|   | DN/MODIFICATION   | OF CONTRACT  |  |  |  | 1 4  |
|---|---|--|--|--|--|--|
| 2. AMENDMENT/MODIFICATION NO.   | 3. EFFECTIVE DATE   | 4. REQUISITION/PUR   | CHAS   | E HEQ. NO.   | 5. PROJEC                                  | T NO. (If applicable)                            |
| Six (6)   | JUN 2 7 1988  | RES-86-113 dtd   | 1 4/   | 19/88  |  |  |
| S. ISSUED BY COD  | E   | 7. ADMINISTERED BY   | (110   | ther than Item   | 6) CODE                                    | · L  |
| U.S. Nuclear Regulatory Com<br>Division of Contracts<br>Washington, D.C. 20555  | mission   |  |  |  |  |  |
| NAME AND ADDRESS OF CONTRACTOR (  | io., street, county, State and  | ZIP Code)  | 10   | 9A. AMENDA   | MENT OF SO                                 | LICITATION NO.                                   |
|   |   |  | 1  |  |  |  |
| University of Arizona<br>Babcock Building, Room 331<br>Tucson, Arizona, 85721   | 3   |  |  | 98. DATED (  | SEE ITEM I                                 | <u>n</u>   |
| rueson, Arizona corer   |   |  | -  | 10A. MODIFI  | CATION OF                                  | CONTRACT/ORDE                                    |
|   |   |  |  | NO.  |  |  |
|   |   |  | X  | NRC-04   | -86-113                                    |  |
|   |   |  |  | 108. DATED   | (SEE ITEM                                  | 13)  |
| CODE  | FACILITY CODE   |  | 1  | 11/3   | /86  |  |
| 11. THIS IT   | EMONLY APPLIES TO   | AMENDMENTS OF S  | OLIC   | TATIONS  |  |  |
| 13. THIS ITEM /<br>IT MODIFIE<br>MI A. THIS CHANGE ORDER IS ISSUED PUR<br>TRACT ORDER NO. IN ITEM IOA.<br>B. THE ABOVE NUMBERED CONTRACT/<br>appropriation daik, etc.) SET FORTH IN<br>C. THIS SUPPLEMENTAL AGGEMENT I<br>Mutual agreement of the p   | APPLIES ONLY TO MOD<br>S THE CONTRACT/OR<br>ISUANT TO: (Specify outho<br>SUANT TO: (Specify outho<br>SUANT TO: (Specify outho<br>SUANT TO:<br>S ENTERED INTO PURSUA<br>arties | DIFICATIONS OF CON<br>DER NO, AS DESCRIE<br>OP(19) THE CHANGES SE<br>REFLECT THE ADMINIC<br>THE AUTHORITY OF FA  | NTRA<br>BED I<br>T FOR                         | ACTS/ORDER<br>N ITEM 14.<br>RTH IN ITEM 1<br>TIVE CHANGE<br>103(b).                  | ής,<br>a are mac<br>s (s. ch as ch         | DE IN THE CON-                                   |
| D. OTHI.R (Specify type of modification an  | d authority)  |  |  |  |  |  |
| E. IMPORTANT: Contractor is not,  | X is required to sign t<br>ATION (Organized by UCF)   | his document and return<br>section headings, including<br>Section CDesc  | rn<br>solie                                    | 3 copie<br>Itation/contract  | ificatio                                   | uing office.<br>(er where feasible.)<br>ons/Work |
| The purpose of this modificat<br>Statement as follows:  |   |  |  |  |  |  |
| The purpose of this modificat<br>Statement as follows:<br>1. Section C.1.2, <u>Contract</u><br>with the following in li   | <u>Objective</u> , is her<br>eu thereof:  | reby deleted in  | its<br>88                                      | entirety<br>0627   | and rep                                    | laced  |
| The purpose of this modificat<br>Statement as follows:<br>1. Section C.1.2, <u>Contract</u><br>with the following in li<br>"C.1.2 <u>Contract Object</u>  | <u>Objective</u> , is her<br>eu thereof:<br><u>ive</u>  | reby deleted in<br>8807080172<br>PDR CONTR<br>NRC-04-86-   | its<br>88                                      | entirety<br>0627<br>PNU  | and rep                                    | olaced   |
| The purpose of this modificat<br>Statement as follows:<br>1. Section C.1.2, <u>Contract</u><br>with the following in li<br>"C.1.2 <u>Contract Object</u><br>The objective of this co<br>capability to evaluate D  | <u>Objective</u> , is her<br>eu thereof:<br><u>ive</u><br>ntract is to prov<br>OE documents whic  | reby deleted in<br>BB07080172<br>PDR CONTR<br>NRC-04-86-<br>vide the NRC wit<br>ch address seali   | its<br>88<br>113<br>:h_a<br>ing                | entirety<br>0627<br>PNU<br>n indepen<br>of openin                                    | and rep<br>dent<br>gs in a                 | olaced   |
| The purpose of this modificat<br>Statement as follows:<br>1. Section C.1.2, <u>Contract</u><br>with the following in li<br>"C.1.2 <u>Contract Object</u><br>The objective of this co<br>capability to evaluate D<br>Except as provided herein, all terms and condition  | Objective, is her<br>eu thereof:<br>ive<br>ntract is to prov<br>OE documents which<br>sof the document reference  | reby deleted in<br>BB07080172<br>PDR CONTR<br>NRC-04-86-<br>vide the NRC wit<br>ch address seali   | its<br>88<br>113<br>th a<br>ing                | entirety<br>0627<br>PNU<br>n indepen<br>of openin                                    | and rep<br>dent<br>gs in a                 | olaced<br>nged and in full force                 |
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| The purpose of this modificat<br>Statement as follows:<br>1. Section C.1.2, <u>Contract</u><br>with the following in li<br>"C.1.2 <u>Contract Object</u><br>The objective of this co<br>capability to evaluate D<br>Except as provided herein, all terms and condition<br>and effect.<br>ISA, NAME AND TITLE OF SIGNER (Type or P<br>rames I, Wheeler<br>Assistant Vice President | Objective, is her<br>eu thereof:<br>ive<br>ntract is to prov<br>OE documents which<br>sof the document reference<br>r(nt)   | reby deleted in<br>BB070B0172<br>PDR CONTR<br>NRC-04-86-<br>vide the NRC wit<br>ch address seali<br>d in item 9A or 10A, as he<br>16A. NAME AND TITL<br>Timothy F. | its<br>88<br>113<br>th a<br>ing<br>teor<br>Hag | entirety<br>0627<br>PNU<br>n indepen<br>of openin<br>ore changed, rea<br>CONTRACTION | and rep<br>dent<br>gs in a<br>mains unchar | nged and in full force<br>R (Type or print)      |

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tuff repository for HLW. This project will emphasize welded tuff because the primary HLW repository formation is welded tuff."

Section C.1.3, <u>Scope of Work</u>, is hereby deleted in its entirety and replaced with the following in lieu thereof:

# "C.1.3 Scope of Work

2.

The work as specified shall be performed by the Contractor for a three year period. In the following tasks, an approach will be used which integrates field experience and experimentation, laboratory experimentation, and theoretical considerations to investigate current sealing methods and techniques for welded tuff. These investigations will be aimed at providing sufficient information and understanding to support informed licensing decisions and the preparation of NRC technical position papers. The tasks described below are intended to satisfy these objectives.

### Task 2--Detailed Work Plan

The Contractor shall prepare for review and approval by the NRC Project Manager a detailed work plan (including milestones and schedules) for accomplishing the study outlined in Tasks 3 and 4. This work plan shall be submitted no later than 1 month after modification documents are approved by the NRC and the University of Arizona.

The work plan shall identify and confirm that the Contractor has access to a welded tuff site with which to investigate the effectiveness of seals. The work plan shall be sufficiently detailed to include the number of tests, the length and diameter of seals, the sealant materials, etc., and should identify the experimental approach, theoretical methods and parameters to be examined for each task. The work plan shall provide for appropriate extrapolations of data from laboratory to field scale and consider physical and chemical interactions between seal materials and host rock and shaft liners.

#### Task 3--Laboratory Assessment of Seals

#### Subtask 3.1 Sealing Welded Tuff

Seals in welded to f shall be tested (e.g., constant and variable fluid pressure injection tests, dye-injection tests, push out tests) under the following conditions:

o Temperature: Ambient to 95°C (with Intermediate temperatures)

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- Pressure: Atmospheric and up to 10MPa (some intermediate stress levels shall be included)
- o Combined Temperature and Pressure Conditions
- Sealing Materials: Cements, earthen materials and crushed welded tuff
- o Testing fluids: Water and gas.

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## Subtask 3.2 Borehold Stability in Welded Tuff

The Contractor shall conduct experiments of the influence of lithophysae and density variations on borehold strength, stability and failure patterns. This will include a study of the potential for the development of flow paths parallel to the boreholes as a result of induced fractures. It will also include effects from preexisting fractures or swelling sealants. Tests to carry out the studies will include, but not be limited to, instrumented uniaxial tests, triaxial tests and polyaxial strength tests.

### Subtask 3.3 Fracture Grouting in Welded Tuff

Fracture grouting is likely to be required at the Yucca Mountain repository. One of the requirements for grouting is in the context of preventing flow from bypassing seals. The Contractor shall conduct a suite of experiments to assess the effectiveness of sealing fractures in tuff. The study should include the effect of stress on fracture permeability and the influence of different grout formulations on sealing effectiveness. The research should incorporate some of the recommendations discussed under fracture study experiments in basalt, reported under NUREG/CR-4541. Specifically, the study should assess the effectiveness of grouting both natural and tensile undirected fractures and should take into account the geometry of the fractures.

#### Task 4--In-situ (Field) Assessment of Borehold Seals

Shallow holes (up to 30 feet deep) shall be drilled, sealed and tested at a welded tuff site. Sealing materials shall be selected based on laboratory test results. Flow testing shall be conducted with water and/or gas. Tracer tests shall also be performed to determine travel times.

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An evaluation of the physical and chemical properties of the host rock in the drilled holes shall be accomplished and the data shall be used in selecting the sealant materials. Rock tests to be conducted include classification tests, index properties, strength properties including dynamic moduli, thermal properties, petrographic analyses, creep, and permeability and porosity characteristics."

All other terms and conditions of this cooperative agreement including the total ceiling amount of \$728,982.25, remain unchanged.