and this is followed by average values of 0.161, 0.140, and 0.186 mg/L for three rounds of split samples (13Dec88, 11Jan89, 15Feb89) and then back to 0.0848 mg/L on 29Mar89 (see Table 75, page 172 of the ERG report). Averaging the split samples from Homestake and Barringer produces results that are 60 to 100 percent greater than the single results that bracket the split samples. The gross difference in the Homestake and Barringer split results, as well as differences between Homestake, NMEID and CEP, are shown on Figure 2.

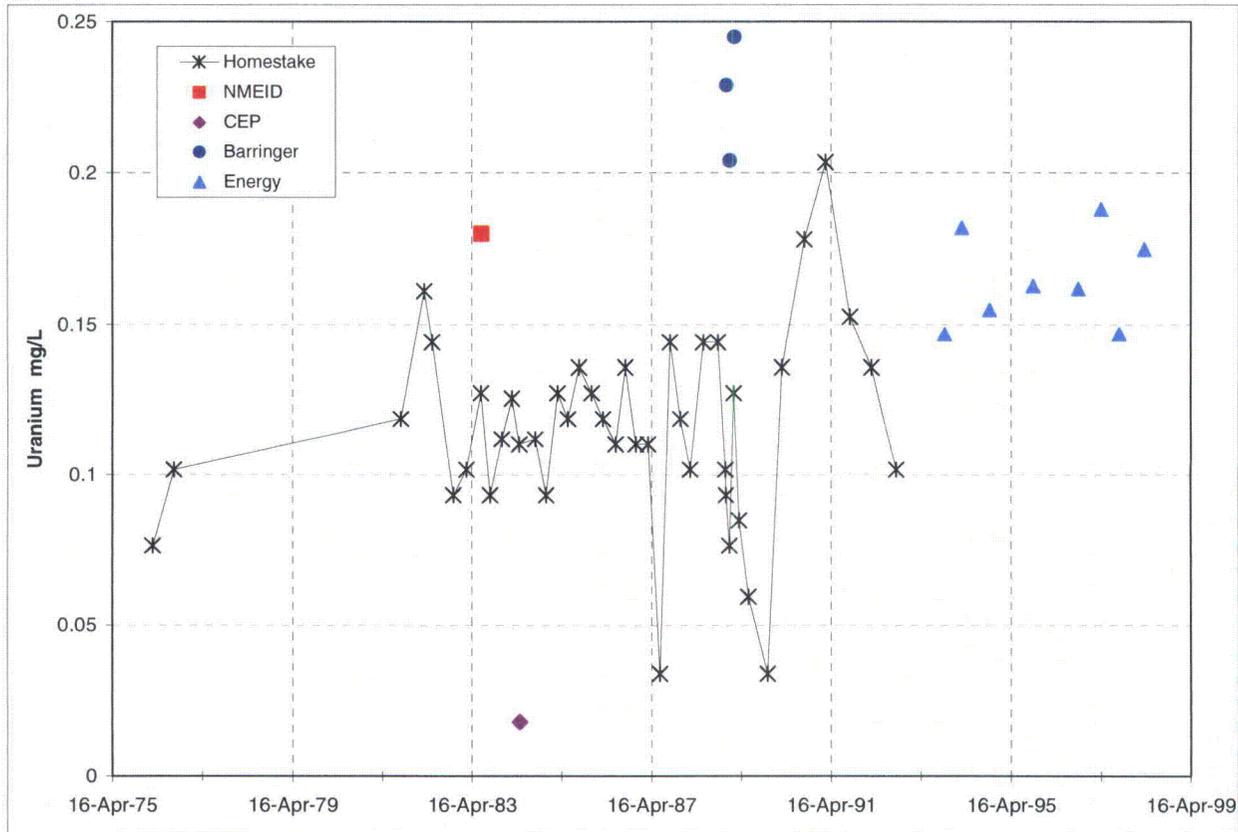


Figure 2. Variation in uranium concentration at well DD over a 22 year period.

Additionally, there is a noted change in the uranium concentration at well DD on 21Oct93, and this reflects a change in the analytical laboratory (Homestake before 21Oct93 and Energy Laboratory on 21Oct93 through 1Apr98). Figure 2 illustrates that prior to 21Oct93, only 4 samples exceeded 0.147 mg/L, whereas after this date all samples are above this value. This shift in values could reflect methods and equipment at different laboratories or it may indicate the arrival of additional contamination at the well. Although the large swing in values reported by Homestake Laboratory over the period 16Apr89 through 16Apr93 suggests analytical and/or sampling problems.

Failure to discuss the laboratory QA/QC leaves a large void in the data interpretation of split-sample results that are significantly different. Which laboratory is reporting the result that is closest to the true value?

Grouping Laboratory Data

Statistical tests were not performed to compare results from independent laboratories prior to grouping the data. Using the duplicate results for Homestake and NMEID for Well DD (14 samples each), the two data sets were found to follow a normal distribution (Shapiro-Wilks Test). Therefore, a t-test group comparison (unequal variances) was performed and the results indicate a significant difference between the two data sets at the 95 percent confidence level. As

expected from the analysis in the preceding section on laboratory QA/QC, there is no statistical justification to combine and average the split sample results.

Grouping Well Data

Statistical tests to compare the near upgradient and far upgradient well sets were performed (page 2, paragraph 5 of the ERG report), but the authors should have performed a comparison of individual wells within each set to determine if the individual wells could be grouped together for statistical analysis. A preliminary nonparametric analysis of uranium concentrations for the near upgradient wells (DD, ND, P, P1, P2, Q and R) indicates that all wells cannot be grouped into a single population. The Kruskal-Wallis Rank Test (EPA 1992) indicates 4 distinct groups of wells (R&P2, P1&Q, P&ND, and DD). Therefore, the conclusions in Section 5 of the report are invalid, and uranium levels in individual wells must be assessed to determine if they represent pre-mining background.

The statistical demonstration of distinct populations for the uranium concentration measured in near upgradient wells implies that the contamination from upstream discharges is following preferential flow paths, and the uranium concentration in the wells is dependent on the location of the well with respect to plume migration. Well R is the least impacted by the contamination, and a comparison of all water-quality data from this well should be made to earlier water-quality studies (EPA 1975, Unknown Report, Table 4) that investigated wells in the subdivisions SW of the HMC tailing piles. For example, the USEPA Office of Radiation Programs estimated 1975 background uranium in the alluvial aquifer below the subdivisions to be approximately 0.018 mg/L, which compares well with a uranium median value of 0.014 mg/L for results from Well R.

FY2010 RARE Proposal

TITLE: Assessing Pre-Mining Water Chemistry for Ground Water within the Grants Mineral Belt, New Mexico

REGION 6 CONTACT/PHONE: Sai Appaji, 214-665-3126

AMOUNT REQUESTED:

\$100,000 Total (\$50,000 FY2010; \$50,000 FY2011)

Funds requested to support this research effort will be used to conduct routine and specialized chemical analyses on ground-water and surface water samples collected from identified locations within the Grants Mineral Belt. Due to the timing limitations for accessing field sampling locations, negotiating access to private wells, and addressing potential seasonal variations in water chemistry for a given watershed, the requested funds are to be distributed over a two-year period. The primary project participant responsible for field sampling will be the New Mexico Environment Department, which represents a significant in-kind contribution and cost savings to EPA. The proposed work will support on-going technical support efforts in Regions 6, 8 & 9 to identify best practices for site characterization and restoration at sites with ground water contaminated with uranium.

BACKGROUND:

The Grants Mineral Belt (GMB) was the primary locus of uranium extraction and production activities in New Mexico from the 1950s until late into the 20th century. The GMB extends along the southern margin of the San Juan basin in Cibola, McKinley, Sandoval, and Bernalillo counties as well as Tribal lands. Operations from uranium and extraction production activities generated liquid wastes that were discharged to alluvium directly and indirectly via infiltration from settling ponds and overland flow. These liquid wastes present a source of uranium and associated contaminants such as arsenic and selenium in excess of concentrations naturally supported by ground-water interactions with mineralized geologic formations in this region of New Mexico. Current-day impacts to ground water from mine sites within the GMB mostly have not been assessed, but are indicated by the results from assessment and abatement work on a few mine sites within the Ambrosia Lake sub-district that have been ordered by the State of New Mexico under its ground-water contamination abatement regulations. A current information gap that constrains implementation of assessment and restoration activities within the potentially impacted aquifers is knowledge of ground-water chemistry that is representative of pre-mining activities within the region. Determination of unimpacted or pre-mining uranium concentrations in ground water is complicated by the size of the potentially impacted area and the lack of historical data on the concentrations and volume of liquid waste releases to the alluvial aquifer. The lack of a complete record of historical contaminant source releases throughout the impacted aquifer(s) warrants implementation of alternative techniques to differentiate between unimpacted and impacted portions of the aquifer(s) underlying the GMB.

Due to the potential for adsorption-desorption reactions between uranium and aquifer



solids, dependence on concentration as a primary factor for differentiating between unimpacted and impacted ground water has limited success. The influence of adsorption-desorption reactions on uranium concentrations in ground water will be influenced both by water chemistry (e.g., pH and alkalinity) and the characteristics of aquifer solids along relevant flow paths (EPA, 2008). For aquifer systems with limited hydrologic characterization and historical water chemistry data, measurements of stable isotopes and radioisotopes have been employed to aid in differentiating sources of uranium in ground water (e.g., Roback et al., 2001; Maher et al., 2006; Sherman et al., 2007).

The planned effort compliments current ground-water characterization efforts undertaken by NMED to assess chemical characteristics of ground water impacted by historical mining/milling activities in the San Mateo Basin. Data showing patterns in stable oxygen-hydrogen isotope distributions and ^{234}U : ^{238}U activity ratios from a selection of ground-water samples from two areas within the watershed are shown in Figure 1. These preliminary data support the notion that stable isotope and uranium radioisotope data may provide a forensic signature for differentiating different water sources to the alluvial aquifer. The planned effort will also capitalize on recent efforts by the U.S. Geological Survey to estimate chemical characteristics of ground water prior to the initiation of mining/milling activities at the Questa molybdenum mine in northern New Mexico (Nordstrom, 2008; see also <http://water.usgs.gov/nrp/proj.bib/nordstrom.html>).

Project Objectives

Work conducted under this project will involve the collection and analysis of water samples from available private/municipal/monitoring wells, springs, and surface water bodies in designated portions of the watershed(s) within the GMB study area. These samples will be analyzed using traditional and non-traditional analytical techniques to characterize the major and trace element chemistry, as well as the stable isotopes of water and uranium radioisotopes. This information, in conjunction with currently available data from NMED and other Federal parties conducting ground-water monitoring within the GMB, will be used to assess the availability of forensic chemical signatures that can be used to differentiate pre- and post-mining impacted ground water. Specific project objectives include:

- Determine if unimpacted and/or pre-mining ground-water chemistry displays elevated concentrations of potential inorganic contaminants that are identified as contaminants of concern for mine-impacted ground water.
- Compile geochemical database for water chemistry within the Grants Mineral Belt that serves as a tool for State and Federal regulators tasked with evaluating ground-water restoration options.
- Determine if forensic water chemistry data may be employed to support differentiation of unimpacted and mine-impacted ground water.

APPROACH:

Selection of the physical extent of the study area, relevant locations for collection of water samples, and methods to be employed for sample collection and measurement of field

water chemistry will be determined via discussions between Region 6, NMED, and EPA/ORD. Collection and shipment of water samples will be conducted by NMED personnel with assistance from EPA/ORD personnel where appropriate and travel funds permit. Sampling will be conducted multiple times at each chosen location in order to capture chemical variations due to seasonal variations in the distribution of water sources recharging the alluvial aquifer. Samples will be shipped to the EPA/ORD Research Laboratory in Ada, OK for analysis by the on-site analytical contractor (Shaw Environmental, Inc.). Analytical methods will be employed to determine the concentrations of major & trace elements (ICP-OES, ICP-MS), uranium radioisotopes (ICP-MS), and stable oxygen-hydrogen isotopes in water (Isotope Ratio Mass Spectrometry). Results documented in contract data report deliverables will be compiled and evaluated by EPA/ORD and provided in the format of technical memoranda to Region 6 and NMED during the course of the investigation. EPA/ORD will prepare a final project report that compiles all data and provides analysis and determination of whether unimpacted and mine-impacted sources of ground water can be differentiated using forensic chemical signatures.

ORD Contacts

Robert Ford (Principal Investigator), Land Remediation and Pollution Control Division, Cincinnati, OH; 513-569-7501, ford.robert@epa.gov
 Steven Acree (Co-Principal Investigator), Ground Water and Ecosystems Restoration Division, Ada, OK; 580-436-8609, acree.steven@epa.gov
 Mary Sue McNeil (Contract Project Officer), Ground Water and Ecosystems Restoration Division, Ada, OK; 580-436-8711, mcneil.mary-sue@epa.gov

Estimated Timeline of Project Tasks

Calendar Year 2010											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Design Sampling Plan & Develop QAPP											
						Field Sampling & Lab Analyses					
									Data Reporting		
Calendar Year 2011											
	Field Sampling & Lab Analyses										
	Data Reporting										
						Development & Review of Final Deliverable					

Project Participant	Tasks
EPA Region 6 Sai Appaji	<ul style="list-style-type: none"> • Coordinate communications and interactions between EPA/ORD and NMED staff for planning field activities and reporting data and technical evaluations. • Participate in identification and prioritization of field sampling locations to support characterization of unimpacted ground water. • Identify sources and obtain data characterizing water chemistry for liquid wastes generated by historical mining/milling

	operations within the GMB.
EPA/ORD (LRPCD & GWERD) Robert Ford Steven Acree	<ul style="list-style-type: none"> • Coordinate with NMED and R6 staff in the identification and prioritization of field sampling locations. • Develop Quality Assurance Project Plan that addresses data collection effort, including identification/development of relevant Standard Operating Procedures to be employed for field sampling and laboratory analytical work. • Prepare and distribute data report deliverables to R6 and NMED project participants. • Compile historical water chemistry data provided by R6/NMED for mining/milling liquid wastes for incorporation into a project database or spreadsheet.
NMED Earle Dixon	<ul style="list-style-type: none"> • Participate in identification and prioritization of field sampling locations to support characterization of unimpacted ground water. • Coordinate with other State and Federal partners operating in areas within the GMB relevant to targeted study site locations for acquisition of split samples from water sources not sampled by NMED. • Coordinate and conduct field sampling activities and deliver water samples to Contractor to ORD. • Identify sources and obtain data characterizing water chemistry for liquid wastes generated by historical mining/milling operations within the GMB; coordinate with other Federal entities to determine availability of chemistry data or sample splits from ground water with know impact from historical mining/milling operations.
Contractor to ORD (Shaw Environmental, Inc.)	<ul style="list-style-type: none"> • Conduct laboratory analyses of water samples received from NMED field sampling staff. • Manage disposal of unused sample and sample-derived wastes generated during analysis. • Prepare analytical data reports for delivery to EPA/ORD.

EXPECTED RESULTS:

Technical evaluation of water chemistry data collected from this study will be used to assess whether forensic chemical indicators are available to differentiate between unimpacted and mine-impacted zones in the alluvial aquifer within the GMB. Technical memoranda will be used to transmit interim technical data reports to Region 6 and the NMED throughout the performance period. Technical findings of the project will be provided within a Final Project Report for delivery at the end of the projected project period. This technical evaluation will provide Region 6 and the NMED with a strategy to assess pre-mining characteristics of alluvial ground water within the study area, and the compiled data will provide a point of reference for subsequent evaluations in areas within the GMB that lie outside of the limits of the study area. Best-practice methods developed under this project for differentiating sources of ground water can

subsequently be applied to other watersheds in Region 6 that may have been impacted by historical uranium mining and milling operations.

References

- Ford, R. G., Wilkin, R. T., and Acree, S. 2008. Site Characterization to Support Use of Monitored Natural Attenuation for Remediation of Inorganic Contaminants in Ground Water. EPA Ground Water Issue Paper, U.S. Environmental Protection Agency, Cincinnati, OH, EPA/600/R-08/114.
<http://www.epa.gov/nrmrl/pubs/600r08114/600r08114.pdf>
- Maher, K., DePaolo, D. J., and Christensen, J. N. U–Sr isotopic speedometer: Fluid flow and chemical weathering rates in aquifers. *Geochimica et Cosmochimica Acta* 70:4417-4435 (2006).
- Nordstrom, D. K. What was the groundwater quality before mining in a mineralized region? Lessons from the Questa Project. *Geosciences Journal* 12:139-149 (2008).
- Roback, R. C., Johnson, T. M., McLing, T. L., Murrell, M. T., Luo, S., and Ku, T.-L. Uranium isotopic evidence for groundwater chemical evolution and flow patterns in the eastern Snake River Plain aquifer, Idaho. *GSA Bulletin* 113:1133-1141 (2001).
- Sherman, H. M., Gierke, J. S., and Anderson, C. P. Controls on spatial variability of uranium in sandstone aquifers. *Ground Water Monitoring & Remediation* 27:106-118 (2007).

Figure 1 Current stable isotope and radioisotope data collected by NMED (Earle Dixon) to begin mapping out water sources throughout the alluvial aquifer within the GMB. Top panel – relationship between hydrogen and oxygen stable isotopes. Bottom panel – relationship between $^{234}\text{U}:$ ^{238}U activity ratio (UAR) and oxygen stable isotopes; dashed line shows UAR value for waters with $^{234}\text{U}:$ ^{238}U at radioactive equilibrium, higher values of UAR are typically associated with old ground water that has been in contact with aquifer solids for long periods of time.

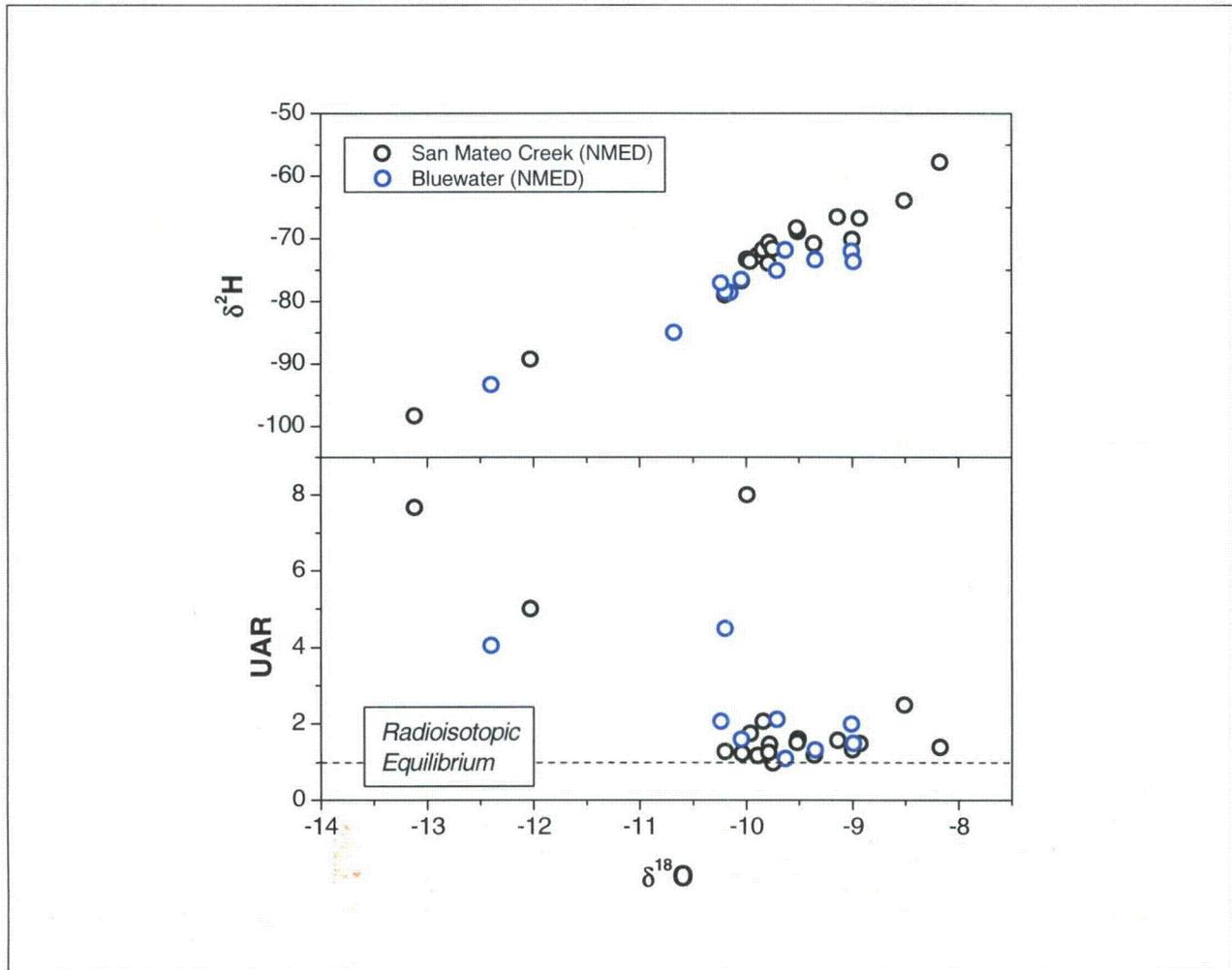
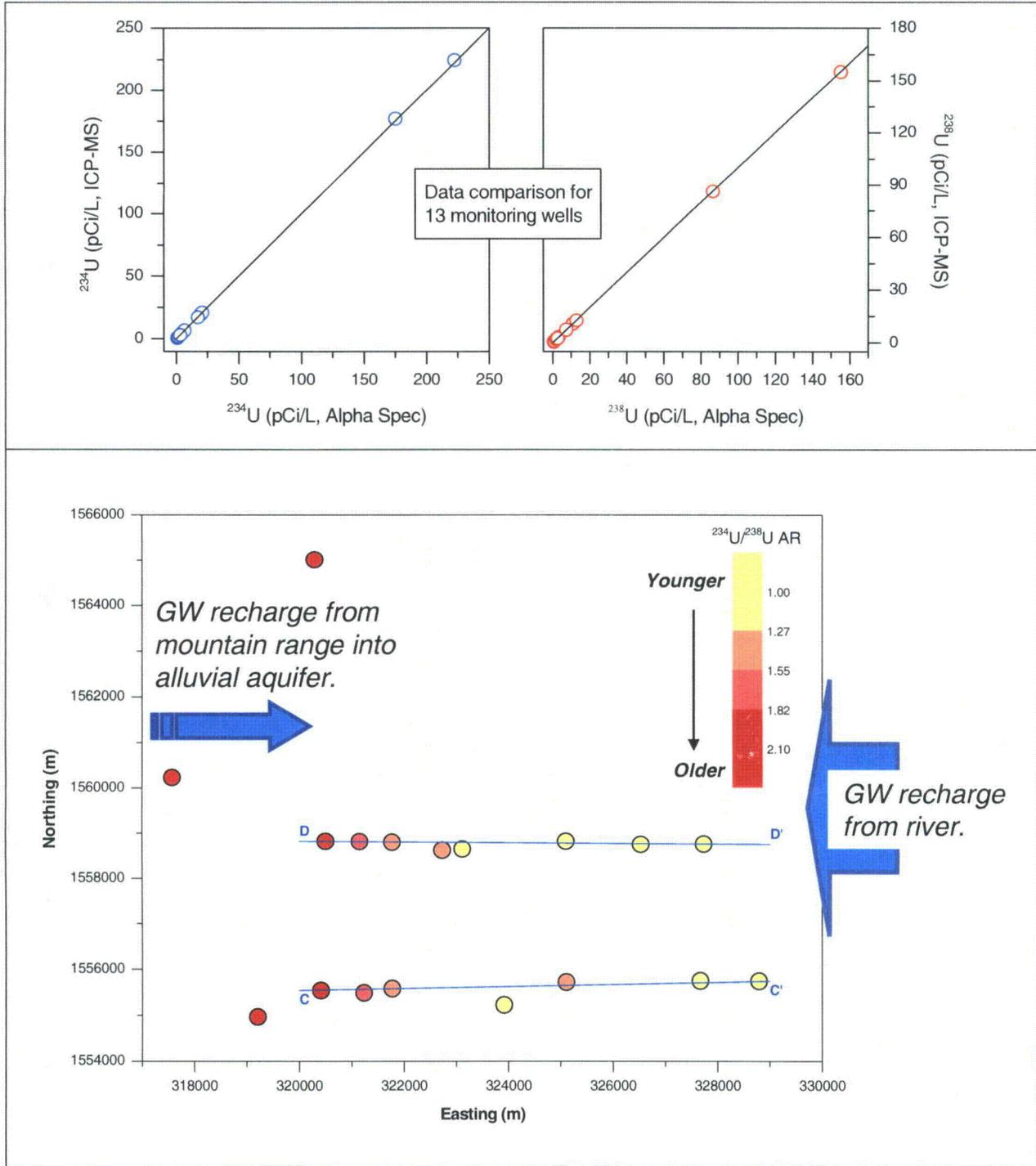
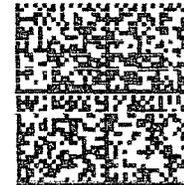


Figure 2 Example data from EPA/ORD technical support effort illustrating use of uranium radioisotopic data measured using ICP-MS to differentiate between water sources within an alluvial aquifer. Top panel – comparison of ^{234}U and ^{238}U activity data determined using ICP-MS and alpha spectrometry. Bottom panel – site example showing patterns in uranium activity ratio (UAR) for ^{234}U : ^{238}U in alluvial ground water.



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