U.S. NUCLEAR REGULATORY COMMISSION
NOTICE OF GRANT/ASSISTANCE AWARD

1. GRANT/AGREEMENT NO.	2. MODIFICATION NO.	3. PERIOD OF PERFORMANCE	4. AUTHORITY
NRC-04-09-167	M003	FROM: 10/01/2009 TO: 05/31/2013	Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended

5. TYPE OF AWARD	6. ORGANIZATION TYPE	7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS
[X] GRANT [ ] COOPERATIVE AGREEMENT	Non-Profit Organization NAICS: 541690 DUNS:041964057	NATIONAL ACADEMY OF SCIENCES NATIONAL RESEARCH COUNCIL 2101 CONSTITUTION AVE NW WASHINGTON DC 204180006

8. PROJECT TITLE:
Subsurface Characterization, Modeling, Monitoring, and Remediation of Fractured Rocks

9. PROJECT WILL BE CONDUCTED	10. TECHNICAL REPORTS ARE REQUIRED	11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS
PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED See Program Description AND APPENDIX A-PROJECT GRANT PROVISIONS	[X] PROGRESS AND FINAL [ ] FINAL ONLY [ ] OTHER (Conference Proceedings)	Ms. Samantha Magsino Board of Earth Sciences and Resources National Research Council 500 Fifth Street, N.W. Washington DC 20001 smagsino@nas.edu

12. NRC PROGRAM OFFICE (NAME and ADDRESS)	13. ACCOUNTING and APPROPRIATION DATA		14. METHOD OF PAYMENT
U.S. Nuclear regulatory Commission Office of Research Attn: Robin Barnes Robin.Barnes1@nrc.gov Mail Stop: C6D20 Rockville MD 20850 301-251-7401 TA: Jacob Philip Jacob.Philip@nrc.gov	APPN. NO: B&R NO: JOB CODE: BOC NO: OFFICE ID NO:	31X0200.160 2011-60-17-6-161 G6867 4110 RFPA: Administrative	[ ] ADVANCE BY TREASURY CHECK [ ] REIMBURSEMENT BY TREASURY CHECK [ ] LETTER OF CREDIT [X] OTHER (SPECIFY) Electronic ASAP.gov (See Remarks in Item #20 "Payment Information")

15. NRC OBLIGATION FUNDS		16. TOTAL FUNDING AGREEMENT	
THIS ACTION	$0.00	NRC	$200,000.00
PREVIOUS OBLIGATION	$200,000.00	RECIPIENT	$0.00
TOTAL	$200,000.00	TOTAL	$200,000.00

This action provides funds for Fiscal Year in the amount of $0.00

17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)

U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: M`Lita R. Carr
Mail Stop: TWB-01-B10M
Rockville MD, 20852
MLita.Carr@nrc.gov

18.

Signature Not Required

19. NRC CONTRACTING OFFICER

Sheila Bumpass 11/2/11
(Signature) (Date)

NAME (TYPED) Sheila Bumpass

TITLE Contracting Officer

TELEPHONE NO. (301) 492-3484

20. PAYMENT INFORMATION

Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).

21. Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients.
Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.

22. ORDER OF PRECEDENCE
In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.

23. By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.

TEMPLATE - ADM001 SUNSI REVIEW COMPLETE ADM002

DESCRIPTION OF MODIFICATION:

The purpose of this modification M003 is:

1. Correct the period of performance;
2. Correct the program description.

As a result of this modification:

1. In M001 the Period of Performance in box 3 of the award document is deleted and replaced with the following:

   FROM: 10/01/2009 TO: 09/30/2011

2. In M002 the Period of Performance in box 3 of the award document is deleted and replaced with the following:

   FROM: 10/01/2009 TO: 05/31/2013

3. Hereby confirms M002 increased the ceiling of the grant from $35,000.00 to $200,000.00.

4. The program description in M002 is corrected to incorporate the attached program description accepted with the proposal submitted on 06/09/2009.

Base Period: October 01, 2009 – May 31, 2013 (changed)
Total Agreement Amount: $200,000.00 (unchanged)
Total Obligated Amount: $200,000.00 (unchanged)

All terms and conditions remain the same.

SUBSURFACE CHARACTERIZATION, MODELING, MONITORING, AND REMEDIATION OF FRACTURED POROUS ROCKS

STATEMENT OF TASK

Geological and geotechnical characterizing, modeling, and monitoring of the subsurface are integral to safe, economical, and environmentally responsible development, maintenance, operation, remediation, and decommissioning of infrastructure related to energy, water, waste, and transportation. Modeling and monitoring fluid travel paths and velocities through subsurface fractures and pore space are among the most significant engineering challenges associated with these tasks. Monitoring and modeling of subsurface fluid flow and transport are especially important at sites where wastes or hazardous substances are produced, stored, or unintentionally released. An ad hoc committee of the National Research Council will conduct a study to address issues relevant to how flow and transport in fractured porous rocks affect groundwater quality near existing and planned facilities. Subsurface characterization, modeling, monitoring, and remediation (SCMMR) aspects applicable throughout the lifecycle of engineered facilities that have potential to release contaminants will be considered. The committee will plan and hold a workshop to examine the state-of-art and state-of-practice in

- Subsurface fracture and matrix characterization, especially relevant geotechnical and hydrological properties, and the development of conceptual models;
- Detection of fluid and contaminant pathways and travel times;
- Detection and modeling of factors that affect change in geotechnical and hydrological properties over time;
- Groundwater and contaminant transport modeling, monitoring, and remediation, and how these can aid decision making during facility design, operation, remediation, and decommissioning;
- Early indicators (such as change in fracture properties; moisture levels) of system failures resulting in unintentional release of fluids; and
- Potential mitigation measures to eliminate or reduce adverse impacts of system failures and related releases.

The committee will issue a final report that will include recommendations with respect to (i) where research and development could improve the current state-of-art in SCMMR, and (ii) where incorporation of scientific and technical advances could enhance the state-of-practice in SCMMR and inform federal regulations and implementing guidance.

PROJECT CONTEXT AND ISSUES

The importance of fractures in efficient and effective design, development, maintenance, operation, remediation, and decommissioning of chemical and petrochemical processing, energy supply, resource extraction, water supply, and related waste management facilities, as well as critical infrastructure such as dams, bridges, and power plants has long been recognized. Fractured porous rocks also are a major source of current and emerging national energy supplies. Two benchmark studies by the National Academies addressed issues related to fracture flow. The 1996 report Rock Fractures and Fluid Flow reviewed characterization of fracture flow from the mid 1970s to the early 1990s. A 2001 study on flow in the unsaturated zone (Conceptual Models of Flow and Transport in the Fractured Vadose Zone) supported understanding of how fractures affect all types of recharge to bedrock groundwater. A third National Academies study, Assessment of the Performance of Engineered Waste Containment Barriers (2007), stressed the need to establish guidelines to increase long-term direct monitoring of waste containment

systems. Technical gaps remain in spite of recent advances in subsurface characterization, modeling, monitoring, and remediation. Regulatory gaps still exist for implementation of policies and programs affected by flow of groundwater and other fluids, and contaminants therein, through fractured porous rocks. As described in the following paragraphs evolving national policies and programs highlight the need to reexamine the state-of-art, state-of-practice, and application of these in regulations and guidelines.

Access to adequate supplies of safe drinking water and protection of groundwater resources are international concerns that, in the U.S., are regulated by the Environmental Protection Agency (EPA). As groundwater is increasingly drawn from fractured porous rocks-particularly complex limestone formations-increased knowledge is required to assure adequate quality and quantity of drinking water. Fractured porous rock and the major role it plays in groundwater availability and contaminant transport are recognized as among the greatest challenges to groundwater protection and clean-up (Steimle, 2002); groundwater contamination occurs and cleanup measures often fail. Limitations on the ability to accurately characterize the geotechnical and hydrological properties of subsurface heterogeneities, and the modeling and monitoring of fluid flow and transport, hamper effective lifecycle planning, mitigation, and remediation activities.

Radioactive contaminants have been detected in groundwater moving through fractured porous rocks in complex geologic formations at sites such as those where materials have been produced to support U.S. government nuclear weapons and nuclear propulsion programs, from waste storage facilities, and at Department of Energy (DOE) research laboratories. Organic solvents and other contaminants also have been detected. Leaks of tritium-bearing water from underground piping systems at existing commercial nuclear power plants have generated both strong public concern and regulatory action. The U.S. Nuclear Regulatory Commission (U.S. NRC) has stepped up regulatory oversight, enhanced communications with the public, and formed a groundwater contamination task force that produces reports and recommendations in response. To address potential problems at new facilities, the U.S. NRC introduced a requirement to minimize contamination (10 CFR 20.1406). Although the requirements of 10 CFR 20.1406 apply to new nuclear power plants, the U.S. NRC also regulates other fuel cycle facilities (e.g., facilities that produce uranium by conventional and in-situ extraction techniques, enrichment facilities, interim storage facilities, and contaminated industrial and governmental sites) where SCMMR are central issues. Effective development and operations of facilities and implementation of the governing regulations would benefit from assessment of the state-of-art and tate-of-practice related to SCMMR in fractured porous rock, together with a delineation of where there are gaps and need for improvements in knowledge. These could form a basis for revised guidance on implementation of regulatory requirements.

Other energy production technologies, such as extraction from conventional petroleum reserves, enhanced oil recovery methods, geothermal reservoirs, and energy storage systems (required for peaking power and potentially to enable wind and solar power to be included as part of the base load power supply) all require significant characterization, modeling, and monitoring. Industry interest in these topics has intensified as higher energy prices make advanced technologies more practical.

Government plans to reexamine the approach to managing spent nuclear fuel and high-level radioactive waste introduce a need for DOE to develop site characterization and selection plans, and to determine how to most effectively use characterization data in disposal system design, monitoring, and performance assessment. Likewise, EPA may need to revise its standard for high-level waste disposal, and the U.S. NRC may need to develop a regulatory framework that

takes into consideration the current state-of-art and state-of-practice. Nearly a decade has passed since advances in the state-of-art and state-of-practice have been examined in a comprehensive manner with respect to changes in the regulatory regimes implementing national policies. The proposed study will bring together experts in SCMMR in a range of applications.

ORIGIN

The Committee on Geological and Geotechnical Engineering (COGGE) used Program Initiation Funds to conduct a workshop on "Lifecycle Geoengineering: Thinking Beyond Construction of Critical Infrastructure" November 28-29,2007. Participants received input from local, state, and federal agencies including the USNRC, FHWA, USACE, and NSF. Discussions that began at that workshop--particularly recognition of the need to initially characterize and then continue to monitor the geotechnical and hydrological properties of geologic materials over time-stimulated the proposed study.

COMMITTEE COMPOSITION

The committee will include expertise in the areas of geotechnical and geohydrological site characterization, hydrogeology, site-scale geotechnical and hydrological modeling, contaminant fate and transport modeling, geotechnical and geohydrological monitoring, environmental engineering and environmental science, and risk assessment. In addition, committee members will include those familiar with the related statutes and regulations, design and operation of related facilities, remediation practices, and current public concerns.

BALANCE

When forming the study committee, consideration will be given to the concerns of public and private interest groups, perspectives of those doing research and those in engineering practice, and the current and developing states of knowledge in basic science and how they are used in engineering practice and applied science, as well as other factors. A balance of expertise will be needed that spans (i) site characterization, particularly with respect to geotechnical and hydrological parameters affecting flow in fractured porous rocks; (ii) saturated and unsaturated flow; (iii) fate and transport of contaminants, including biological and geochemical processes; (iv) environmental science and environmental engineering; (v) instrumentation, monitoring, and data visualization; and (vi) risk and performance assessment of complex systems involving engineered and natural subsystems.

PROJECT AUDIENCES AND IMPACT

The target audiences for this study and report are widespread, encompassing local and federal agency managers responsible for establishing research and development or regulatory agendas related to geoengineering at public or private facilities where contamination of the subsurface is a possibility, and including a variety of academic, industry, and professional groups. Findings of a National Academies study are often used by program managers to stress the importance of specific research topics and regulatory requirements. Industry groups associated with facility development, maintenance, or closure would be informed by identification of the state-of-art and state-of-practice in characterization, modeling, monitoring, and remediation technologies, and would become familiar with the benefits of applying these in a lifecycle approach to geoengineering. Regulatory guidance on design and management of facilities also may be influenced by the findings of this study.

WORK PLAN

The study will be conducted by an ad hoc committee of approximately 10 members under

the auspices of COGGE. The primary source of input to the committee will be an information gathering workshop. The committee also will use published literature, technical reports, personal expertise, and other sources of information from the scientific, research, and industry communities. The committee will meet at least four times during a 15 month period to gather information, analyze input, and prepare its final report. The duration of the study is 15 months, plus 4 additional months for final report printing and dissemination. The resulting product will be a report with recommendations authored by the committee. The chair of the committee will travel to Washington, D.C. to brief the sponsors on the report.