

SUPPLEMENTAL AGREEMENT  
BETWEEN  
ARIZONA BOARD OF REGENTS  
AND  
THE U. S. NUCLEAR REGULATORY COMMISSION

THIS SUPPLEMENTAL AGREEMENT, effective the 30th day of June, 1985 by and between the UNITED STATES OF AMERICA (hereinafter referred to as the "Government"), as represented by the UNITED STATES NUCLEAR REGULATORY COMMISSION (hereinafter referred to as the "Commission"), and ARIZONA BOARD OF REGENTS

(hereinafter referred to as the "Contractor"),

WITNESSETH THAT:

WHEREAS, the parties desire to modify Contract No. NRC-04-78-275 as hereinafter provided, and this supplemental agreement is authorized by law, including the Energy Reorganization Act of 1974, as amended, and the Atomic Energy Act of 1954, as amended.

NOW, THEREFORE, said contract is hereby modified as follows:

1. Appendix A, attached to this supplemental agreement and made a part hereof, supercedes in its entirety the Appendix A attached to Modification No. 16 of this contract, and provides for the research to be performed by the Contractor during the contract period specified therein.
2. In Article II - The Period of Performance, the date "September 30, 1985" substituted for the date "June 30, 1985."
3. In Article III - Consideration, the sum "\$2,324,268.00" is increased by "\$70,000.00" to "\$2,394,268.00."

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PDR CONTR  
NRC-04-78-275 PDR

IN WITNESS WHEREOF, the parties have executed this document.

UNITED STATES OF AMERICA

BY:

Paul J. Edgeworth  
Paul J. Edgeworth  
Contracting Officer  
(title)

6/27/85  
Date

Nuclear Regulatory Commission

BY:

Floyd A. Swenson  
FLOYD A. SWENSON  
CONTRACTING OFFICER  
(title)

7/16/85  
Date

I, James T. Wheeler, certify that I am the  
(attester)

Asst. Vice President for Research of the Contractor named  
(title)

under this document; that Floyd A. Swenson  
(signatory)

who signed this document on behalf of said Contractor was then

Contracting Officer of said Contractor; that  
this document was duly signed for and on behalf of said Contractor by  
authority of its governing body and is within the scope of its legal  
powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of  
said Contractor.

(SEAL)

James T. Wheeler  
James T. Wheeler, Assistant Vice President  
University of Arizona, Babcock Bldg. Rm. #3313  
Tucson, Arizona 85721

CONTRACTOR: ARIZONA BOARD OF REGENTS

## APPENDIX A

For the Contract period June 1, 1980 through September 30, 1985

### Article A-1 RESEARCH TO BE PERFORMED BY CONTRACTOR

- (a) The unclassified scope of work under this contract entitled "Field and Theoretical Investigations of Mass and Energy Transport in Subsurface Materials at Waste Disposal Sites" is as follows:

#### REPORTS

Progress reports shall be submitted semi-annually. An annual topical report shall be submitted at the end of each of the four (4) periods of work. A final report shall be submitted upon completion of the contract performance.

#### BACKGROUND

As part of an effort to understand phenomena relevant to the migration of radionuclides from buried high-level radioactive waste (HLW), NRC has been sponsoring a research project (this project, FIN B5753, NRC-04-78-275) at the University of Arizona since 1979 on the flow of water and the transport of contaminants through saturated fractured geologic media. The tasks carried out in this project and brief summaries of their accomplishments are listed below.

June 1, 1980 through September 30, 1985:

- Task 1: Establishment and operation of a field test facility.** A field test facility was established near Oracle, AZ and is now fully operational. Under this task, a new method for measuring anisotropic hydraulic conductivity in the field was devised and demonstrated.
- Task 2: Tracer selection and analysis.** Extensive tracer testing was done at the Oracle site. The tests provided insight into the special problems which arise when tracer studies are attempted in low permeability rocks. Extensive laboratory research on sorptive properties of tracers has also been done.
- Task 3: Critical review and possible reformulation of equations governing flow and transport in saturated fractured rocks.** An extensive theory of three dimensional flow to wells in anisotropic saturated fractured rocks was developed. The contractor demonstrated how geostatistical concepts can be used to describe spatial variability of hydraulic conductivities of fractured rocks in three dimensions. A rigorous stochastic theory of far-field contaminant dispersion that uses the geostatistical information on hydraulic conductivities to predict far-field dispersion was developed.

Task 4: Evaluation of existing computer codes which contain models of flow and transport in saturated geologic media. Work in this task consisted of an in-depth comparative analysis of the fundamental theoretical basis for several computer programs used in analyzing flow and transport in geologic media. As a result of the comparison, a new numerical method which combines the positive attributes of particle tracking algorithms and finite difference or finite element algorithms while eliminating many of their drawbacks was formulated and shown to perform satisfactorily.

Information obtained in these tasks has been and is being made available to the staff of NMSS/DWM for pre-licensing guidance to the Department of Energy (DOE), the HLW licensee, in technical areas related to hydrogeology. Some of the information has been used by NMSS/DWM in preparing its technical position on hydrogeologic testing in saturated fractured rocks. The results of the work in this contract will also be available to NMSS/DWM at all future stages of the HLW licensing process.

In addition to providing information of direct use to NMSS/DWM, the results and ongoing research activities of this project have been helpful to other NRC waste management contractual efforts, especially at Sandia National Laboratories and the University of Arizona.

This project (FIN B5753) is scheduled to end on June 30, 1985. In spite of the extensive research which has been done for NRC in this project, additional research on flow and transport in saturated fractured media has to be done in order to provide NMSS/DWM with a sufficient information base for making licensing decisions about the disposal of HLW in saturated fractured rocks. To this end, a Request for Proposal (RFP) (FIN D1163) has been prepared, coordinated with NMSS/DWM, and approved by the Waste Management Review Group, the Senior Contract Review Board, and the Commission.

#### OBJECTIVE

NRC wishes to maintain continuity in its saturated hydrology HLW research program so that outstanding issues related to flow and transport in fractured rock can be addressed in a timely manner. To the extent practicable, it is desirable to use existing facilities and experienced personnel to maintain this continuity. To that end, work on Tasks 1 and 2 of this project (FIN B5753) will be extended (after June 30, 1985) until September 30, 1985 or until the contract for FIN D1163 is awarded, whichever comes first. If the contract for D1163 is not awarded by September 30, 1985, an additional extension may be proposed.

Results from the extended tasks will add to the information base which will be useful to NMSS/DWM in making HLW licensing decisions.

#### WORK TO BE PERFORMED AND EXPECTED RESULTS

##### Task 1: Field Test Facility Operations

The contractor shall conduct three dimensional cross-hole pressure tests

as described in NUREG/CR3213 at the Oracle site. The hydraulic conductivity data obtained from these tests shall be analyzed to assess the validity of the hypothesis that a fractured geologic medium can be characterized as an equivalent porous medium for repository performance assessment models.

## Task 2: Tracer Selection and Analysis

Chemical tracer tests used in hydrologic studies have two major disadvantages. First, the concentration of the tracer cannot be measured in situ. Second, the tracer contaminates the site where it is used so that the identical tracer can not be used immediately thereafter in the neighborhood of where it has already been used. Another chemical tracer, distinguishable from the first one has to be used instead for a certain period of time. Heat transport in saturated geologic media is believed to behave in a manner analogous to chemical transport. Temperature is measurable in situ and when the heat is dissipated, there is no residual contamination. Using heat as a tracer can not provide a substitute for chemical tracers in all applications because thermal conduction usually dominates thermal dispersion and it is very unlikely that a heated water tracer could be used to measure dispersive effects or provide a measure of effective porosity. However, a heat tracer can serve as an auxiliary to chemical tracers in providing an economical confirmatory method (about 10% of the cost of a corresponding chemical tracer method) for verifying the connectivity of the fractures forming the flow paths which chemical tracers were believed to follow. The contractor shall

- 1) investigate the possibility of using water cooler (or hotter) than the ambient temperature as a tracer in fractured rocks (Cooler water shall be emphasized because cold water's flow properties are less sensitive to temperature changes than hot water's flow properties.),
- 2) conduct a preliminary theoretical examination of the scientific basis and technical feasibility of such a technique,
- 3) examine the relationship between the transport of solute and the transport of energy in fractured rocks, and
- 4) examine the feasibility of measuring, in situ, the thermal conductivity and heat capacity (needed to evaluate the effectiveness of the heat tracer) of the rock through which the thermally perturbed water is flowing.

## RELATIONSHIP TO OTHER PROJECTS

This project shall be coordinated with several NRC projects which are being conducted by investigators other than those associated with this project. The coordination shall consist of direct contacts between this project's personnel and personnel working on the other projects, and additional interactions deemed necessary by this project's or the other projects' NRC program managers. NRC projects which have special relevance to this project are listed below.

FIN's A1192 and A1266. Sandia's development of risk methodologies for HLW disposal.



FIN B6985. Corstar's benchmarking of computer codes which contain models of phenomena relevant to HLW disposal.

FIN B7291. The University of Arizona's project on transport of radionuclides in unsaturated rocks.

FIN B3046. Lawrence Berkeley Laboratory's project on thermal, hydrologic, mechanical, and chemical interactions in the host rock near the emplaced waste.

FIN B8965. The Massachusetts Institute of Technology's LLW project on stochastic analysis of solute transport in unsaturated soils.

FIN B6627. The University of Arizona's project on rock mass sealing.

FIN B6628. The University of Arizona's project on ground water dating.

FIN B7330. NMSS/DWM's Basic Ordering Agreement for technical assistance in hydrogeology.

## REPORTING REQUIREMENTS

### Business Letter Reports

A quarterly letter-report shall be submitted by the 15th of the month following each quarter of the contracting period to those persons listed under the heading Report Distribution in this section of this SOW. These reports shall identify the title of the contract, the contract number, the FIN, the Principal Investigators, the period of performance, and the reporting period. The reports shall contain two sections as described below.

### PROJECT STATUS SECTION

- 1) A list of the efforts completed and milestones reached during the reporting period. If milestones are missed, an explanation shall be provided.
- 2) Any problems or delays encountered or anticipated and recommendations for resolution. If the recommended resolution involves a contract modification (e.g. a change in work requirements), level of effort (costs), or period of performance, a separate letter shall be prepared and submitted to the Contracting Officer (Division of Contracts), with copies provided to:

Director, Division of Radiation Programs and Earth Sciences, attention:  
Enrico F. Conti

John D. Randall, Waste Management Branch, Project Officer

Office of Nuclear Regulatory Research, attention: Resources Management Branch.

- 3) A summary of progress to date expressed in terms of percentage completion for each task. This summary shall summarize all technical tasks conducted

during the corresponding quarters which have not been treated in topical reports. Significant findings and conclusions pertinent to the objectives of the project shall be highlighted.

4) Plans for the next reporting period.

FINANCIAL STATUS SECTION

- 1) Provide the total cost (value) of the work done to date, the total amount of funds obligated to date for the contract, and the balance of funds to complete the work by fiscal year as follows:

<u>Total</u> <u>Projected</u> <u>Project Cost</u>	<u>Funds</u> <u>Obligated</u> <u>To Date</u>	<u>Balance of Funds</u> <u>By Fiscal Year</u> <u>FY85</u>
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- 2) Provide the total amount of funds expended (costed) during the reporting period and accumulated from the beginning of the project in the following categories:

<u>Category</u>	<u>Costs for</u> <u>Reporting</u> <u>Period</u>	<u>Costs</u> <u>Accumulated</u> <u>to Date</u>
a. Direct Labor		
b. Indirect Labor		
c. ADP Support		
d. Travel		
e. Subcontracts		
f. Equipment and Materials		
g. Overhead (G&A)		
h. Fee		
TOTAL		

Under total accumulated costs, the percentage of total funds obligated to date shall also be provided.

Technical Reports

The reports and papers which are derived from this project shall be subject to peer review by appropriate technical experts.

The contractor shall submit a NUREG/CR report on the work performed in this project from July 1, 1985 until the contract ends. If the contract is terminated after September 30, 1985, the contractor shall submit a letter-report on the work done from July 1, 1985 until September 30, 1985.

One copy of each conference or archival technical publication which is related to or funded by this project shall be transmitted to the RES project manager.

Report Distribution

Copies of the topical and letter-reports shall be sent to the following NRC personnel.

John D. Randall, Project Manager  
Division of Radiation Programs and Earth Sciences, RES, 7 copies,

Office of the Director, RES  
Attention: Administration and Resource Control Staff, 1 copy,

Karl R. Goller, Director  
Division of Radiation Programs and Earth Sciences, RES, 1 copy,

Enrico F. Conti, Deputy Director  
Division of Radiation Programs and Earth Sciences, RES, 1 copy,

Frank A. Costanzi, Chief  
Division of Radiation Programs and Earth Sciences, RES, 1 copy,

Resources Management Branch, RES, 1 copy, and

Contracting Officer  
Division of Contracts, 1 copy.

Copies of the topical reports and the Project Status Sections of the letter-reports shall be sent to the following NRC personnel.

Robert E. Browning, Director  
Division of Waste Management, NMSS, 1 copy,

Michael J. Bell, Deputy Director  
Division of Waste Management, NMSS, 1 copy,

Matthew Gordon  
Division of Waste Management, NMSS, 1 copy,

Jeffrey Pohle  
Division of Waste Management, NMSS, 1 copy,

Malcolm R. Knapp  
Division of Waste Management, NMSS, 1 copy,

Myron H. Fliegel  
Division of Waste Management, NMSS, 1 copy,

Hubert J. Miller  
Division of Waste Management, NMSS, 1 copy, and

Document Control Center  
Division of Waste Management, NMSS, 1 copy.

The RES project manager may supply the contractor with additional names for



report distribution when appropriate.

Microfiche is required of all reports to be published as NUREG or NUREG/CR documents. The specifications for this microfiche are listed in Enclosure 1, and the distribution is as follows:

Document Management Branch, Division of Technical Information and Document Control	1 microfiche (master)
Document Control Center, Division of Waste Management, NMSS	1 microfiche (duplicate)

#### QUALITY ASSURANCE

The contractor shall develop and submit to NRC for review, a quality assurance (QA) program plan for work to be performed under the contract or shall indicate that a previously approved applicable QA program will be applied to the work done under this contract.

Any work (i.e., data, interpretations, analyses, computations, methods, etc.), developed under the contract that may be used to address regulatory issues shall be performed under an adequate QA program. Quality assurance comprises all those planned and systematic actions necessary to provide adequate confidence that the research has been satisfactorily performed. Quality assurance includes sufficient documentation to assure the reproducibility of the results of the research. That is, the methods and techniques used to collect, reduce, and interpret data produced by the research are sufficiently precise, accurate, traceable, and articulated so that other researchers could duplicate the work done and independently evaluate the results.

An adequate QA program should address the following areas, as appropriate:

Experimental design and rationale--sample selection, number of samples, sampling frequency, controls;

Statistical evaluation of experimental design--assessment of statistical power of sampling scheme and measurement techniques, including expected accuracy and precision;

Sample preparation--selection of sample type, treatment of samples, sample identification;

Measurement techniques used--description of measurement process, description/identification of equipment used;

Calibration methods--frequency, techniques, standards, traceability;

Data recording--method of recording data, identification of person(s) recording/certifying data;

Data reduction--methods and code(s) (including identification of modifications and updates);

Data analysis--description of techniques used, methods of data verification (e.g. spot checking of measurements, calculations, etc.);

Records management--identification, location, and retention time of data, analyses, associated records, duplicate data and/or records; and

Statistical evaluation--interpretation of data, stating actual accuracy and precision of results achieved.

In addition, if standard test or calibration procedures are employed (e.g., ASTM standards) these should be cited in the program. Finally, if appropriate to the size and nature of the contract, the work and results should receive exposure in the scientific community through publication of results in refereed journals, or through peer reviews, or both.

#### MEETINGS AND TRAVEL

##### Technical Review Meetings

NRC and University of Arizona staff shall meet at least once during the contract extension period, either at NRC Headquarters or at University of Arizona, to review the technical aspects of this project. The times and locations of the meetings shall be designated by the RES project manager.

##### Travel

Any travel to be charged against project funds requires prior approval by the NRC project manager.

##### DOE FURNISHED MATERIALS

None.

##### NRC FURNISHED MATERIALS

To facilitate the work described in the section on WORK TO BE PERFORMED AND EXPECTED RESULTS of this SOW, the NRC shall provide to the University of Arizona SOW's and reports from the projects listed in the section on RELATIONSHIP TO OTHER PROJECTS of this SOW.

##### CAPITAL EQUIPMENT

All capital equipment expenditures require the prior written approval of the NRC Project Manager.

SUBCONTRACTS

Subcontracts require the prior written approval of the NRC Project Manager.

DISPOSAL OF PROPERTIES

Not applicable.

TECHNICAL DIRECTION

Dr. John D. Randall (FTS or 301-427-4633) will be responsible for directing this project.

ARTICLE A-11 WAYS AND MEANS OF PERFORMANCE

(a) Items for which support will be provided as indicated in A-111, below

(1) Salaries and Wages \$ 186,636.00

(2) Equipment to be purchased or  
fabricated by the Contractor \$ 3,500.00

(3) Travel (i) Domestic \$ 9,000.00

(ii) Foreign \$ 0

(4) Other direct costs including staff benefits \$ 76,664.00

(5) Indirect costs based on a predetermined rate of 44 percent applicable  
to direct costs excluding equipment.

(b) Items, if any, significant to the performance of this contract, but  
excluded from computation of Support Cost and from consideration in  
proportioning costs: None

(c) Time or effort of Principal Investigator(s) including indirect costs  
and fringe benefits contributed by Contractor but excluded from com-  
putation of Support Cost and from consideration in proportioning  
costs: None

## Article A-411

The total estimated cost of items under A-II(a) above for the contract period stated in this Appendix A is increased from \$2,324,268.00 by \$70,000.00 to \$2,394,268.00. The Commission will pay 100 percent of the actual costs of these items incurred during the contract period stated in this Appendix A, subject to the provisions of Article III and Article B-XXVIII. The estimated NRC Support Cost for the contract period stated in this Appendix A is increased from **\$2,324,268.00** by \$70,000.00 to \$2,394,268.00.

The estimated NRC Support Cost is funded as follows:

- (a) Estimated unexpended balance from prior period(s) \$ 0
- (b) New funds for the current period (7/1/85-9/30/85) \$ 70,000.00
- (c) The new funds being added in A-III(b) constitute the basis for advance payments provided under Article B-X.



ENCLOSURE 1

MICROFORM SPECIFICATIONS FOR  
WASTE MANAGEMENT CONTRACTS

Microfiche used for submittal purposes shall conform to the following specifications:

1. Microfiche containing source documentation shall conform to the NMA Type 1 format (ANSI/NMA MS.5) consisting of 98 frames arranged in 7 rows and 14 columns.
2. The reduction ratio shall be 24:1 for all microfiche.
3. The microfiche shall be standard 148mm X 105mm.
4. The microfiche shall be one silver-halide master and one diazo placed in individual acid free envelopes.
5. Diazo duplicates may be either blue/black or black.
6. The microfiche shall be titled in the following manner:

FIN No.	Title of Report	Date
Contract No.		
NUREG/CR No.		
Fiche No.		

Fiche number refers to pagination information, e.g. 1 of 2, 2 of 2, . etc.

7. Title information shall be eye readable on a clear background.
8. The submittal of microfiche containing proprietary material shall be coordinated with the Document Control Branch, Division of Technical Information and Document Control, U. S. Nuclear Regulatory Commission, Washington, DC 20555 to set format and procedures for submittal.
9. Foldouts, if any shall be segmented and filmed in logical order.
10. The first frame shall be blank, and the second frame shall contain the resolution target (NBS 1010A).
11. Questions on microfiche specifications should be submitted in writing to:

Document Management Branch  
Division of Technical Information and Document Control  
U. S. Nuclear Regulatory Commission  
Washington, DC 20555.