

## Holm, Eric

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**From:** Lees, Michael  
**Sent:** Tuesday, February 21, 2012 4:58 PM  
**To:** 'Shea.Valois@epa.gov'  
**Cc:** Cepak, Mike; Holm, Eric  
**Subject:** FW: Web conference invitation : USGS EPA RARE Project Presentation on Dewey Burdock

**Importance:** High

Valois:

Please send us a user name and password for access to the EPA Web Application Access portal, or otherwise explain how we're supposed to access your 2-22-12 web presentation.

Thanks.

Mike Lees  
SD DENR  
Minerals & Mining Program  
523 East Capitol Ave  
Pierre, SD 57501

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**From:** Cepak, Mike  
**Sent:** Friday, February 17, 2012 2:34 PM  
**To:** Hudson, Roberta; Hicks, Matt; Walsh, Brian; Lees, Michael; Townsend, Bob; Holm, Eric; Brandner, Tom; Hamann, Jordan D (S-Watertown); Markley, Bill  
**Subject:** RE: Web conference invitation : USGS EPA RARE Project Presentation on Dewey Burdock

For the folks in Pierre I have the lower level conference room reserved. I will get a projector and hopefully we can make the computer connection.

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**From:** Cepak, Mike  
**Sent:** Friday, February 17, 2012 3:25 PM  
**To:** Hudson, Roberta; Hicks, Matt; Walsh, Brian; Lees, Michael; Iles, Derric; Townsend, Bob; Holm, Eric; Brandner, Tom; Filipovic, Dragan; Hamann, Jordan D (S-Watertown); Markley, Bill  
**Cc:** Cepak, Mike  
**Subject:** FW: Web conference invitation : USGS EPA RARE Project Presentation on Dewey Burdock

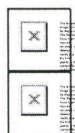
This web conference is in regards to the Dewey Burdock Permit & USGS presentation new geologic and hydrologic information to EPA Region 8. Date/Date: February 22 from 2 :00 to 4:30 PM CT.

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**From:** [Shea.Valois@epa.gov](mailto:Shea.Valois@epa.gov) [<mailto:Shea.Valois@epa.gov>]  
**Sent:** Friday, February 17, 2012 3:03 PM  
**To:** Cepak, Mike  
**Subject:** Web conference invitation : USGS EPA RARE Project Presentation on Dewey Burdock

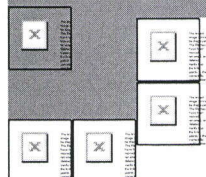
Please forward the link to anyone else who might be interested.

Valois Shea  
US EPA Region 8  
8P-W-GW  
1595 Wynkoop Street  
Denver, CO 80202-1129  
phone: 303-312-6276  
fax: 303-312-6741



## Web Conference

### Web conference invitation : USGS EPA RARE Project Presentation on Dewey Burdock



Dear [Mike.Cepak@state.sd.us](mailto:Mike.Cepak@state.sd.us) :

You have been invited for Web conference USGS EPA RARE Project Presentation on Dewey Burdock.

 [Join Conference](#)

If you have problems accessing the conference using the above link, copy and paste the following link into your browser:  
[http://hawkeye.epa.gov/imtapp/app/cmn\\_jm.uix?mID=739630&emailAddr=Mike.Cepak@state.sd.us](http://hawkeye.epa.gov/imtapp/app/cmn_jm.uix?mID=739630&emailAddr=Mike.Cepak@state.sd.us)

## Conference Details

Conference Title	<b>USGS EPA RARE Project Presentation on Dewey Burdock</b>
Conference ID	<b>739630</b>
Conference Key	
Date and Time	<b>22-Feb-2012 1:00 PM</b>
Duration	<b>2 Hours, 30 Mins</b>
Timezone	<b>(UTC-07:00) US Mountain Time</b>
Dial-In Number	<b>866-299-9141 passcode: 89673565</b>
Information	This presentation will include the results of the USGS EPA Regional Applied Research Effort aquifer modeling project at the proposed Dewey Burdock uranium ISR project in conjunction with a presentation from Powertech on new geologic and hydrologic information.
Invited Attendees	Attendee list is not published.

## Conference Materials

Document Name	File Name	File Type	Description
No pre-conference document			

To check that your system is ready for web conferencing, click [New User](#) and then Test.

## Holm, Eric

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**From:** Walsh, Brian  
**Sent:** Monday, August 16, 2010 9:27 AM  
**To:** Walsh, Brian; Brandner, Tom; Buhler, Ken; Cepak, Mike; Erbele, Garland; Filipovic, Dragan; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; Iles, Derric; Lees, Michael; Markley, Bill; Townsend, Bob  
**Subject:** FW: final Dewey Burdock QAPP  
**Attachments:** USGS DB RARE QAPP signature page.pdf; USGS DB RARE QAPP Final revision 0.doc

FYI

-----Original Message-----

**From:** Raymond H Johnson [<mailto:rhjohnso@usgs.gov>]  
**Sent:** Tuesday, August 10, 2010 5:05 PM  
**To:** "Rick Wilkin" <[@epa.gov](mailto:wilkin.rick@epa.gov)>/@usgs.gov  
**Subject:** final Dewey Burdock QAPP

Hi all,

For your records, version 0.0 of the Dewey Burdock quality assurance plan. Document file and scanned signature page.

Ray

\*\*\*\*\*

Raymond H. Johnson, Ph.D.  
U.S. Geological Survey  
Crustal Imaging and Characterization Team  
Mail Stop 964D  
Denver Federal Center  
P. O. Box 25046  
Denver, CO 80225-0046

Phone: 303-236-1885  
Fax: 303-236-3200  
E-mail: [rhjohnso@usgs.gov](mailto:rhjohnso@usgs.gov)  
\*\*\*\*\*

**Holm, Eric**

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**From:** Walsh, Brian  
**Sent:** Monday, October 31, 2011 1:53 PM  
**To:** Brandner, Tom; Buhler, Ken; Cepak, Mike; 'Filipovic, Dragan'; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; 'Iles, Derric'; Lees, Michael; Markley, Bill; Townsend, Bob; Walsh, Brian  
**Subject:** FW: updates on the Dewey Burdock project  
**Attachments:** 10-2011 - DB monthly report.doc

FYI

**From:** Raymond H Johnson [<mailto:rhjohnso@usgs.gov>]  
**Sent:** Monday, October 31, 2011 11:20 AM  
**To:** "Rick Wilkin <[@epa.gov](mailto:wilkin.rick@epa.gov)/usgs.gov  
**Subject:** updates on the Dewey Burdock project

Hi all,

See attached, an "October" monthly update that covers this summer and upcoming report/presentation plans on the EPA/USGS Dewey Burdock project.

Cheers,

Ray

\*\*\*\*\*

Raymond H. Johnson, Ph.D.  
U.S. Geological Survey  
Crustal Imaging and Characterization Team  
Mail Stop 964D  
Denver Federal Center  
P. O. Box 25046  
Denver, CO 80225-0046

Phone: 303-236-1885  
Fax: 303-236-3200  
E-mail: [rhjohnso@usgs.gov](mailto:rhjohnso@usgs.gov)

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USGS Interrog Have "Oct update"

Holm, Eric

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**From:** Walsh, Brian  
**Sent:** Monday, October 31, 2011 1:53 PM  
**To:** Brandner, Tom; Buhler, Ken; Cepak, Mike; 'Filipovic, Dragan'; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; 'Iles, Derric'; Lees, Michael; Markley, Bill; Townsend, Bob; Walsh, Brian  
**Subject:** FW: updates on the Dewey Burdock project  
**Attachments:** 10-2011 - DB monthly report.doc

FYI

**From:** Raymond H Johnson [<mailto:rhjohnso@usgs.gov>]  
**Sent:** Monday, October 31, 2011 11:20 AM  
**To:** "Rick Wilkin <[wilkin.rick@epa.gov](mailto:wilkin.rick@epa.gov)>@usgs.gov  
**Subject:** updates on the Dewey Burdock project

Hi all,

See attached, an "October" monthly update that covers this summer and upcoming report/presentation plans on the EPA/USGS Dewey Burdock project.

Cheers,

Ray

\*\*\*\*\*

Raymond H. Johnson, Ph.D.  
U.S. Geological Survey  
Crustal Imaging and Characterization Team  
Mail Stop 964D  
Denver Federal Center  
P. O. Box 25046  
Denver, CO 80225-0046

Phone: 303-236-1885  
Fax: 303-236-3200  
E-mail: [rhjohnso@usgs.gov](mailto:rhjohnso@usgs.gov)

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## **EPA/USGS Dewey Burdock Project Monthly Report for October 2011**

With summer field work, vacations, and September travel, I have been remiss in getting any monthly reports out to everyone. This report is a catch up for May through October and I will begin monthly reports again from now until the project documents go to review.

### Groundwater samples

31 wells were sampled at the Dewey Burdock site the last two weeks of June, 2011. Sampling went as planned and all the groundwater data has been received. Ray is currently working on a USGS Open-File Report (OFR) that will release all of the data and the sampling/analysis methods. Release of the data has been requested by Powertech and the NRC.

Analyses completed are as follows:

ICP-MS: EPA on a limited suite of elements, USGS full 55 element suite

ICP-AES (or OES): EPA

IC: EPA

DOC: EPA

18-O and D (stable isotopes): EPA

234U/238U: Northern Arizona University, Mike Ketterer

34-S: University of Arizona, Chris Eastoe

Iron pairs (3+ and 2+): USGS, David Fey

Tritium: USGS, Robert Michel, Menlo Park

C-14: bottles were collected and are currently in a walk-in cooler – no analyses have been completed

### Solid phase samples

The USGS has several, relatively complete, rock cores that were provided by Powertech. This includes core from Powertech's storage shed and leftover core from Hazen laboratories. That core has now been organized into core boxes and is stored at the USGS hot rocks room (core is available for viewing upon request). 30 samples were taken from the core for analyses.

Analyses from the core and status are as follows:

Total carbon and sulfur: EPA – data has been received

Whole rock: full elemental suite – USGS, data has been received

Thin sections for mineralogy: thin sections completed, analysis is on going by Sharon Diehl (USGS)

XRD/XRF: samples have been prepared, analysis is on going by Bill Benzel (USGS)

Full radiological scan completed.

Past presentation summary – full history

Abstract only:

Johnson, R.H., 2011, Reactive transport modeling for the proposed Dewey-Burdock uranium in-situ recovery mine, Edgemont, South Dakota, 6<sup>th</sup> Uranium Mining and Hydrogeology Conference in Freiberg, Germany, September 18-22, 2011.

Johnson, R.H., 2011, Use of reactive transport modelling to determine influences on groundwater at a proposed uranium in-situ recovery mine – geochemistry and radionuclide distribution before mining, Workshop on naturally occurring radioactive materials (NORM) in the environment – geochemical and biological behaviour, tools for risk assessment, September 14-15, 2011, University of Eastern Finland, Kuopio, Finland.

Johnson, R.H., 2011, Use of reactive transport modelling to determine influences on groundwater at a proposed uranium in-situ recovery mine – geochemistry and radionuclide movement during and after mining, Workshop on naturally occurring radioactive materials (NORM) in the environment – geochemical and biological behaviour, tools for risk assessment, September 14-15, 2011, University of Eastern Finland, Kuopio, Finland.

Johnson, R.H., 2011, Reactive transport modeling for the proposed Dewey-Burdock uranium in-situ recovery mine, Edgemont, South Dakota, *South Dakota Department of Environment and Natural Resources*, 23<sup>rd</sup> Annual Environmental and Ground Water Quality Conference, March 23-24, 2011.

Johnson, R.H., Yoshino, M.E., Hall, S.M., Shea, V.R., 2010, Predictive modeling strategies for proposed uranium in-situ recovery mines: *Geological Society of America*, Abstracts with Programs Vo. 42, No. 5. (Also SME 2011, and EPA workshop, Sept. 29, 2010).

[http://gsa.confex.com/gsa/2010AM/finalprogram/abstract\\_177436.htm](http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_177436.htm)

NOTE: the SME 2011 presentation received an award for the best SME environmental division presentation

Presentations with a short published paper:

Johnson, Raymond H., 2011, Reactive Transport Modeling for the Proposed Dewey Burdock Uranium In-Situ Recovery Mine, Edgemont, South Dakota, USA. – In: Rüde, R. T., Freund, A. and Wolkersdorfer, C. (eds.): *Mine Water – Managing the Challenges*. p. 221 – 225; Aachen, Germany

[http://www.imwa.info/docs/imwa\\_2011/IMWA2011\\_Johnson\\_340.pdf](http://www.imwa.info/docs/imwa_2011/IMWA2011_Johnson_340.pdf)



Johnson, R.H., Yoshino, M.E., Hall, S.M., Shea, V.R., 2011, Predictive modeling strategies for proposed uranium in-situ recovery mines: MODFLOW and More 2011, International Groundwater Modeling Center, Golden, CO, June 5-8, 2011.

Johnson, Raymond H.; Yoshino, Miori E.; Hall, Susan M.; Shea, Valois R., 2010, Predictive Modeling Strategies for Operations and Closure at Uranium In-Situ Recovery Mines. – In: Wolkersdorfer, C. and Freund, A.: Mine Water & Innovative Thinking. – p. 475 – 479; Sydney, Nova Scotia (CBU Press).  
[http://www.imwa.info/docs/imwa\\_2010/IMWA2010\\_Johnson\\_402.pdf](http://www.imwa.info/docs/imwa_2010/IMWA2010_Johnson_402.pdf)

#### Personnel summary

In order to complete the USGS/EPA Dewey Burdock project, the following staff are currently planned to assist in final interpretations and report preparation under USGS internal funding (current EPA RARE grant expired on Sept. 30, 2011).

Ray Johnson: 8 pay periods, project lead, reactive transport modeling, lead author on reports.

Sharon Diehl: 6 pay periods, mineralogic interpretations.

Jean Morrison: 4 pay periods, geochemistry and geochemical modeling.

Tanya Gallegos: approx. 3 pay periods, research of solid phase reducing capacities for natural attenuation at ISR sites, research falls under USGS uranium environmental task but overlaps with the Dewey Burdock project site and may include work on core from this site.

#### Planned reports

The following is the planned reports to complete this project. Note that titles and authorship are not finalized. The timeline for the OFRs is for on line publication in Jan/Feb 2012 and the two journal articles to be in review by spring/early summer.

Geochemical data from groundwater at the Dewey Burdock proposed uranium in-situ recovery mine, South Dakota, Johnson and others, USGS OFR

Geochemical data and mineralogy from rock cores at the Dewey Burdock proposed uranium in-situ recovery mine, South Dakota, Johnson and others, USGS OFR

Data requirements for reactive transport modeling at uranium in-situ recovery mines, Johnson and others, general “how-to” review article in a journal, for use by EPA, NRC and others.



Reactive transport modeling at the Dewey Burdock proposed uranium in-situ recovery mine, Johnson and others, journal article on details, results, interpretation of the reactive transport modeling.

#### Planned presentations

Note that titles and authorship are not finalized.

Mineralogy from the Dewey Burdock, proposed uranium in-situ recovery mine, Diehl, Benzel, Johnson, South Dakota Water Quality Conference in Fort Pierre, SD, March, 2012.

Using reactive transport modeling to predict groundwater quality after uranium in-situ recovery mining, Johnson, Morrison, Diehl, Benzel, South Dakota Water Quality Conference in Fort Pierre, SD, March, 2012.

Using reactive transport modeling to predict groundwater quality after uranium in-situ recovery mining, Johnson, Morrison, Diehl, Benzel, National Ground Water Association's Ground Water Summit, Garden Grove, CA, May, 2012.

We are hoping that Errol Lawrence, Petrotek, will give a presentation in either or both the above California and South Dakota meetings on the groundwater flow modeling that they have done at the Dewey Burdock site. In addition, some of the above presentations have the potential to be given at NRC's annual uranium recovery workshop given at the end of May in Denver each year (need to be invited).

Summary presentation by Ray Johnson at the EPA to complete EPA RARE grant requirements. Full title and date – to be determined.

USGS

Have Proposal?

Holm, Eric

**From:** Walsh, Brian  
**Sent:** Monday, May 10, 2010 4:59 PM  
**To:** Walsh, Brian; Brandner, Tom; Buhler, Ken; Cepak, Mike; Erbele, Garland; Filipovic, Dragan; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; Iles, Derric; Lees, Michael; Markley, Bill; Townsend, Bob  
**Subject:** FW: USGS Work Plan  
**Attachments:** R8UIC\_ISR\_FY10\_RARE\_Proposal.doc

FYI

-----Original Message-----

**From:** [Shea.Valois@epamail.epa.gov](mailto:Shea.Valois@epamail.epa.gov) [<mailto:Shea.Valois@epamail.epa.gov>]

**Sent:** Monday, May 10, 2010 4:51 PM

**To:** Walsh, Brian

**Subject:** Re: USGS Work Plan

Hi Brian,

Here is the proposal. The work plan hasn't been developed yet - the grant hasn't officially started.

(See attached file: R8UIC\_ISR\_FY10\_RARE\_Proposal.doc)

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Valois Shea  
US EPA Region 8  
8P-W-GW  
1595 Wynkoop Street  
Denver, CO 80202-1129  
phone: 303-312-6276  
fax: 303-312-6741

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| From: |

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|<[Brian.Walsh@state.sd.us](mailto:Brian.Walsh@state.sd.us)> |

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| To: |

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|Valois Shea/R8/USEPA/US@EPA |

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| Cc: |

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|<Brian.Walsh@state.sd.us> |  
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| Date: |  
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|05/10/2010 03:45 PM |  
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| Subject: |  
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|USGS Work Plan |  
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Hi Valois,

Is there a work plan for your contract with USGS to do the modeling work for the Dewey - Burdock project? If so, is there any chance we could see a copy before we meet next week? It might help us focus our comments for the USGS folks. Let me know.

Thanks,

=====  
Brian J. Walsh  
Hydrology Specialist  
SD DENR  
523 E. Capitol Ave.  
Pierre SD 57501  
605.773.6477  
(fax) 605.773.6035  
[Brian.Walsh@state.sd.us](mailto:Brian.Walsh@state.sd.us)  
=====



Region 8 UIC Program/Office of Research and Development  
FY2010 Regional Applied Research Effort Project Proposal

**Project Title:** Development of Hydrogeologic and Geochemical Modeling Methodologies for Characterization of Potential Groundwater Impacts from In-Situ Recovery of Uranium

<b>Regional Technical Contact:</b>	
Valois Shea, Groundwater Program, Office of Partnerships and Regulatory Assistance shea.valois@epa.gov (303) 312-6276	
<b>Supervisory signatures acknowledging that proposal topic is a priority area of research:</b>	
Sadie Hoskie, Director Water Program  _____ Signature	Debra H. Thomas, Deputy ARA Office of Partnerships and Regulatory Assistance  _____ Signature
<b>Region 8 Science Liaison:</b>	<b>ORD Project Office Principal Investigator:</b>
Patti Lynne Tyler  _____ Signature	Richard T. Wilkin, Ph.D. U.S. EPA National Risk Management Research Laboratory 919 Kerr Research Drive, Ada, OK 74820 wilkin.rick@epa.gov (580) 436-8874

**I. Abstract:**

The EPA Region 8 Underground Injection Control (UIC) Program has received a permit application for a proposed uranium in-situ recovery (ISR) mine site located approximately 65 miles southwest of Rapid City, South Dakota. This ISR injection project will be the first ever authorized directly by the EPA. The authorization will entail issuing a UIC permit for injection activity and an aquifer exemption to allow injected lixiviant to mobilize contaminants through the uranium-ore-bearing portions of the aquifer.

Previously permitted ISR uranium mine sites in Wyoming, Texas, and Nebraska are located in unpopulated areas where the ore-bearing aquifers are not being used as drinking water sources near the mine sites. Groundwater models of ISR projects to date are useful for large scale hydrologic and geochemical evaluations, but have not been called upon to provide detailed geochemical and hydrologic analysis simulating private well use near the aquifer exemption boundary during mining and restoration. There are private drinking water wells near the proposed aquifer exemption boundary of the proposed ISR site in South Dakota. Detailed analyses of fate and transport of the mobilized contaminants within and around the ore-bodies, and sensitivity analyses are needed to evaluate the impact of aquifer exemption boundary delineation on these drinking water wells during the uranium mining and post-mining groundwater restoration.

The UIC Program is tasked under the Safe Drinking Water Act (SDWA) with developing injection well permit requirements and aquifer exemption boundary delineations that are protective of underground sources of drinking water. The Region 8 UIC Program is seeking support from the EPA Office of Research and Development (ORD) and the U.S. Geological Survey (USGS) for the analysis of aquifer characterization and modeling methodologies and to develop a strategy to aid UIC permit writers with evaluation of permit application data and establishing sound, science-based, permit requirements.

**II. Background:**

A renewed interest in uranium mining has been motivated by a number of factors, including concern for America's energy security, an interest in developing energy resources that result in smaller carbon footprints, and the depletion of national uranium reserves. The resulting rise in uranium ore prices in the past few years has uranium mining companies re-evaluating uranium deposits originally characterized during the early 1980s as economically viable mining projects.

The ISR process involves the use of injection wells to introduce an oxidizing solution (lixiviant) into a uranium orebody located within a permeable sandstone confined aquifer. The lixiviant flows through the uranium deposit, dissolves the uranium, and transports it in solution to production wells that pump the uranium-bearing "pregnant" solution from the ground. In Region 8, the ore-bearing aquifers are usually of drinking water quality, except where ore bodies create localized contamination within the aquifer. The EPA will be tasked with issuing a UIC permit for injection activity and an aquifer exemption to allow lixiviant to mobilize contaminants regulated under the SDWA through the mined portion



of the aquifer. The aquifer exemptions will permanently exempt the mineable portion of the aquifer from protection as an underground source of drinking water under the SDWA.

Region 8 contains several potential uranium ISR prospects. The Region 8 UIC Program has received an ISR injection well permit for a proposed uranium mine site approximately 65 miles southeast of Rapid City, South Dakota, and anticipates receiving another permit application for a proposed site 70 miles northeast of Denver, Colorado before the end of 2010. The proposed South Dakota ISR project will be the first ever authorized directly by the EPA. These two proposed mine sites are located in areas that are more populated than previously permitted ISR uranium sites in Wyoming, Texas, and Nebraska. There are private drinking water wells located near the proposed aquifer exemption boundaries.

Although the ISR method of uranium mining has a less disruptive overall environmental impact compared to open-pit mining, this mining method significantly alters the groundwater chemistry and flow patterns during mining and the subsequent groundwater restoration process which, in theory, returns the mined aquifer to its pre-mining conditions. The USGS prepared a report for the United States Nuclear Regulatory Commission (NRC)<sup>1</sup> that discussed the modeling of groundwater flow, solute transport, and geochemical reactions associated with a particular ISR site in order to estimate costs for the groundwater restoration process after mining is completed. The report discusses groundwater-modeling techniques that are useful for mining companies and regulators to establish operating plans and permitting conditions for mining and groundwater restoration. While useful for large scale hydrogeologic and geochemical evaluations, groundwater models of ISR projects to date have not had to provide detailed analyses of geochemical and hydrologic impacts simulating of the private well use near the aquifer exemption boundary during mining and restoration.

Protecting both the water quality and production volume of private wells near the mining sites will depend on more detailed, site-specific evaluation of hydrologic characteristics of the mined aquifer, especially along boundaries of the permitted area. The South Dakota site is further complicated by the existence of abandoned, open-pit, uranium mines currently filled with water, and variability in the confining properties of the geologic unit above the ore-bearing aquifer. Determining the effects of these features will be critical for establishing permit requirements that will impose tight controls along the ISR perimeters. Proposed ISR uranium sites in Region 8 are generating a high level of concern and scrutiny from local residents, officials, and U.S. congressional representatives regarding groundwater contamination. Public concerns include: the potential for groundwater contamination; production volume loss in private drinking water wells; and the veracity and credibility of data and information supplied by the applicant.

### III. Research Objectives:

Hydrologic and geochemical modeling of the uranium ore-bearing aquifers will provide information to support the development of effective EPA permit requirements and aquifer exemption delineations. The results of this research effort will ensure that permit requirements and aquifer exemption decisions are based on sound science and are protective of underground sources of drinking water as mandated by the SDWA. These results will be achieved through the following objectives:

1. Development of a methodology to test and verify the soundness of applicant-submitted data and groundwater modeling results;
2. Characterization of site-specific hydrologic and geochemical impacts of lixiviant-aquifer interactions by conducting independent groundwater and geochemical modeling;
3. Development of an appropriate modeling strategy that can more fully answer questions regarding impact on nearby drinking water resources (contamination and availability) during ISR mining and restoration; and
4. Performance of sensitivity analyses to identify areas where tighter controls will be needed to protect private water wells near the ISR wellfields.

The project will provide information and methodologies for environmentally protective decision-making that will benefit the South Dakota Department of Environment and Natural Resources (DENR) agencies and NRC which are tasked with regulating different aspects of the overall uranium extraction project, including groundwater protection and

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<sup>1</sup> Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities. NUREG/CR-6870, January 2007. Prepared by J.A. Davis and G.P. Curtis, US Geologic Survey, A. Schwartzman, NRC Project Manager; for the Division of Fuel, Engineering and Radiological Research, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission.



restoration. The methodologies developed will be transferrable to other similar projects, benefitting other EPA Regions and state programs. These methodologies will provide ORD with another tool to assist other EPA Regions tasked with making similar regulatory decisions.

#### **IV. Research Approach:**

The mining company has generated a detailed three-dimensional geologic model of the proposed mine site, based on an extensive network of exploratory drill holes. This geologic information will serve as the framework for the aquifer model. The mining company has also conducted more than five quarters of water quality sampling to establish baseline data for the proposed mine site. Two aquifer tests have been conducted to provide preliminary aquifer characterization. USGS has committed to two months of preliminary modeling work before this research effort begins. This time will be used to set up the initial geochemical, geologic and aquifer property models that will support the work to be performed under this research project.

The first step of this project will involve a review by USGS to determine if the information provided by the mining company is adequate to support this research effort. This step will involve using data provided by the mining company to proceed with hydrologic and geochemical modeling to verify modeling results presented in the permit application. This step would determine whether actual site conditions are well understood and adequately characterized.

The second step will involve a more detailed analysis of area along the proposed aquifer exemption boundary where private drinking water wells are located adjacent to the mine site. The effects of injection and pumping wells will be added to the model to simulate the hydrologic impact of proposed well fields. Geologic anomalies, such as the abandoned surface mines and variability in the confining unit, will be investigated. Sensitivity analyses will be performed to determine the effects of pumping rate and injection pressure. Excursions detection and recovery will be simulated in conjunction with private well usage during the mining process. Modeling of more detailed areas will be conducted to identify and fine-tune those parameters that will have the greater effects on groundwater quality and quantity.

The third step will involve recording and documenting the aquifer characterization, geochemical, and hydrologic modeling methodologies in a draft report. The methodologies will be part of a written "how-to" strategy to aid UIC permit writers with evaluation of permit application data, what constitutes adequate modeling, and how different modeling outcomes affect permit requirements. In addition, this draft report will highlight modeling uncertainties and limitations due to such things as lack of data, inadequate parameter characterization, modeling code deficiencies, etc. Project results will generate science-based recommendations for the EPA to use in establishing protective operating and monitoring conditions in the permit. The project will also provide information for the NRC and South Dakota state agencies with the authority to establish the requirements for post-mining, groundwater restoration.

Once the EPA injection well permit is issued, the ISR well fields will be installed. The mining company will conduct more detailed, site-specific aquifer tests on the well fields. Information from these tests will be used to evaluate and calibrate the models developed. Once mining begins, additional aquifer characterization data will be generated to further evaluate and calibrate project models. A final report will be generated at end of the project summarizing the whole modeling effort and the effectiveness of permit requirements based on the earlier modeling work. In addition, the USGS will provide a longer-term follow up on model calibration and usefulness with the addition on any new company data beyond this initial project.

#### **V. Research Products:**

This research effort is expected to provide a significant body of information regarding the effects that ISR uranium mining will have on impacted aquifers. Highly transferrable aquifer evaluation methodologies will be developed that will benefit ORD, other EPA Regions, and state programs regulating similar sites. It will provide EPA, and other agencies, with a solid scientific basis for regulatory decision making for determining critical permitting requirements and for setting and evaluating groundwater restoration standards and goals. It also will provide information on subsurface hydrologic and geologic characteristics affecting subsurface flow of mineral-bearing fluids during both mining and groundwater restoration phases. Finally, the data gathered will support critical hydrologic modeling of groundwater flow from outside the mining area that is pulled in by the inward hydraulic gradient created during the mining and groundwater restoration phases of the operation. According to a report prepared for the NRC in January 2007<sup>1</sup>, groundwater restoration after mining is a substantial part of the operation, and dynamic modeling using reliable



Region 8 UIC Program/Office of Research and Development  
FY2010 Regional Applied Research Effort Project Proposal

data is critical to accurately modeling the groundwater system and achieving effective post-mining groundwater restoration.

ISR uranium mining requires significantly altering groundwater chemistry during mining in order to mine the ore body, and the long-term effects of significantly altering the geochemistry of a drinking water aquifer for the purpose of mobilizing uranium and other metals at ISR operations are not well established or understood, even when significant post-closure remediation has been undertaken. In particular, post-production restoration of the mining site is required to restore the groundwater quality to state and NRC standards; however, there is a lack of understanding about how successful restoration processes will be, and what will be the eventual long-term impacts to groundwater quality.

This project will provide a significant start for a longer term USGS project that will continue aquifer evaluation through post-mining groundwater restoration, while meeting the shorter term needs of EPA. EPA needs include an analysis of aquifer characterization and modeling methodologies, and the development of a strategy to aid UIC permit writers with evaluation of permit application data and establishing sound, science-based, permit requirements.

#### VI. Project Budget and Calendar:

By the start date of the project, USGS will have already created the basic design for the model based on an electronic three-dimensional geologic model provided by the mining company.

Date	Milestone
June 1, 2010	Begin loading model with geochemical and aquifer flow properties.
September 30, 2010	Completion of hydrologic and geochemical modeling to establish permit conditions.
October 31, 2010	Evaluation of methods and models used
December 15, 2010	Draft Report detailing site-specific findings, outlining methodologies and aquifer characterization strategies for permit writers.
after permit issuance	Mining company will install wellfields and conduct site-specific aquifer tests Evaluate and calibrate models with more detailed characterization data
wellfield mining commences	Evaluate and calibrate models with aquifer behavior data generated during the mining process
By 1 year after start of project	Final Modeling Methodology and Strategy Report that includes description of model development and calibration as more data becomes available

#### Participants and Region 8 Contacts:

The EPA Region 8 Lead Technical Contact, Valois Shea will:

- Be considered the primary contact and will administer grant requirements.
- Work closely with the ORD Principal Investigator, Richard T. Wilkin, Ph.D., to jointly manage the project mission, goals, and completion of research products.
- Solicit and provide principal project management of collaborative work with two research associates at USGS to ensure timely accomplishment of EPA objectives.

**Budget:** \$ 150,000

The project will require a year of funding so that baseline results and interpretations can be recalibrated as the mining project proceeds and new information becomes available. Salaries are mainly for USGS staff. Contracts include analytical support from ORD.

Categories	1 <sup>st</sup> Year
Salaries	\$100,000
Contracts	\$ 20,000
Travel	\$ 8,000
Materials and Supplies	\$ 12,000
Equipment	\$ 10,000
<b>Total</b>	<b>\$150,000.00</b>

## Cepak, Mike

---

**From:** Walsh, Brian  
**Sent:** Monday, August 16, 2010 9:27 AM  
**To:** Walsh, Brian; Brandner, Tom; Buhler, Ken; Cepak, Mike; Erbele, Garland; Filipovic, Dragan; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; Iles, Derric; Lees, Michael; Markley, Bill; Townsend, Bob  
**Subject:** FW: final Dewey Burdock QAPP  
**Attachments:** USGS DB RARE QAPP signature page.pdf; USGS DB RARE QAPP Final revision 0.doc

FYI

-----Original Message-----

**From:** Raymond H Johnson [<mailto:rhjohnso@usgs.gov>]  
**Sent:** Tuesday, August 10, 2010 5:05 PM  
**To:** "Rick Wilkin" <[wilkin.rick@epa.gov](mailto:wilkin.rick@epa.gov)/@usgs.gov>  
**Subject:** final Dewey Burdock QAPP

Hi all,

For your records, version 0.0 of the Dewey Burdock quality assurance plan. Document file and scanned signature page.

Ray

\*\*\*\*\*

Raymond H. Johnson, Ph.D.  
U.S. Geological Survey  
Crustal Imaging and Characterization Team  
Mail Stop 964D  
Denver Federal Center  
P. O. Box 25046  
Denver, CO 80225-0046

Phone: 303-236-1885  
Fax: 303-236-3200  
E-mail: [rhjohnso@usgs.gov](mailto:rhjohnso@usgs.gov)  
\*\*\*\*\*



Holm, Eric

---

**From:** Walsh, Brian  
**Sent:** Monday, August 16, 2010 9:27 AM  
**To:** Walsh, Brian; Brandner, Tom; Buhler, Ken; Cepak, Mike; Erbele, Garland; Filipovic, Dragan; Hamann, Sheldon; Hicks, Matt; Holm, Eric; Hudson, Roberta; Iles, Derric; Lees, Michael; Markley, Bill; Townsend, Bob  
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**Subject:** final Dewey Burdock QAPP

Hi all,

For your records, version 0.0 of the Dewey Burdock quality assurance plan. Document file and scanned signature page.

Ray

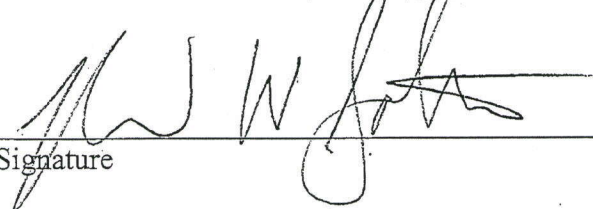
\*\*\*\*\*  
Raymond H. Johnson, Ph.D.  
U.S. Geological Survey  
Crustal Imaging and Characterization Team  
Mail Stop 964D  
Denver Federal Center  
P. O. Box 25046  
Denver, CO 80225-0046

Phone: 303-236-1885  
Fax: 303-236-3200  
E-mail: [rhjohnso@usgs.gov](mailto:rhjohnso@usgs.gov)  
\*\*\*\*\*

## Section A. Project Management

### A.1 Approval Sheet

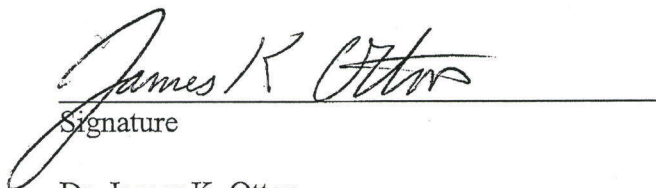
Organization: U.S. Geological Survey Geologic Discipline  
Crustal Geophysics and Geochemistry Science Center

  
Signature

8/10/10  
Date

Dr. Richard Saltus acting for Dr. James G. Crock  
Associate Science Center Director  
USGS Geologic Discipline  
Crustal Geophysics and Geochemistry Science Center

Organization: U.S. Geological Survey Geologic Discipline  
Central Energy Resources Science Center

  
Signature

8/10/10  
Date

Dr. James K. Otton  
Uranium Resource Specialist  
USGS Geologic Discipline  
Central Energy Resources Science Center

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 2 of 22

**U. S. Geological Survey**  
**Quality Assurance Project Plan**  
**for the Development of a Hydrogeologic and Geochemical**  
**Model of Potential Groundwater Impacts from**  
**In-Situ Recovery of Uranium at the Dewey-Burdock Site**  
**July 1, 2010**

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 1 of 1

## Section A. Project Management

### A.1 Approval Sheet

Organization: U.S. Geological Survey Geologic Discipline  
Crustal Geophysics and Geochemistry Science Center

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

Dr. Richard Saltus acting for Dr. James G. Crock  
Associate Science Center Director  
USGS Geologic Discipline  
Crustal Geophysics and Geochemistry Science Center

Organization: U.S. Geological Survey Geologic Discipline  
Central Energy Resources Science Center

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

Dr. James K. Otton  
Uranium Resource Specialist  
USGS Geologic Discipline  
Central Energy Resources Science Center

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 2 of 2



## A.2 Table of Contents

Section A. Project Management	
A.1	Approval Sheet.....2
A.2	Table of Contents.....3
A.3	Distribution List.....4
A.4	Project/Task Organization.....5
A.5	Problem Definition/Background.....6
A.6	Project Description/Schedule.....8
A.7	Quality Objectives and Criteria for Measurement Data. . . . .9
A.7.1	Quality Objectives and Criteria for Model Development..... 10
A.7.2	Quality Objectives and Criteria for Secondary Data.....12
A.7.3	Quality Objectives and Criteria for Primary Data Acquisition.... 12
A.8	Special Training Requirements/Certification.....13
A.9	Documentation and Records.....13
Section B. Measurements and Data Acquisition.....14	
B.1	Sampling process Design.....14
B.2	Sampling Methods.....14
B.3	Sample Handling and Custody.....15
B.4	Analytical Methods.....15
B.5	Quality Control.....15
B.6	Instrument/Equipment Testing, Inspection, and Maintenance.....15
B.7	Calibration and Frequency.....15
B.7.1	Calibration of Field Sampling and Analytical Laboratory Equipment for Primary Data Collection.....15
B.7.2	Model Calibration .....16
B.8	Inspection Acceptance of Supplies and Consumables.....16
B.9	Non-Direct Measurements.....16
B.10	Data Management and Hardware/Software Configuration.....16
B.10.1	Data Management.....17
B.10.2	Hardware/Software Configuration.....17
Section C. Assessment and Oversight.....17	
C.1	Assessment and Response Actions.....17
C.1.1	Assessment and Response Actions for Modeling Results.....17
C.1.2	Assessment and Response Actions for the Use of Secondary Data.....19
C.1.3	Assessment and Response Actions for Primary Data Collection.....19
C.2	Reports.....19
Section D. Data Validation and Usability.....20	
D.1	Data Review, Verification, and Validation.....20
D.2	Verification and Validation Methods..... 21
D.3	Reconciliation with User Requirements.....21
References.....22	

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 3 of 3

### A.3 Distribution List

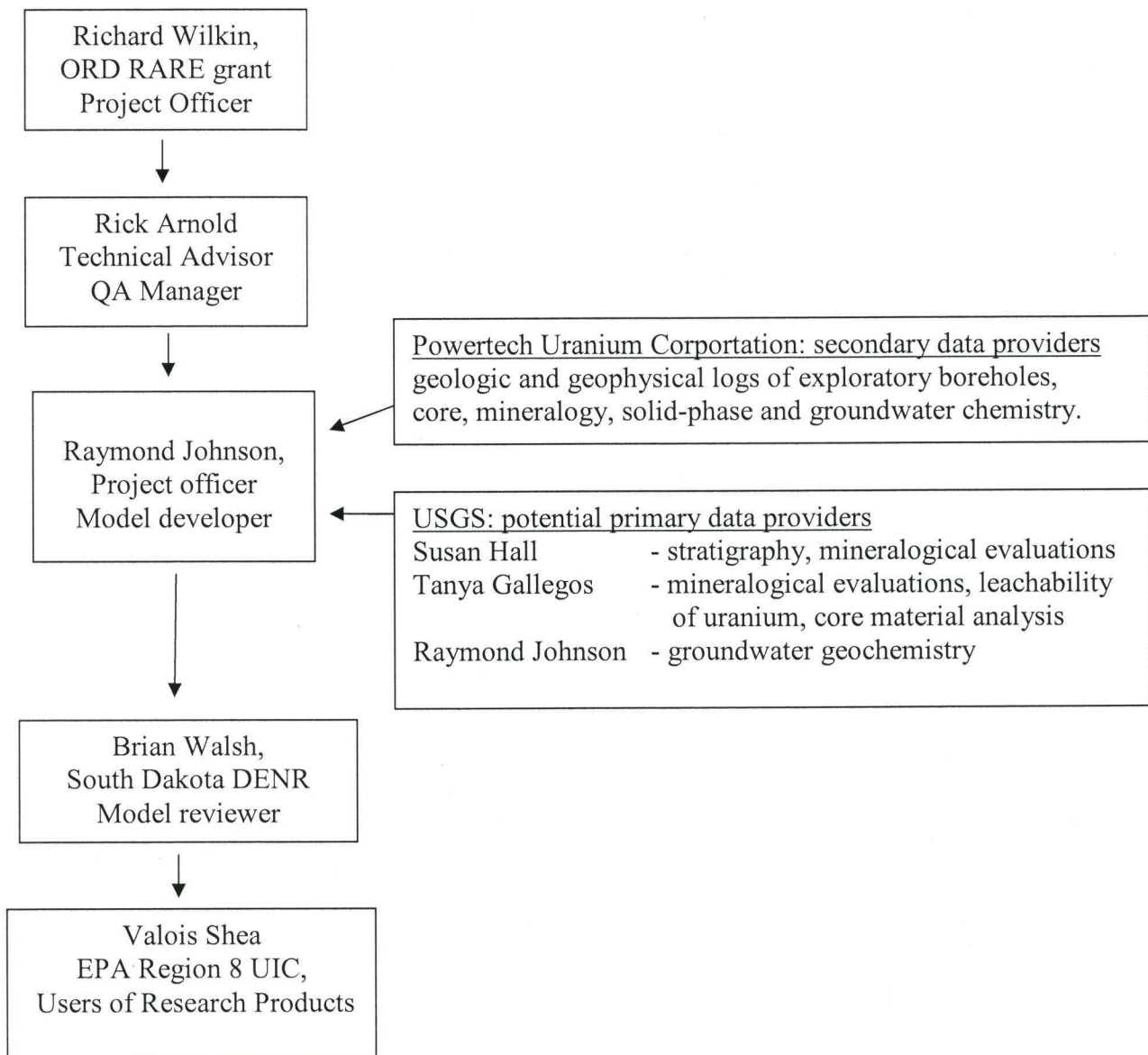
This document, and any subsequent updates, will be distributed to the following list of people:

Name	email	Organization Code
Richard Wilkin	<a href="mailto:wilkin.rick@epa.gov">wilkin.rick@epa.gov</a>	US EPA ORD
James Otton	<a href="mailto:jkotton@usgs.gov">jkotton@usgs.gov</a>	USGS Energy
Raymond Johnson	<a href="mailto:rhjohnso@usgs.gov">rhjohnso@usgs.gov</a>	USGS Crustal
James Crock	<a href="mailto:jcrock@usgs.gov">jcrock@usgs.gov</a>	USGS Crustal
Susan Hall	<a href="mailto:susanhall@usgs.gov">susanhall@usgs.gov</a>	USGS Energy
Tanya Gallegos	<a href="mailto:tgalligos@usgs.gov">tgalligos@usgs.gov</a>	USGS Energy
L. Rick Arnold	<a href="mailto:lrarnold@usgs.gov">lrarnold@usgs.gov</a>	USGS WRD
Brian Walsh	<a href="mailto:Brian.Walsh@state.sd.us">Brian.Walsh@state.sd.us</a>	South Dakota DENR
Valois Shea	<a href="mailto:shea.valois@epa.gov">shea.valois@epa.gov</a>	US EPA Region 8

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 4 of 4

#### A.4 Project/Task Organization

This project is being conducted by the U.S. Geological Survey (USGS) under a Regional Applied Research Effort (RARE) grant administered through an Interagency Agreement (IAG) by the Environmental Protection Agency (EPA) Office of Research and Development (ORD). Richard Wilkin is the project officer for the ORD IAG. In the USGS, the project officer and model developer is Raymond Johnson and Rick Arnold will be the quality assurance (QA) manager. Since the project site is in South Dakota, the South Dakota Department of Environment and Natural Resources will be continually updated on project status and provide input and reviews of the modeling efforts. Valois Shea is the EPA Region 8 Technical Project Officer as one of the end users of the research product.



USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 5 of 5



Raymond Johnson will be responsible for maintaining the official, approved QA Project Plan. He will determine when changes in the project trigger an update of the QA Project Plan. He will be responsible for updating the QA Project Plan, routing the updated plan through USGS review and approval, and distributing the updated, approved plan to the individuals identified in the distribution list.

## **A.5 Problem Definition/Background**

The recent rise in uranium ore prices in the past few years has resulted in renewed interest in uranium mining. Uranium mining companies are re-evaluating uranium deposits originally characterized during the 1970s and early 1980s as economically viable. The Dewey Burdock uranium project site, located approximately 65 miles southeast of Rapid City, South Dakota, is one of the areas being considered for in-situ recovery (ISR) of uranium. The Environmental Protection Agency (EPA) Region 8 Underground Injection Control (UIC) Program has received an injection well application from Powertech Uranium Corporation (Powertech) for ISR mining of uranium at the project site.

The ISR process involves the use of injection wells to introduce an oxidizing solution (lixiviant) into a uranium orebody located within a permeable sandstone confined aquifer. The lixiviant flows through the uranium deposit, dissolves the uranium, and transports it in solution to production wells that pump the uranium-bearing “pregnant” solution from the ground. In Region 8, the ore-bearing aquifers are often of drinking water quality, except where ore bodies create localized contamination within the aquifer. The EPA will be tasked with issuing a UIC permit for injection activity and an aquifer exemption to allow lixiviant to mobilize contaminants regulated under the Safe Drinking Water Act (SDWA) through the mined portion of the aquifer. The aquifer exemptions will permanently exempt the mineable portion of the aquifer from protection as an underground source of drinking water under the SDWA. The proposed Dewey Burdock ISR project will be the first uranium ISR site administered by EPA Region 8 for permitting.

Although the ISR method of uranium mining has a less disruptive overall environmental impact compared to open-pit mining, this mining method significantly alters the groundwater chemistry and flow patterns during mining. The subsequent groundwater restoration process, in theory, returns the mined aquifer to its pre-mining conditions. The USGS prepared a report for the United States Nuclear Regulatory Commission (NRC)<sup>1</sup>

---

<sup>1</sup> Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities. NUREG/CR-6870, January 2007. Prepared by J.A. Davis and G.P. Curtis, US Geologic Survey, A. Schwartzman, NRC Project Manager; for the Division of Fuel, Engineering and Radiological Research, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission.

that discussed the modeling of groundwater flow, solute transport, and geochemical reactions associated with uranium ISR mining in order to estimate costs for the groundwater restoration process after mining is completed. This report discusses geochemical modeling techniques that are useful for mining companies and regulators to establish operating plans and permitting conditions for mining and groundwater restoration. While this report is useful for generic hydrogeologic and geochemical evaluations, groundwater and geochemical models of ISR projects to date have not had to provide detailed analyses of potential future geochemical and hydrologic impacts of private well use near the aquifer exemption boundary during and after mining and restoration.

The Dewey Burdock ISR uranium site is generating a high level of concern and scrutiny from local residents, officials, and U.S. congressional representatives regarding the potential for groundwater contamination. Modeling the potential for future groundwater impacts at the proposed Dewey-Burdock ISR site is the goal of this project. Permit requirements will need to be developed to protect both the water quality and production volume of private wells near the mining sites. Detailed, site-specific evaluation of hydrologic characteristics of the mined aquifer, especially along boundaries of the permitted area, will help identify the level of protection the permit will need to provide. The subsequent groundwater restoration process, in theory, returns the mined aquifer to its pre-mining conditions. However, identifying the extent and duration of contaminant migration during and after groundwater restoration will provide science-based criteria for establishing a boundary for aquifer exemption area surrounding the wellfields.

The South Dakota site is further complicated by the existence of abandoned, open-pit, uranium mines currently filled with water, and variability in the confining properties of the geologic unit above the ore-bearing aquifer. Determining the effects of these features will be critical for establishing permit requirements and additional data collection may be required.

This research proposes strategies for addressing the following questions:

1. How well do identified aquitards limit groundwater flow between aquifers?
2. What is the groundwater quality at the end of mining after restoration efforts are complete?
3. What is the long-term fate and transport of any groundwater contaminants away from the mined zone?

In order to address these questions, a number of steps will be taken to determine how surrounding groundwater quality may or may not be affected by ISR uranium recovery. First, understanding the basic hydrogeologic and geochemical system is critical. Second, predictive modeling using reactive transport simulations can be used to simulate future groundwater conditions (during mining and post-restoration). Third, predictive modeling can be used to evaluate how well surrounding groundwater quality is protected under the proposed mine plan design and to evaluate possible design alternatives. Fourth, model

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 7 of 7



shortcomings should be evaluated to provide a reasonable range of prediction uncertainties. The goal of this research is to provide strategies for better understanding the most probable fate and transport of uranium and other constituents during and after ISR operations. This information will assist mining companies, permitting agencies, and local groundwater users in making more informed decisions on final mine designs/operations and closure strategies that maximize protection of groundwater quality.

#### **A.6 Project Description/Schedule**

Powertech, the mining company for the Dewey Burdock site, has generated a geologic model of the proposed mine site, based on an extensive network of exploratory drill holes. This geologic information will serve as the framework for any hydrogeologic simulations. Powertech has also conducted more than five quarters of water quality sampling to establish baseline data for the proposed mine site. In addition, two aquifer pumping tests have been conducted to provide preliminary aquifer characterization.

The first step of this project will involve a review by USGS to determine if the information provided by Powertech is adequate to support this research effort. This step will involve using data provided by Powertech (defined as secondary data) to proceed with hydrologic and geochemical modeling to verify what is presented in the permit application. This step will determine whether actual site conditions are well understood and adequately characterized.

The second step will involve a more detailed analysis of the area along the proposed aquifer exemption boundary where private drinking water wells are located adjacent to the mine site. The effects of injection and pumping wells will be added to the model to simulate the hydrologic impact of the proposed well fields. Geologic anomalies, such as the abandoned surface mines and variability in the confining unit, will be investigated. Sensitivity analyses will be performed to determine the effects of pumping rate and injection pressure. Excursions detection and recovery will be simulated in conjunction with private well usage during the mining process. Modeling of more detailed areas will be conducted to identify and fine-tune those parameters that will have the greatest effects on groundwater quality and quantity. Part of this second step will include the evaluation of additional data needs. If the research indicates that additional data (i.e., mineralogy, groundwater geochemistry, hydraulic heads, etc.) will greatly improve model predictions, work may be conducted by Powertech and/or the USGS to obtain these data (covered by a separate cooperative research agreement between Powertech and the USGS).

The third step will involve recording and documenting the aquifer characterization, and the geochemical and hydrologic modeling methodologies in draft reports. One report will discuss the groundwater flow and geochemical modeling development and results. In addition, this report will highlight modeling uncertainties and limitations due to such things such as lack of data, inadequate parameter characterization, modeling code

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 8 of 8



deficiencies, etc. Any new data collection (if completed) will be published in a separate report such as a USGS Open-File Report. The second report will discuss the overall methodologies in more detail and will be part of a written “how-to” strategy to aid UIC permit writers with evaluation of permit application data, what constitutes adequate modeling, and how different modeling outcomes affect permit requirements. Project results will generate science-based recommendations for the EPA to use in establishing protective operating and monitoring conditions in future permits. The project will also provide information for the Nuclear Regulatory Commission (NRC) and South Dakota state agencies with the authority to establish the requirements for post-mining, groundwater restoration.

The fourth step will involve future monitoring, additional data collection, and model calibration during and after any mining operations. This effort may require additional funding beyond the current research effort, but is included here as potential longer-term collaborative research by the EPA and USGS. Such an effort would provide significant post-model development evaluation and recalibration.

Table 1 shows the anticipated schedule for project milestones.

**Table 1. Anticipated schedule for project milestones.**

Date	Milestone
July 1, 2010	Step 1: Begin detailed review of available data.
December 30, 2010	Step 2: Initial groundwater flow and geochemical model development with associated report.
On-going	Step 2: Evaluate additional data needs
On-going as needed	Step 2: Additional data collection
July 1, 2011	Step 3: Draft groundwater flow and geochemical model with an associated report that includes any new data (in review, final report within 6 months).
July 1, 2011	Step 3: Draft report detailing site-specific findings, outlining methodologies and aquifer characterization strategies for permit writers (in review, final report within 6 months).
After permit issuance (if issued)	Step 4: Mining company will install wellfields and conduct site-specific aquifer tests. Evaluate and calibrate models with more detailed characterization data.
Mining commences	Evaluate and calibrate models with aquifer behavior data generated during the mining process.
Post-restoration	Evaluate and calibrate models with aquifer behavior data generated during and after the restoration process.

#### **A.7 Quality Objectives and Criteria for Measurement Data**

This project involves the use of both primary and secondary data for use as model inputs, in addition to model development. Secondary data will be provided by Powertech;

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 9 of 9

primary data will be collected by USGS. This section addresses the quality objectives and criteria for model development, the use of secondary data, and the acquisition of primary data.

#### **A.7.1 Quality Objectives and Criteria for Model Development**

The main objective for this project is to provide a predictive model that describes the groundwater flow and geochemical changes along with longer-term transport of dissolved constituents during and after the uranium ISR mining process.

Powertech, the mining company for the Dewey Burdock site, has generated a geologic model of the proposed mine site, based on an extensive network of exploratory drill holes. This geologic information will serve as the framework for the aquifer model. Powertech also has groundwater geochemistry and solid-phase geochemistry data available. An evaluation of these data will be completed in order to determine any additional data requirements. Lack of data may influence prediction uncertainties during modeling. These uncertainties will be evaluated and provided in appropriate reports.

Hydro GeoBuilder (by Schlumberger Water Services, Inc.) will be used to create the conceptual model based on geophysical logs from the exploratory drill holes. This software will be used to build the stratigraphic layering to represent the stratigraphy at the mine site, which will be evaluated independently from Powertech's interpretations, but will rely on the original well logs. Hydro GeoBuilder links directly with Visual MODFLOW Pro (also by Schlumberger Water Services, Inc.) which will be used to assign the grid cells for developing a MODFLOW simulation. Subsequent dissolved constituent transport is simulated within Visual MODFLOW using MT3DMS and reactive transport using PHT3D (which couples MODFLOW and PHREEQC). A summary with references for these models is as follows:

Hydro GeoBuilder – graphical interface for 3D visualization of geologic logs and provides conceptual model input into Visual MODFLOW  
(<http://www.swstechnology.com/groundwater-software/groundwater-data-visualization/hydro-geobuilder>).

Visual MODFLOW Pro – graphical interface that will run MODFLOW, MT3DMS, and PHT3D (website). This program provides easy input of parameters, visualization in three dimensions, and post-processing display (<http://www.swstechnology.com/groundwater-software/groundwater-modeling/visual-modflow-pro>).

MODFLOW – finite difference groundwater flow code  
(<http://water.usgs.gov/nrp/gwsoftware/modflow.html>).



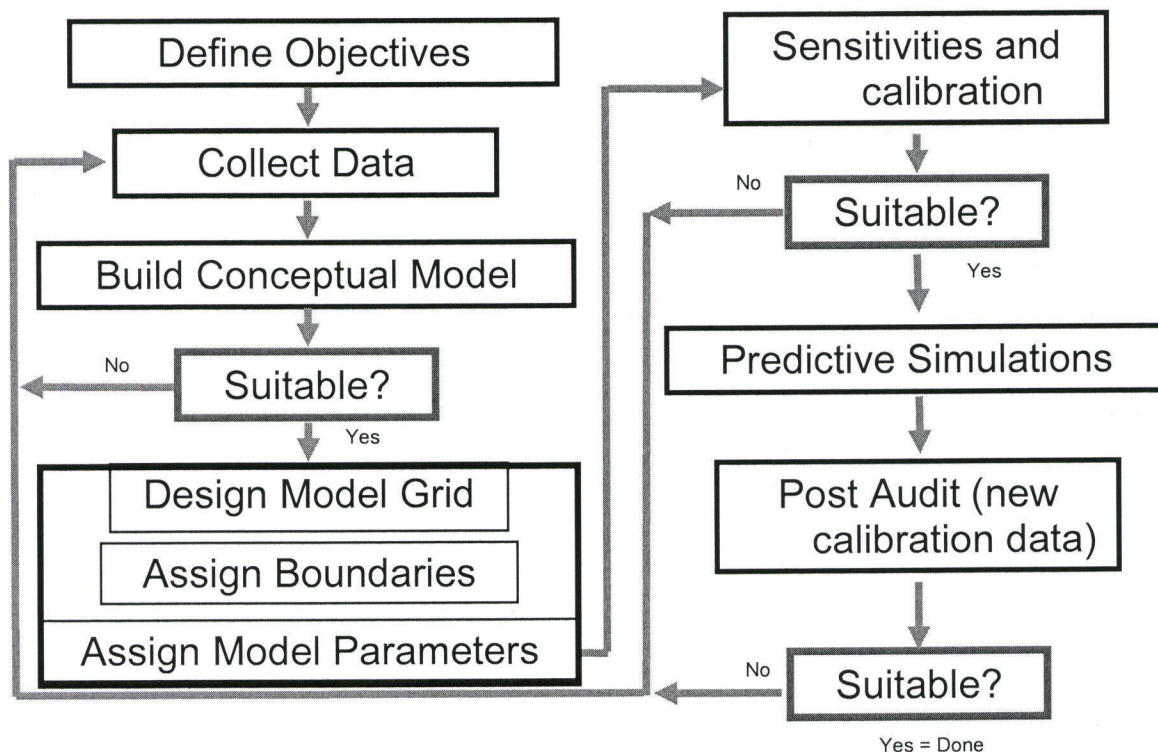
MT3DMS – contaminant transport modeling code that simulates advection and dispersion (<http://hydro.geo.ua.edu/mt3d>).

PHREEQC – geochemical modeling code that simulates reactions between groundwater and solid-phase mineralogy ([http://wwwbrr.cr.usgs.gov/projects/GWC\\_coupled/phreeqc](http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc)).

PHT3D – reactive transport code that links MODFLOW and PHREEQC. This code simulates the reactions at each time step in each cell using PHREEQC, transports groundwater to the next cell with the next time step and then repeats the process (solid-phase geochemical changes are also included) <http://www.pht3d.org/>.

A generalized modeling flowchart is shown below. During conceptual model development, multiple conceptual models may be used. Such a procedure will assist in understanding model uncertainty. For example, at the Dewey-Burdock site, the nature and competence of the confining layer (Fuson Shale) is somewhat uncertain and may need to be simulated with different hydraulic conductivities and different thickness configurations. This approach is necessary in order to understand how these differences may or may not influence groundwater flow and reactive transport.

## Modeling Flowchart



USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 11 of 11



The final outcome of this project is to report modeling efforts in terms of required modeling steps, methodologies to evaluate data requirements, and evaluations of how lack of data can influence predictive uncertainties.

#### **A.7.2 Quality Objectives and Criteria for Secondary Data**

Secondary data that will be provided by Powertech for use as model input includes:

- geologic and geophysical logs of exploratory boreholes,
- core,
- ore analysis, and
- groundwater chemistry.

USGS will analyze and evaluate the geologic and geophysical logs of exploratory boreholes data for identification and stratigraphic correlation of ore-bearing sandstone units from borehole to borehole. Impermeable confinement zones above and below the ore-bearing units will also be identified and correlated across boreholes. This independent analysis by USGS will help to verify Powertech's interpretation of the same information.

Original core material may be provided by Powertech for USGS evaluation to compare lithologic and electronic well logs against core as a "spot check" evaluation of Powertech's interpretive identification of stratigraphic units against observed stratigraphy in core material. Chemical analysis of core material and groundwater geochemistry may also be provided by Powertech. These analyses will be used to determine redox conditions, solid phase mineralogy, and trace element analysis in the ore-bearing zone for use as model input.

#### **A.7.3 Quality Objectives and Criteria for Primary Data Acquisition**

USGS anticipates the need for the following types of primary data collection:

- whole rock geochemistry
- mineralogy,
- X-ray diffraction analysis

USGS anticipates the need to collect groundwater samples for analysis using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for the following parameters:

- metals, and
- iron pairs.

The following parameters may be measured in the field:

- pH,
- O<sub>2</sub>,
- conductivity, and
- alkalinity.

At this time, an evaluation of existing data has not been completed, so site-specific sampling listed above is a general guideline. Once an evaluation of existing data is complete, a site-specific Sampling and Analysis Plan (SAP) will be developed for each field sampling event that will cover the specific quality assurance elements applicable to the sampling event.

#### **A.8 Special Training Requirements/Certification**

For the successful completion of this project, the model developer must have specialized understanding of and training in groundwater flow and geochemical modeling. This experience is provided by Raymond H. Johnson (Ph.D.). He has experience in understanding and modeling the geochemistry and groundwater flow in a variety of settings, including areas with past and current mining.

#### **A.9 Documentation and Records**

This research effort is expected to provide a significant body of information regarding the effects that ISR of uranium may have on surrounding aquifers. Highly transferrable aquifer evaluation methodologies will be developed that will benefit ORD, other EPA Regions, and state programs regulating similar sites. It will provide EPA, and other agencies, with a solid scientific basis for regulatory decision making for determining critical permitting requirements and for setting and evaluating groundwater restoration standards and goals. It also will provide information on subsurface hydrologic and geologic characteristics affecting subsurface flow of mineral-bearing fluids during both mining and groundwater restoration phases. Finally, the data gathered will support critical hydrologic modeling of groundwater flow from outside the mining area that is pulled in by the inward hydraulic gradient created during the mining and groundwater restoration phases of the operation.

Records include:

The QAPP

Monthly reports to ORD

Documentation of all modeling procedures

USGS primary data collection

Powertech secondary data

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 13 of 13



The QAPP will be updated as changes are identified. A new version will be emailed to everyone on the distribution list. Version control will be maintained. All of these efforts will be managed by Raymond Johnson.

Monthly reports will be provided by Raymond Johnson to the Project Officer for the interagency agreement at the EPA ORD( Rick Wilkin), with copies sent to the EPA Region 8 technical project officer (Valois Shea). Everyone else on the distribution list at the front of this document will also be given copies of the monthly reports.

All modeling procedures will be documented by Raymond Johnson in electronic files which will be used to create final reports by the USGS for public release.

Any primary data collection results will be filed as electronic and printed files in the office of Raymond Johnson. These data will also be released as USGS Open-File Reports (OFR) or other publications as a public data release.

Any Powertech secondary data may also be released and used by the USGS, but are subject to a Powertech – USGS cooperative research and development agreement (CRADA) that protects proprietary information. The majority of the Powertech data will already be publicly available. Raymond Johnson will keep a detailed log of the status of Powertech data (i.e., already public, good for OFR release, or propriety information). All data copies will be filed in the office of Raymond Johnson.

## **Section B. Measurements and Data Acquisition**

This project involves the use of both primary and secondary data for use as model inputs, in addition to model development. Secondary data will be provided by Powertech and primary data will be collected by USGS. USGS will evaluate the secondary data to determine the need for the collection of primary data, as discussed under Sections A.6 and A.7. If USGS determines that primary data collection is needed, then the following data elements will be discussed in a site-specific SAP. As discussed in Section A.7.3, site-specific SAPs will not be developed until the secondary data has been fully evaluated.

### **B.1 Sampling process Design**

Sample collection locations and types of samples to be collected will be described in the site-specific SAP for any sampling events.

### **B.2 Sampling Methods**

Sampling methods, field parameters, and field sampling protocols and standard operating procedures will be described in the site-specific SAP for any sampling events.

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 14 of 14



### **B.3 Sample Handling and Custody**

Sample handling, sample labels, and chain of custody procedures and forms will be described in the site-specific SAP for any sampling events.

### **B.4 Analytical Methods**

Analytical methods for each type of sample to be collected will be described in the site-specific SAP for any sampling events.

### **B.5 Quality Control**

Types and frequency of quality control samples will be described in the site-specific SAP for any sampling events.

### **B.6 Instrument/Equipment Testing, Inspection, and Maintenance**

Procedures for testing, inspection, and maintenance of instruments and equipment required during the field sampling event will be described in the site-specific SAP for any sampling events.

### **B.7 Calibration and Frequency**

Two types of calibration will be required during the execution of this project:

1. calibration procedures related to the collection of primary data and
2. model calibration.

#### **B.7.1 Calibration of Field Sampling and Analytical Laboratory Equipment for Primary Data Collection**

Procedures for calibration of instruments and equipment required during the field sampling event will be described in the site-specific SAP for any sampling events. Generally all field equipment (pH, conductivity, dissolved oxygen meters, etc.) will be checked for calibration two times a day or checked at additional times if deemed necessary.

Procedures for calibration of analytical instruments will be maintained by the laboratory performing the analyses of samples. USGS will submit duplicate and blank samples during sample submittal to assure the accuracy and precision of field and analytical procedures. Additional internal samples may be used by the laboratory during sample processing for internal quality assurance/quality control procedures. The number and type of quality control samples used by the laboratory, and the analytical results of these quality control samples, will be included in the data package and reviewed by USGS. If

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 15 of 15

USGS identifies any problems during this review, a copy of the laboratory's Quality Management Plan for review and/or Standard Operating Procedures for the analytical methods in question may be requested.

#### **B.7.2 Model Calibration**

All groundwater flow and geochemical models developed will be calibrated to the maximum extent based on available data. This will include plots that show the match between observed and simulated hydraulic heads and geochemical data. Inverse modeling (automated calibration) will be used to the maximum extent that is possible using such codes as UCODE

(<http://igwmc.mines.edu/freeware/ucode/?CMSPAGE=igwmc/freeware/ucode>), PEST ([http://www.scientificsoftwaregroup.com/pages/detailed\\_description.php?products\\_id=82](http://www.scientificsoftwaregroup.com/pages/detailed_description.php?products_id=82)), or inversion routines already available in MODFLOW. Additional calibration and model adjustment may be completed if the ISR well field is installed and additional data becomes available. In addition, the USGS may be able to provide a longer-term follow up on model calibration and usefulness with the addition on any new company data beyond this initial project.

#### **B.8 Inspection Acceptance of Supplies and Consumables**

This section is not applicable to this project.

#### **B.9 Non-Direct Measurements**

"Non-direct" measurements refer to data and other information that have been previously collected or generated under some effort outside the specific project being addressed by the QA Project Plan. Frequently, using existing data rather than generating new data is sufficient to meet the needs of some phases of a modeling project. Because the data have already been collected and therefore, the needs of the project cannot influence how these measurements were generated, these data need special consideration. A list of non-direct measurements that may be used for this project is included under section A.7.2 Quality Objectives and Criteria for Secondary Data. During the initial review of any pre-existing data (non-direct measurements), the USGS will evaluate the quality of these data. Any ground truthing of geophysical logs will be investigated and any quality assurance/quality control samples provided with geochemical data (water or solid-phase) will be evaluated and documented.

#### **B.10 Data Management and Hardware/Software Configuration**

This element is divided into the 2 sections listed below.

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 16 of 16



### **B.10.1 Data Management**

An electronic file will be maintained by Raymond Johnson on all the types of data used for this project. This file will indicate the data types, data origin, any intermediate data manipulation (i.e., lab data entered into a spreadsheet), and final data reporting.

### **B.10.2 Hardware/Software Configuration**

A high-end standard desktop computer with Microsoft Excel and Access, along with the software listed in A.7.1 is all that is required for this project.

## **Section C. Assessment and Oversight**

### **C.1 Assessment and Response Actions**

This project involves the use of both primary and secondary data for use as model inputs, in addition to model development. Secondary data will be provided by Powertech; primary data will be collected by USGS. This section addresses the assessment and response actions for model development, the use of secondary data, and the acquisition of primary data.

#### **C.1.1 Assessment and Response Actions for Modeling Results**

Internal assessments of modeling procedures and products will be done by the USGS QA Officer as part of the monthly project reports. External assessments of the project will be done via a quarterly meeting (in person or conference call) with South Dakota DENR staff. This quarterly assessment will also provide the SD DENR staff with a project update. SD DENR will also receive the monthly progress reports.

- **Quantitative Assessments:** The uncertainty in some sources—such as some model parameters and some input data—can be estimated through quantitative assessments involving statistical uncertainty and sensitivity analyses. Sensitivity analyses will be completed using the software and procedures discussed in Section B.7.2 for Model Calibration. An assessment of the thermodynamic databases being used in the geochemical models will also be evaluated via a literature review and potentially with new laboratory measurements, if necessary.
- **Qualitative Assessments:** Some of the uncertainty in model predictions may arise from sources whose uncertainty cannot be easily quantified, such as varying conceptual models, which may include different hydraulic conductivity zonations. These various conceptual models will be evaluated and sensitivities to model output will be reported.

The purpose of the quantitative and qualitative assessment listed above is to evaluate all the sources of model uncertainty. In some cases, unacceptable levels of uncertainty will

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 17 of 17



require additional data collection, with an associate SAP that describes in detail the reason for the additional data collection and the planning procedures.

• **Model Performance Evaluations:** Model performance evaluations are conducted to answer the question, “Does the model perform the required task while meeting the quality objectives?” Such evaluations include the following:

- Model theory assessments: all of the models being used for this project use highly accepted hydrogeologic and geochemical theory.
- Model algorithm assessments: all of the models and software being used for this project have been thoroughly tested and evaluated by peer review.
- Data acquisition assessments will assess the quality of non-direct measurements using secondary data as specified in the QA Project Plan [Element B9 (Non-direct Measurements)];
- Model calibration studies will be completed to quantitatively assess the uncertainty and suitability of data used to develop values of model parameters and the amount of discrepancy between model predictions and appropriate, measured field or laboratory data [Element B7 (Calibration)];
- Sensitivity analyses will be completed to identify the key model input parameters;
- Uncertainty analyses will assess the range of predicted values from the model that could occur because of the uncertainty of model components, assumptions and input data, or the uncertainty over space and time of the value of some model parameters;
- Data quality assessments will assess whether (1) the model input data have the precision and accuracy needed and satisfy all assumptions needed for use in the model, and (2) the variability and/or uncertainty of initial model outputs achieve the specified Data Quality Objectives (decision performance criteria) and model performance criteria specified in Element A7 (Quality Objectives and Criteria for Model Inputs/Outputs of the QA Project Plan);
- Model evaluations (or verification tests) will not be necessary as all the models being used have published literature verifying model results with laboratory tests, field data, analytical solutions, synthetic test data sets, or other well-accepted models.
- Internal peer review will be completed within the USGS before any reports are published and the QA Manager will oversee and comment on any performance issues. Additional reviews and consultation on modeling efforts will be provided by an external review by the South Dakota DENR (Brian Walsh). These experts will be involved in reviewing the model development, code preparation and use, model application, and results. A qualified hydrogeologist at EPA Region 8 (Andrew Schmidt) will be consulted on an as needed basis and will be provided with quarterly updates/presentations, but will not be directly involved in the project.

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 18 of 18

### **C.1.2 Assessment and Response Actions for the Use of Secondary Data**

Evaluation of secondary data will include a review of precision, accuracy, completeness, and representativeness to determine additional data needs to be collected at the site for model input. Detection limits for analytical methods used will be evaluated to determine if the precision is adequate for model input. Accuracy will be determined by an evaluation of comparability of geologic units and analytical results from borehole to borehole. Completeness of data will be determined by an evaluation of spatial distance from borehole to borehole, core availability, and analytes of interest. If USGS determines that data provided by Powertech is not complete enough to provide adequate model input to meet the data quality objectives, then USGS may collect additional data.

### **C.1.3 Assessment and Response Actions for Primary Data Collection**

The field measurements, field notes, and reports of analytical results provided from analytical laboratories will be reviewed to identify any unusual circumstances that would cause the data to be flagged or qualified as to any limitation of the use of the data. These unusual circumstances will be evaluated to determine if the data meets the data quality objective for the model and can be still used as input to the model.

If the flagged or qualified data can be used for model input, then the reason for the flag or qualification will be noted in the documentation for the model, and any limitation on model results because of the condition of the data will be noted. It will be useful to include in the user's manual deliverable, which is an output of this project, how flagged or qualified data can still be usable as a model input parameter and any restrictions in model output might result from the use of flagged or qualified data. Sensitivity analysis may assist in the evaluation of the usability of flagged or qualified data. The more sensitive a parameter is to model output, the less desirable it is to use flagged or qualified data as an input for this parameter.

If the flagged or qualified data cannot be used for model input, then another sampling event may be planned and executed to obtain the needed data. The SAP for the follow-up sampling event will include the fact that the data was flagged and the reason the analytical results were compromised. Any precautions that can be taken in the field to prevent the reoccurrence will be described in an appropriate SAP.

## **C.2 Reports**

Monthly reports will be provided to the EPA ORD IAG Project Officer and the USGS QA Manager. The EPA technical project office will receive copies of these reports. These reports will be prepared by Raymond Johnson and provided to everyone on the distribution list.

USGS RARE Grant  
Quality Assurance Project Plan  
Revision No. 0.0  
Date: August 10, 2010  
Page 19 of 19



Content of monthly reports may include (but are not limited to):

- adherence to project schedule and budget as described in the Project Work Plan;
- any deviations from Project Work Plan and approved QA Project Plans and any updated QAPP versions;
- the impact of these deviations on model prediction, application quality, and uncertainty;
- the need for and results of response actions to correct the deviations;
- potential uncertainties in decisions based on model predictions and data; and
- Data Quality Assessment findings regarding model input data and model outputs (predictions).
- overall status update and work completed for the month

Additional reports include the following:

- Project Work Plan
- final version of the QA Project Plan,
- administrative report on the initial groundwater flow and geochemical model development (Dec. 31, 2010)
- administrative report on any additional data requirements,
- any required SAPs,
- Draft (July 1, 2011) and final groundwater flow and geochemical model report,
- Draft report (July 1, 2011) detailing site-specific findings, outlining methodologies and aquifer characterization strategies for permit writers.

## **Section D. Data Validation and Usability**

### **D.1 Data Review, Verification, and Validation**

Review of model input data will be conducted to evaluate if all data meet the data quality objectives described in Element A7.

Three types of data review, verification, and validation efforts will be conducted for this project. USGS review of secondary data will determine if the existing data is of sufficient quality to meet the data quality objective of the modeling process as discussed under section A.7.2. Incompleteness of existing data will be addressed by the collection of primary data.

Review of primary data will be conducted to determine if all data are of sufficient quality to meet the data quality objectives of the modeling project as discussed under section A.7.3. Site specific SAPs will be developed for the collection of primary data as needed.

Model output will be evaluated by comparison to existing conditions. If the UIC injection well permit and NRC license are issued in a timely manner, model output will also be



compared with wellfield aquifer test results and monitoring of mining and restoration activities as required under the permit and license.

## **D.2 Verification and Validation Methods**

Verification and validation of secondary data will be accomplished by USGS review. Lithologic interpretation of borehole logs provided by Powertech will be evaluated by USGS. Stratigraphic correlations between boreholes will also be reviewed by USGS for use in establishing the hydrogeologic framework of the model. Geochemical data will be evaluated to determine if it fulfills the modeling requirements. Data gaps will be filled by the collection of primary data.

Primary data verification and validation will be conducted by comparing field notes on field sampling and measurement procedures with standard operating procedures referenced in the site specific SAPs. Sample handling and Chain of Custody documentation will be reviewed. Analytical results of quality control samples will be evaluated to determine if data quality objectives are met. Laboratory quality control will be evaluated for analytical method detection limits, analytical results of duplicate duplicate, and matrix spike recovery percentages.

Verification and validation of model outputs for groundwater flow and geochemistry simulations will be conducted by comparing model simulations with current conditions.

The criteria used to assess the usability of the model output is specified in Element A7 of the QA Project Plan. If the model output fails to meet these criteria, the modeling methodology will still be outlined and detailed and reported. This failure may come about if insufficient data is available for an adequate predictive model. Section C.1.1 discusses the assessments and response actions planned for verification and validation of modeling outputs to determine if the modeling results are meeting the data quality objectives of the project.

## **D.3 Reconciliation with User Requirements**

If the data quality of the existing secondary is of insufficient quality or completeness to meet the data quality objective of the model, the first attempt to fill identified data gaps will be addressed by the collection of primary data. If primary data collection cannot fill all data gaps, these gaps will be addressed by evaluating the sensitivity of model results to the types of data gaps identified. Documentation of the effects of insufficient quality or completeness of data on model results is useful information.

The procedures that will be used for the reconciliation of the data quality of primary data with user requirements are covered under section C.1.3.

Modeling results of this project will continually be discussed with the EPA Region 8 project officer (Valois Shea) and provided in monthly project reports to ensure that user requirements are being met. If the user requirements are not being met, discussions between Valois Shea and Raymond Johnson will take place to reconcile any problems. These discussions will be documented as part of the monthly report. If any differences cannot be reconciled, the QA manager may be requested to intervene as an arbitrator.

## References

Guidance for Quality Assurance Project Plans - EPA QA/G-5, EPA/240/R-02/009, December 2002, United States Environmental Protection Agency, Office of Environmental Information, Washington, DC 20460.

Guidance for Quality Assurance Project Plans for Modeling - EPA QA/G-5M, EPA/240/R-02/007, December 2002, United States Environmental Protection Agency, Office of Environmental Information, Washington, DC 20460.

NRMRL QAPP Requirements for Research Model Development and Application Projects, Revision 0, October 2008, EPA Office of Research & Development National Risk Management Research Lab QA website: <http://www.epa.gov/nrmrl/qa/qappreq.html>

NRMRL QAPP Requirements for Secondary Data Projects, Revision 0, October 2008, EPA Office of Research & Development National Risk Management Research Lab QA website: <http://www.epa.gov/nrmrl/qa/qappreq.html>