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Yucca Mountain Saturated Zone Carbon-14

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Scientific Investigation Plan (SIP)

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Revision History

Revision Number	Effective Date	Purpose of the Revision
0	03/10/2005	Initial issue

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Acronyms and Abbreviations

DCA	Direct Charge Agreement
DIC	dissolved inorganic carbon
DOC	dissolved organic carbon
DOE	U.S. Department of Energy
DRI	Desert Research Institute
ERA	Environmental Resource Associates
GCP	geochemical procedure
HP	hydrologic procedure
ICPMS	inductively coupled plasma mass spectrometer
NWQL	National Water Quality Laboratory
OCRWM	Office of Civilian Radioactive Waste Management
OSTI	Office of Science and Technology and International
PMC	Percent Modern Carbon
QA	Quality Assurance
S&T	Science and Technology (Project)
SIP	Scientific Investigation Plan
SN	scientific notebook
UGTA	Underground Test Area (Project)
USGS	U.S. Geological Survey
YMP	Yucca Mountain Project
YMPB	Yucca Mountain Project Branch

YUCCA MOUNTAIN SATURATED ZONE CARBON-14

1 SCOPE AND OBJECTIVES

This Scientific Investigation Plan (SIP) provides an overview of the work described in "Yucca Mountain Saturated Zone Carbon-14", a proposal funded by the U.S. Department of Energy's (DOE) Office of Repository Development under the UCCSN/YMP Co-op in support of the Science and Technology Initiatives. The objective of this work is to provide improved estimates of the time required for ground water to travel from the site of the proposed high-level radioactive waste repository at Yucca Mountain, Nevada, to the accessible environment.

Current estimates of ground-water travel time (i.e., residence time since recharge) at Yucca Mountain are derived from flow and transport models using Darcy's law and poorly constrained hydrologic properties, and from radiocarbon (^{14}C) measurements on dissolved inorganic carbon (DIC) in ground water. The basic assumption in radiocarbon dating of ground water is that the ^{14}C percent modern carbon (pmc) acquired at recharge through the soil zone changes along the flow paths only by radioactive decay of ^{14}C. This assumption is invalid if "dead" carbon (i.e., carbon free of ^{14}C) is dissolved by ground water along the flow path. Corrections for this open-system behavior can be made by examining $^{13}C/^{12}C$ ratios in the ground water, solid carbon containing phases (such as calcite and dolomite, and gases (CO_2 gas) and by making assumptions about the degree of water-rock interaction. Large uncertainties in these assumptions translate into large uncertainties in the corrected DIC radiocarbon ages. Uncorrected DIC radiocarbon ages can be thousands of years too old. However, it can be useful to assess the differences in ages along assumed flow paths where these differences may be more meaningful than the absolute ages. Radiocarbon dating of dissolved organic carbon (DOC) has the advantage of not requiring corrections based on assumed models of water-rock interaction. Like DIC, DOC is acquired from the soil zone during recharge; however, ^{14}C-bearing DOC is not likely to be present along the flow paths. Thus, radiocarbon dating of DOC will give a direct measure of the amount of time elapsed since the ground water was recharged (Wassenaar *et al.,* 1991; Wassenaar *et al.*, 1992; Clark and Fritz, 1997). Because any DOC in aquifers down gradient from recharge areas would not contain DOC ^{14}C, ground-water ages determined by carbon isotopes of DOC are maximum ages that can be used in conjunction with DIC corrected ages to constrain the time since the water was recharged.

2 APPROACH

This study will be conducted by the Desert Research Institute (DRI) in cooperation with the U.S. Geological Survey, Yucca Mountain Project Branch, Environmental Science Team (USGS-YMPB-EST). DRI is the research division of the University and Community College System of Nevada and has the only facility in the United States with the capability of extracting organic carbon from water samples to perform organic carbon isotope analyses.

DRI will be responsible for analyzing the samples for isotopes of DOC (^{14}C and ^{13}C) in accordance with this SIP. These data, in combination with the USGS flow path data, will be used to determine ground-water travel times.

Collected water samples are identified by site name/location and are kept refrigerated in a locked lab, accessible only to authorized personnel with keys and swipe cards. Water samples are custom sealed at collection site and seals are removed just prior to evaporation.

All DRI work is subject to the UCCSN QA Program for Yucca Mountain quality assurance procedures. All data collected for this study will be compiled in a final report documenting the work performed and highlighting interpretations of the distribution and nature of ground-water flow through Yucca Mountain and vicinity.

This SIP presents an independent confirmatory study supporting previously gathered information.

3 SCHEDULE OF WORK

This study will consist of a series of tasks that will be performed as described below.

Task	Start	Finish
1. Prepare Scientific Investigation Plan (SIP).	07/01/04	11/15/04
2. Process water samples for DOC carbon isotope (^{14}C and ^{13}C) analyses. Submit samples for isotope analyses on the U of A accelerator.	11/15/04	04/01/05
3. Develop and refine the database in preparation for hydrochemical modeling.	11/15/04	02/01/05
4. Conduct geochemical modeling of DIC data to correct for water-rock interaction and calculate ground-water ages along flow paths.	01/01/05	04/01/05
5. Scientific Notebook technical and QA reviews	04/01/05	04/15/05
6. Calculate DOC ground-water ages along flow paths.	04/01/05	05/01/05
7. Update the USGS Hydrochemical and Isotopic Database.	11/15/04	07/31/05
8. Compare results of DIC and DOC ground-water age calculations to improve current constraints on ground-water flow and transport calculations.	12/01/05	05/30/06
9. Publish results.	12/01/05	06/30/06

4 INTERFACE CONTROLS

The DRI will interface with the USGS-YMPB-EST to obtain water samples collected for this study by the USGS. Sample handling will be conducted in accordance with existing implementing procedures, as described in Section 6. DRI will obtain USGS major ion chemistry and DIC carbon isotope data from TDMS. TDMS currently contains all historical USGS Yucca Mountain Q data and all Q data collected by the USGS for this study is planned to be entered into TDMS if allowed by DOE S and T.

Other interfaces outside DRI include the University of Arizona (U of A) Accelerator Facility. The U of A Accelerator Facility will analyze DOC samples prepared by DRI for carbon-13 and carbon-14 isotopes. The U of A is in the process of being qualified as an OCRWM supplier. No samples will be analyzed at the U of A Accelerator facility until they qualify for the supplier list. However, if U of A Accelerator Facility does not qualify as an approved vendor, an option is to use the U of A Accelerator Facility staff as "augmented" staff, i.e., trained under the UCCSN QA Program & procedures to do the work in the U of A facility under UCCSN task personnel guidance.

Interface controls obligating funds to the contractor and obligating the contractor to submit a deliverable to DRI are included in the task agreements.

James Thomas, DRI will be both the internal and external interface for this project. Information will be transferred across interfaces by electronic methods using zip files and CRC to verify the data that are transferred. Verifications of electronic data will be documented in the Scientific Notebook i.a.w. QAP-3.1, "Control of Electronic Data."

5 STANDARDS

There are no special standards and criteria for this task. No specific job skills are required beyond those stated in the position descriptions filed with HRC. The U of A Accelerator Facility, a qualified vendor, will be using the NBS OX-1 and NBS OX-2 standards to calibrate their accelerator for carbon isotope analyses. The NBS OX-1 and OX-2 standards are purchased from the National Institute of Standards and Technology (NIST). Accuracy and precision will be addressed by U of A using OX-1 and OX-2 standards and replicate measurements.

6 IMPLEMENTING PROCEDURES

Technical methods vary according to the pertinent physical quantities to be measured and the properties to be derived. Transferring of water samples between the USGS and DRI and sample control at DRI will be i.a.w. QAPs 8.0 and QAP 8.1. Specific requirements are recorded in detail in scientific notebooks (SNs) and UCCSN Implementing procedures (IPRs):

Document Number	Document Title
UCCSN-DRI-083 VOL.1	Processing Groundwater Samples for DOC carbon Isotope Analyses
UCCSN-DRI-083 VOL.2	Analyze samples for DOC-14 and DOC-13
IPR-029	Evaporation of DOC water samples
IPR-030	Combustion of DOC samples

7 EQUIPMENT AND INSTRUMENTS

DRI will use evaporation equipment and a combustion line to convert DOC in water samples into a CO2 gas to ship to the University of Arizona Accelerator Facility for carbon isotope analyses.

8 SOFTWARE AND MODELS

Standard, commercially-available word processing software and graphics software will be used to record, compile, and prepare the data for submittal in digital form, and to prepare the data for eventual publication. The listed software will be obtained in accordance with QAP-3.2. One additional software program, PHREECI v2.10.0.0 which generates input files for PHREEQC using a graphical user interface may be used. This software will be qualified with QAP-3.2. There will be no models developed for this task. Reaction path modeling will be conducted using the following software:

Software Name and version	Software Tracking Number	Date of Release for Use
PHREEQC, Ver. 2.0	10068-2.0-00	2000
PHREEQC, Ver. 2.3	10068-2.3-00	2000
NETPATH, Ver. 2.13	10303-2.13-00	2000

9 HOLD POINTS

Processing of water samples for DOC will not be initiated prior to approval of this SIP.

10 DATA

Analytical results will be recorded in scientific notebooks. Scientific notebooks are in a limited access building.

All reduced data generated for this study will be submitted to the TDA in accordance with QAP 3.6. All computers are in a limited access building. Computers are password protected and all project files are backed up on the DRI server weekly.

There are no plans to use unqualified data.

There are no plans to use data established as fact.

11 REVIEWS

Data, Scientific Notebook and SIP reviews will be conducted in accordance with Q.A.P 3.0. Technical and management reviews and revisions of planning documents (i.e., this SIP) will be completed prior to final approval and initiation of technical work.

The Scientific Notebooks used in this study will require technical and QA reviews. All data generated for this study will be reviewed by a qualified individual, as selected by the principal investigator. Data that are unsuitable for use will be clearly identified and the reason for rejection of the data shall be stated. Data reviews will be completed prior to final data submittal. The final interpretive report will be reviewed by at least two qualified individuals prior to approval for public dissemination. For both data and report reviews, outstanding technical issues will be resolved to the satisfaction of the reviewer or the principal investigator.

12 RECORDS AND SUBMITTALS

QA records will be created and controlled i.a.w. QAP 17.0.

Results of this study will include both data and interpretations. DOC carbon isotopic data will be submitted as formal records by the end of the data-collection period.

A final interpretive report describing the overall analytical results will be prepared after data collection is completed and data packages have been finalized. The report will document all work completed and summarize analytical results. The report will be completed and submitted to DOE ORD administrators by June 30, 2006. It is anticipated that this report will be submitted for publication and widespread dissemination in a refereed technical journal shortly after that date, or as a DRI or USGS publication.

The final Technical Report will be controlled & submitted to DCC in accordance with QAP-3.4.

13 REFERENCES

Clark, I.D. and Fritz, P., 1997. Environmental Isotopes in Hydrogeology, Lewis Publishers, New York, NY, 290 pp.

Wassenaar, L., Aravena, R., Hendry, J., and Fritz, P., 1991. Radiocarbon in Dissolved Organic Carbon, A Possible Groundwater Dating Method: Case Studies From Western Canada, Water Resources Research, v. 27, no. 8, pp. 1975 to 1986.

Wassenaar, L., Aravena, R., and Fritz, P., 1992. Radiocarbon Contents of Dissolved Organic and Inorganic Carbon in Shallow Groundwater Systems: Implications for Groundwater Dating, *in* Isotope Techniques in Water Resources Development 1991, Proceedings of an International Symposium on isotope Techniques in Water Resources Development, International Atomic Energy Agency, Vienna, pp. 143 to 151.