SAND2018-4673R

Project Plan: Salt in Situ Heater Test

Spent Fuel and Waste Disposition

Prepared for
U.S. Department of Energy
Spent Fuel and Waste Science and Technology

Sandia National Laboratories
Los Alamos National Laboratory
Lawrence Berkeley National Laboratory

April 30, 2018

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories

SUMMARY

This project plan gives a high-level description of the US Department of Energy Office of Nuclear Energy (DOE-NE) Spent Fuel and Waste Disposition (SFWD) campaign *in situ* borehole heater test project being planned for the Waste Isolation Pilot Plant (WIPP) site This plan provides an overview of the schedule and responsibilities of the parties involved. This project is a collaborative effort by Sandia, Los Alamos, and Lawrence Berkeley National Laboratories to execute a series of small-diameter borehole heater tests in salt for the DOE-NE SFWD campaign. Design of a heater test in salt at WIPP has evolved over several years. The current design was completed in fiscal year 2017 (FY17), an equipment shakedown experiment is underway in April FY18, and the test implementation will begin in summer of FY18.

The project comprises a suite of modular tests, which consist of a group of nearby boreholes in the wall of drifts at WIPP. Each test is centered around a packer-isolated heated borehole (5" diameter) containing equipment for water-vapor collection and brine sampling, surrounded by smaller-diameter (2" diameter) satellite observation boreholes. Observation boreholes will contain temperature sensors, tracer release points, electrical resistivity tomography (ERT) sensors, fiber optic sensing, and acoustic emission (AE) measurements, and sonic velocity sources and sensors. These satellite boreholes will also be used for plugging/sealing tests. The first two tests to be implemented will have the packer-isolated borehole heated to 120°C, with one observation borehole used to monitor changes. Follow-on tests will be designed using information gathered from the first two tests, will be conducted at other temperatures, will use multiple observation boreholes, and may include other measurement types and test designs.

This project plan satisfies SFWST milestone M3SF-18SN010303033, as part of the SNL "Salt Disposal R&D" work package.

REVISION HISTORY

Rev.	Date	Reason
0	April 30, 2018	Initial version

CONTENTS

ACRONYMS

AE	acoustic emissions
BCP	baseline change proposal
CBFO	DOE-EM Carlsbad Field Office
DOE	Department of Energy
DOE-EM	DOE Office of Environmental Management
DOE-NE	DOE Office of Nuclear Energy
DRZ	disturbed rock zone
ERT	electrical resistivity tomography
EVMS	earned value management system
FY	fiscal year
IPT	integrated project team
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
M&O	Management and Operations
NWP	Nuclear Waste Partnership (WIPP M&O contractor)
PICS:NE	Project Information Collection System: Nuclear Energy
QA	quality assurance
RTD	resistive temperature device
SDI	salt disposal investigations
SNL	Sandia National Laboratories
SFWD	Spent Fuel and Waste Disposition
SFWST	Spent Fuel and Waste Science and Technology
TCO	test coordination office
THMC	thermal-hydraulic-mechanical-chemical
U.S.	United States
WBS	work breakdown structure
WIPP	Waste Isolation Pilot Plant

1. INTRODUCTION

1.1 Field Test Project Motivation

The long-term goals of the DOE-NE Spent Fuel and Waste Disposition (SFWD) campaign field-testing project for salt are related to the permanent isolation safety case for disposal of heat-generating radioactive waste in a generic salt repository concept. This borehole heater test is one component of the field-testing campaign, focused on the quantification of brine inflow and composition (Stauffer et al., 2015; Kuhlman et al. 2017; Johnson et al. 2017b). The transient evolution of brine inflow and the brine composition after excavating a drift or borehole are initial conditions relevant to the long-term performance assessment of a generic salt repository system. This field test is being conducted within the context of the larger testing program for generic salt systems, which includes laboratory testing and larger conceptual field testing. The goals of this field test are to:

1) improve understanding of brine availability and brine composition in bedded salt;
2) collect datasets for parameterizing numerical models, populating constitutive models, and generally improving process understanding;
3) improve understanding of bedded salt acid vapor generation mechanisms during heating; and
4) rebuild in-house expertise for implementing *in situ* experiments in salt.

The proposed borehole heater tests are comprised of relatively low-cost repeatable tests performed across a set of adjacent boreholes (one central heater borehole and multiple surrounding observation boreholes). Heated tests will be used to assess changes in physical-chemical properties associated with brine and vapor liberation and migration at elevated temperature. These borehole tests will include international collaboration on model prediction, validation, and follow-on test design.

The main focus of the first round of borehole heater tests is brine availability to better understand how much brine may flow into an excavation (e.g., borehole or room). Brine potentially leads to waste package corrosion, limits closure of brine-filled cavities, or facilitates radionuclide transport. In a generic salt repository for "hot" radioactive waste (e.g., above brine boiling temperature at the waste package surface) water vapor will in general be driven away from hot waste packages, while brine will still migrate towards the excavation. A convection process may set up around the waste, driving salts to precipitate near the waste package and creep closure will reconsolidate backfill and close gaps around the waste package to create a relatively dry, intact, low-permeability zone around the waste packages. As the radioactive decay heat decreases, the temperature will drop below the brine boiling temperature, and additional liquid may then migrate back toward the waste packages. However, the low-permeability salt surrounding the heater will minimize the amount of brine that can flow from the far field to the waste packages. Knowledge of brine availability and brine composition facilitates understanding long-term behavior of consolidated salt around waste packages and possible brine-radionuclide interactions that may affect transport.

In all salt disposal systems, the far-field ultra-low permeability of the salt provides the primary natural barrier that contains radioactive waste over performance assessment relevant time scales (10^4 to 10^6 years). Salt creep closes open excavations and fractures in the near field that could facilitate transport. This borehole heater project is focused on the quantification of inflow rates and brine composition in the near field (at scales of cm to m from heat source) at relatively short time scales (weeks to months). This is essentially to improve process understanding and to develop an initial condition in the long-term performance of a generic salt repository system, for which we have great confidence in its ability to provide isolation from the shallow geosphere.

1.2 Field Test Project Description

The project is primarily focused on brine availability to a small-diameter (10 to 15 cm [4" to 6"]) horizontal borehole. Understanding the amount of brine available to flow into such a borehole and a relevant excavation in a generic salt repository involves understanding: 1) the sources of brine in salt, and 2) the mechanism of brine migration through the disturbed rock zone (DRZ) surrounding an excavation at ambient and elevated temperatures. Each test will collect unique data on the time-variable brine composition. Brine composition will reflect the transport of multiple types of brine present in a bedded salt formation (e.g., intragranular fluid inclusions, intergranular brine, water evolved from hydrous minerals). This horizontal borehole heater test will quantify relevant thermal-hydrological-mechanical-chemical (THMC) processes in salt, which will be upscaled to the drift scale. The main benefit of a horizontal test interval is avoidance of mapped clay or anhydrite layers. Temperature, brine inflow rate and composition, resistivity, acoustic emission, and gas samples will be collected to develop validation datasets for existing and future of numerical models. The project is designed to produce data for conceptual process validation, rather than as part of a more complex disposal demonstration (e.g., DOE CBFO 2011 & 2013).

Each test will have a central packer-isolated borehole with smaller-diameter satellite observation boreholes drilled around the heater borehole (Figure 1; Kuhlman et al. 2017). The heater borehole will be used to quantify brine inflow by circulating dry nitrogen gas through the packer-isolated borehole, while monitoring the humidity and temperature of the gas stream leaving the borehole. The observation boreholes will include the ability to monitor evolution of the salt resistivity, temperature, and strain through electrical resistivity tomography (ERT) and fiber optic sensing, and the salt mechanical properties through ultrasonic wave velocity and acoustic emission (AE) sensors. Both gas and liquid samples will be collected from the heated borehole to monitor brine composition and tracer (deuterated water) migration through the salt.

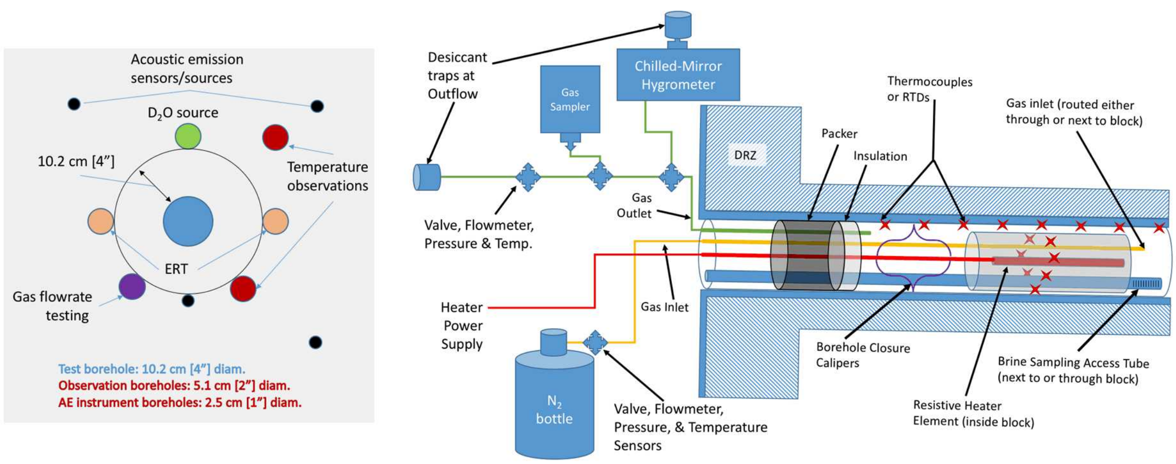

Figure 1. Borehole layout view (left) and longitudinal cross-section view (right) of typical heater test. Note: not to scale.

As of April 2018, equipment testing is underway in existing (> 4 yr old) horizontal WIPP boreholes in drift E-140, having started in February 2018 with test installation and pressurization of the packer system. This system was developed following the test plan as best as possible (Johnson et al. 2017b), but is being implemented with available materials, boreholes, and limited budget. The test will include: dry nitrogen gas circulation with a humidity gage (not a chilled-mirror hygrometer in the initial test) and gas sampling to measure water inflow, a heater at 120° C, and a sampling port for collecting liquid brine samples. The data collected from these existing boreholes will be preliminary compared to data collected from new boreholes, as the existing boreholes are no longer circular in cross-section and the potential initial pulse of brine inflow (~first year after drilling) has long passed. However, these serve well as the test bed for equipment assessment. A test of LBNL's ERT system will also be conducted before testing in newly drilled boreholes. Measurements of the internal borehole temperature, using thermocouples or resistance temperature detectors (RTDs), and closure, using a borehole closure caliper, will also be made. This initial test in existing boreholes is mainly an equipment and personnel dry-run to maximize the likelihood of collecting useful data in new boreholes.

New groups of boreholes will be drilled at WIPP for executing the heater tests. Each group of boreholes will include a central 5” [12.7 cm] diameter collection borehole 10 to 20 feet [3 to 6.1 m] long, and several 2” diameter observation boreholes. Observation boreholes will be used to measure temperature; conduct ERT; measure temperature, acoustic, and strain using fiber-optic based sensors; and emplace tracers. These measurements are described in greater detail in Stauffer et al. (2015). Using new boreholes, two test will be instrumented around packers, boreholes closure instruments, and brine collection systems. One of the tests will set the central heater at (120° C) and the other test will be at ambient (~30° C). These tests will run concurrently to demonstrate the effects the heat has on brine availability, brine chemistry, borehole closure, acoustic emissions, and acid vapor generation.

2. MANAGEMENT STRUCTURE

The salt heater test project is relatively small in scope and, therefore, has a somewhat informal structure. It is managed as part of the DOE-NE Spent Fuel and Waste Science and Technology (SFWST) Program. Sandia National Laboratories (SNL) serves as the project management lead, while Los Alamos National Laboratory (LANL) Carlsbad serves as the underground testing coordinator. SNL, LANL, and Lawrence Berkeley National Laboratory (LBNL) are all contributing to test design and implementation. Site preparation work will be conducted by the WIPP management and operations (M&O) contractor Nuclear Waste Partnership (NWP). Additional staff from those listed below may be involved in aspects of the project, but the staff that have been working on the project to date are listed.

2.1 Roles and Responsibilities

Sandia National Laboratories (SNL) Project Manager

- Responsible and accountable to DOE for executing the Project within scope, cost, and schedule in a safe and responsible manner
- Provides Project technical guidance to collaborating team members
- Provides access to SNL resources, systems, and capabilities required to execute the Project
- Represents the Project in interactions with the DOE and international partners, participates in management meetings with DOE, and communicates Project status and issues
- Identifies and manages Project risks
- Designs and builds components of the Project related to borehole closure, acoustic emissions, ultrasonic wave velocity, and brine sampling
- Designs and builds engineered barrier system (EBS) components of the Project
- Performs laboratory analyses and characterization on salt and brine samples
- Work with the TCO for the development of job hazard analyses and work control documentation necessary to conduct work in the WIPP underground
- Work within the controls established by the test plans and work authorization documentation to implement and operate the testing programs
- Provides personnel for underground installation of experimental equipment

Involved SNL staff: Kris Kuhlman, Melissa Mills, Courtney Herrick, Ed Matteo

Los Alamos National Laboratory Carlsbad Office (LANL-CO) WIPP Underground Test Coordination Office (TCO)

- Provides interface role between Project and US Department of Energy Office of Environmental Management (DOE-EM) Carlsbad Field Office (CBFO) and WIPP M&O contractor
- Provides implementation technical guidance to collaborating team members
- Designs and builds temperature sensing, data acquisition, and on-site control aspects of Project
- Provides access to TCO and WIPP resources, systems and capabilities required to execute the Project
- Provides the mechanism to deliver project funds to the WIPP M&O contractor for drilling new boreholes
- Collects and distributes data from the automated Data Acquisition Systems as coordinated with the National Laboratory project staff
- Provides on-site sample collection and sample control processes and resources as requested by

the National Laboratories project staff

- Develop (with the National Laboratories) appropriate work authorization and work control documentation for testing activities (for NWP review/acceptance), compliant with national laboratory and NWP requirements, to ensure the safe and consistent conduct of physical scientific work activities in the WIPP underground.

Involved LANL-CO staff: Doug Weaver, Shawn Otto, Brian Dozier

Los Alamos National Laboratory (LANL)

- Provides access to LANL resources, systems, and capabilities required to execute the Project
- Performs numerical modeling of thermal-hydrological-chemical system to design experiments, locate thermal measurement locations, and interpret results of the Project
- Designs and builds heater, gas handling, and packer components of the Project
- Performs laboratory analysis of brine and gas samples
- Work with the TCO for the development of job hazard analyses and work control documentation necessary to conduct work in the WIPP underground
- Work within the controls established by the test plans and work authorization documentation to implement and operate the testing programs
- Provides personnel for underground installation of experimental equipment
- Participates in interactions with the DOE and international partners

Involved LANL staff: Phil Stauffer, Hakim Boukhalfa, Peter Johnson

Lawrence Berkeley National Laboratory (LBNL)

- Provides access to LBNL resources, systems, and capabilities required to execute the Project
- Performs numerical modeling of the thermal-mechanical-hydrological system to design the test and interpret results of the Project
- Design and build geophysical (ERT, fiber optics-based temperature, acoustics, and strain) monitoring components of the Project
- Conduct necessary laboratory tests to support field geophysical monitoring efforts in of the Project
- Work with the TCO for the development of job hazard analyses and work control documentation necessary to conduct work in the WIPP underground
- Work within the controls established by the test plans and work authorization documentation to implement and operate the ERT systems
- Participates in interactions with the DOE and international partners

Involved LBNL staff: Jonny Rutqvist, Yuxin Wu

Nuclear Waste Partnership (NWP) site M&O Contractor

- Works through the WIPP Underground Test Coordination Office
- Cores and prepares new horizontal boreholes for Project
- Prepares required underground infrastructure for Project including appropriate ventilation, ground control, lighting, communications, and electrical in accordance with applicable budget authorization and/or Contracting Officer direction.
- Provides axillary services required to conduct the Project including underground access, hoisting,

training, work control, lockout/tagout, environmental, safety and health, industrial hygiene, survey, and infrastructure maintenance.

2.2 Team Interfaces and Safety

It is mandatory that all WIPP underground science program participants and personnel performing work associated with the science and testing activities in the WIPP underground and on the WIPP site abide by the NWP guidelines and requirements referenced in the Integrated Project Team (IPT) Charter for Science and Testing Activities in the WIPP Underground (DOE 2016). Scientists and personnel associated with the underground test programs are not only responsible for their own health and safety, but are also responsible for the safety of fellow employees, and for the safe operation of the experiment, not precluding TCO and NWP oversight of the scientific work. The CBFO holds NWP accountable for safe operations at the WIPP and gives NWP authority to enforce safety rules and policies on all WIPP science participant organizations.

Work within the WIPP facility is strictly controlled to ensure safety and quality. This is accomplished primarily through an integrated work control and authorization process. All scientific testing activities conducted in the WIPP underground will be conducted under a work control package created in accordance with the process described in the IPT Charter (DOE 2016). The process ensures that planned science work scope is appropriately reviewed, authorized, scheduled, released for work, and integrated with the underground controller and field work supervisor for access and support in the underground.

3. INTEGRATED PROJECT BASELINE

3.1 Scope

The salt heater test project has the technical goals to 1) improve understanding of brine availability and brine chemistry in bedded salt; 2) collect datasets for parameterizing numerical models, populating constitutive models, and improving process model understanding; and 3) collect field data to improve understanding of acid vapor generation mechanisms. The project has the additional programmatic goal to rebuild in-house expertise at participating national laboratories in implementing *in situ* experiments in salt.

The technical justification and background relevant to these tests is laid out in Stauffer et al. (2015) and Kuhlman et al. (2017) and the design of the experiments is given in Johnson et al. (2017b). The following is a high-level summary of ongoing and planned activities in FY18 and FY19 work breakdown structure (WBS).

3.1.1 Instrumentation Dry Run (WBS 1.1)

The instrumentation dry-run is currently underway and is being conducted in existing boreholes in drift E-140 (see Figure 2 for location). This testing is being performed to test equipment and procedures, as well as getting personnel experience working in the WIPP underground. One of the existing boreholes is being instrumented with a packer, heater, borehole closure gage, temperature sensors, and gas flow system. The heater that will operate at 120°C. Both gas and liquid samples will be collected to monitor brine availability, composition, and migration through the salt. The test will include dry nitrogen gas circulation with a humidity gage and gas sampling to measure water inflow, and a sampling port for collecting liquid brine samples. An ERT system, to measure the change in salt resistivity, is being tested in a different, but nearby, location to minimize the effects of chain-link fencing and rock bolts that exist near the boreholes in the wall of drift E-140. Measurements of the internal borehole temperature, using thermocouples or resistance temperature detectors (RTDs), and closure, using a borehole closure caliper, are also being performed.

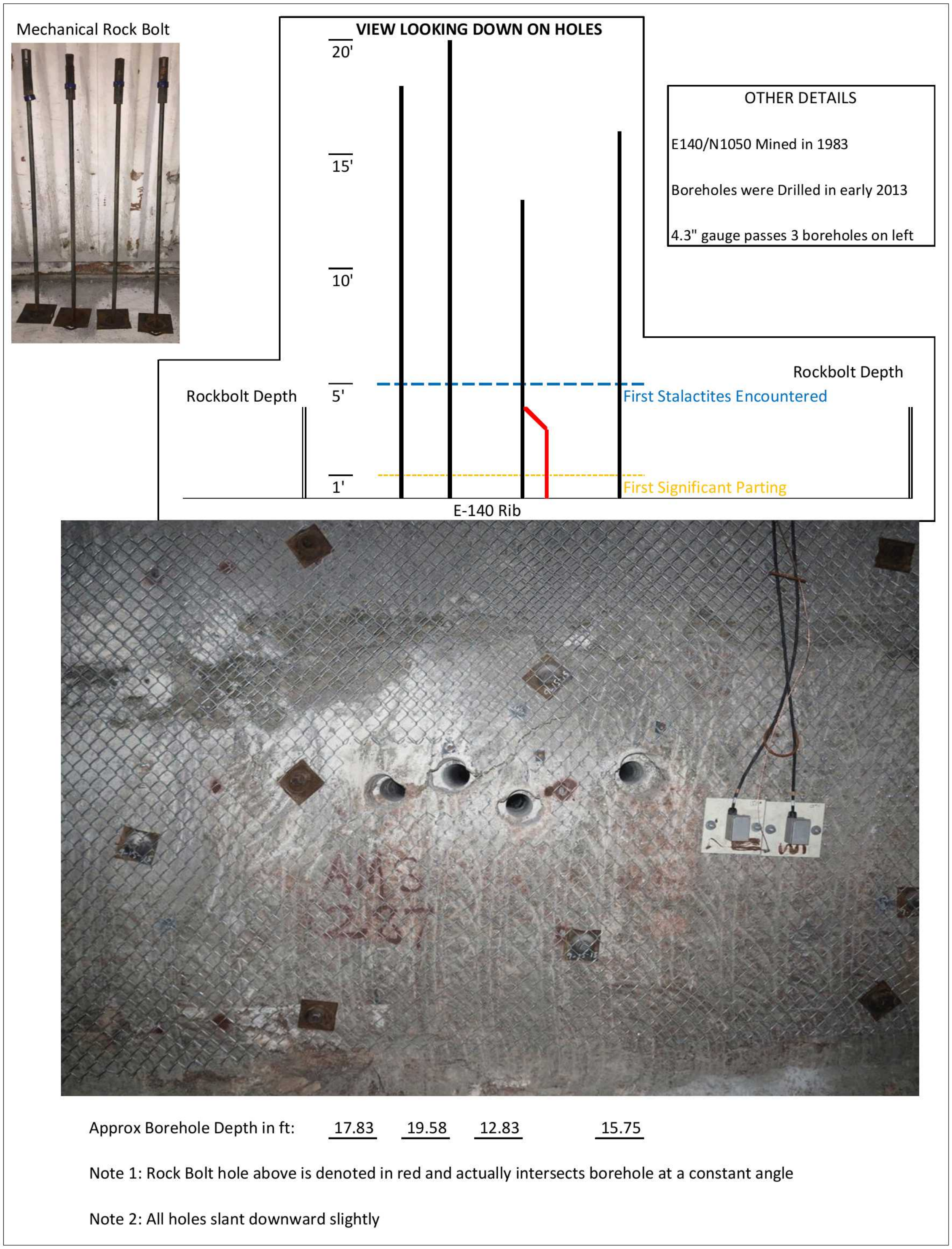

Figure 2. Configuration of existing boreholes in drift E-140 at WIPP (Johnson et al. 2017b)

3.1.2 Borehole Tests in New Boreholes (WBS 1.2)

Several groups of new boreholes will be cored, with preference for location in the salt disposal investigations (SDI) experimental area (see red shaded portion of "SDI AREA" on Figure 3), but this depends on NWP and the reconfiguration of ventilation to allow access to this area.

Initially, two parallel tests will be conducted using two sets of boreholes (as many as 5 sets of boreholes will be drilled to maximize utilization of drilling crew capabilities), where each set will consist of a larger-diameter borehole for sampling and heating, and a number of smaller-diameter observation boreholes. The tests in new borehole sets will follow the plan of Johnson et al. (2017b), while incorporating lessons learned from the instrumentation dry run test.

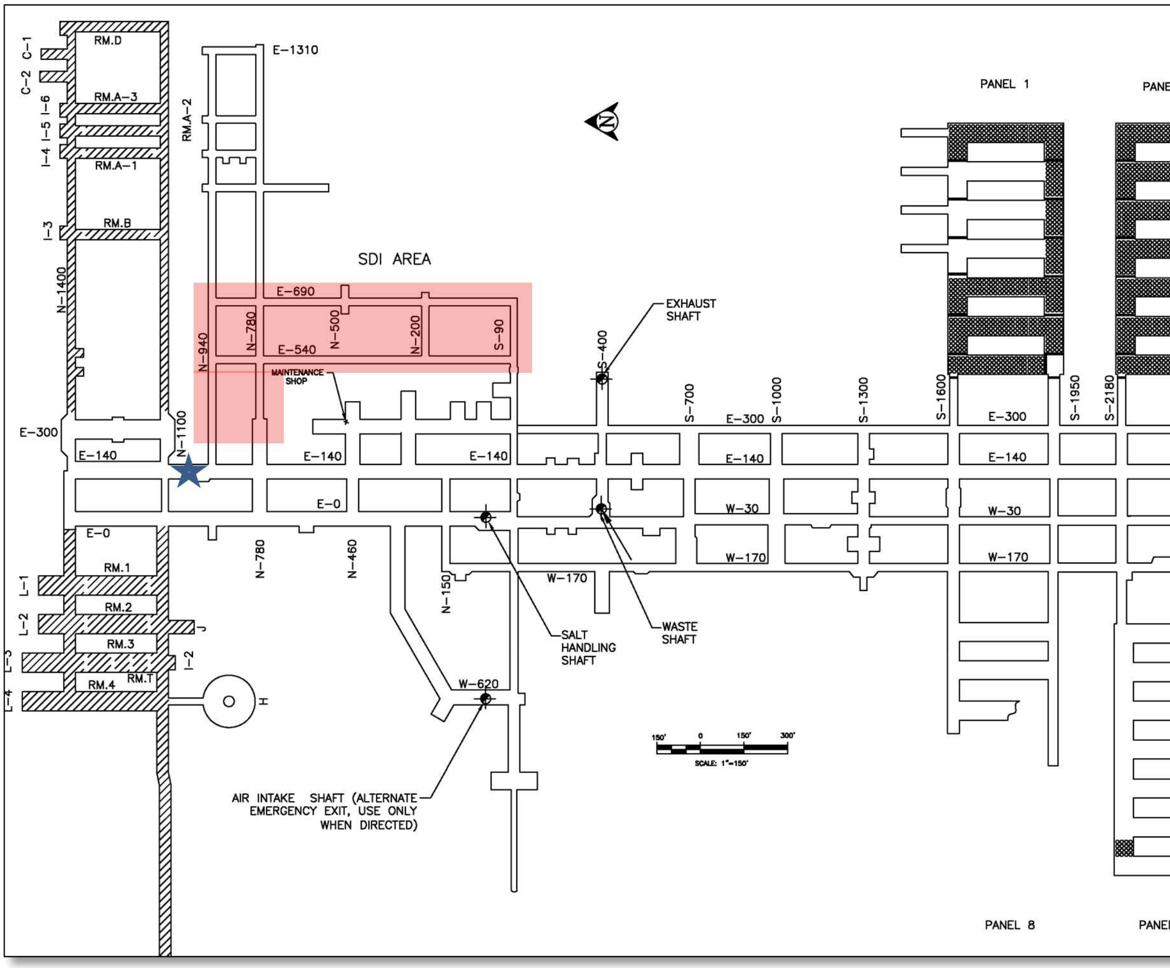

Figure 3. Preferred locations for new boreholes in red. Existing boreholes located at blue star.

3.1.3 Laboratory Analyses (WBS 1.3)

Salt samples (i.e., cores and salt precipitate samples from boreholes) will be analyzed to characterize the effect heating and brine flow have on the salt, and to characterize the salt geochemistry precipitated from brine entering the hole during the test. Brine samples will be analyzed for dissolved constituents, including isotopes and pH, and standard physical properties (e.g., density, electrical conductivity). Gas samples will be analyzed for composition (including isotopes). Salt cores taken before and after the tests will be analyzed to determine the change in electrical resistivity, ultrasonic wave velocity, frequency, amplitude, energy, and rate with increasing temperature. Sonic velocity changes are a sensitive method of assessing the degree of fracturing or healing that has occurred within the samples and will be used to interpret *in situ* data collected around the boreholes. Samples will be analyzed from salt cores to determine changes in porosity and salt mineralogy.

3.1.4 Pre- and Post-Test Modeling (WBS 1.4)

Numerical modeling has already been conducted (Johnson et al. 2017a; Rutqvist et al. 2017) and these models will continue to be updated to match the actual geometry and boundary conditions encountered during the tests. The numerical model predictions will be used to help locate sensors and design test durations, interpret the data, motivate additional model capability developments, and facilitate integrating the results in to the geologic disposal systems analysis program.

3.1.5 Follow-on Tests (WBS 1.5)

The instrumentation dry-run is being performed to provide experience to improve the first two heater tests in new boreholes for the Project. Results from these first two new borehole tests will lead to revised and improved test design for follow-on tests. While fielding multiple tests simultaneously increases equipment costs (i.e., multiple packer or data logger systems), waiting to begin additional tests until the first tests finish will allow the boreholes to age before the beginning of the experiments. This task includes planning for additional tests, and monitoring/preserving new boreholes until later tests are conducted in them, to increase their likelihood of producing good data (e.g., sealing boreholes from mine ventilation with plugs).

3.1.6 International Collaborations (WBS 1.6)

Working with existing foreign partners made through the US/German workshops (e.g., Institut für Gebirgsmechanik (IfG), Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), and Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in Germany, and Centrale Organisatie Voor Radioactief Afval (COVRA) in The Netherlands), we will strive to increase the impact of our work by seeking input and feedback during all aspects of the test development and implementation. International collaborations will involve participating in numerical model benchmarking exercises and sharing data with interested parties.

3.2 Schedule

The following schedule (Table 1) shows a high-level summary of planned execution of the first two parallel tests in new boreholes, which will be conducted in FY18 and FY19. The instrumentation dry-run is taking place in FY18, while new boreholes will be drilled as soon as possible in FY18, with implementation beginning in summer of FY18 and continuing into FY19. Planning and preparations for follow-on tests will begin in the second half of FY19. Laboratory analysis, modeling and international collaborations will continue throughout the life of the project.

Table 1. Projected Borehole Heater Test Schedule Components

		FY18		FY19			
WBS	**Work Scope Element**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1.1	Instrumentation Dry Run						
1.2	First Two Tests in New Boreholes						
1.3	Laboratory Analyses						
1.4	Pre- and Post-Test Modeling						
1.5	Follow on Tests						
1.6	International Collaborations						

3.3 Costs

Lumped costs across all partners (including all the National Laboratories and NWP) for the different WBS elements of the program are given in Table 2.

Table 2 Projected Borehole Heater Test Costs ($K) across SNL, LANL & LBNL

WBS	Work Scope Element	FY18	FY19	FY20	Total
1.1	Instrumentation Dry Run	300			**300**
1.2	First Two Tests in New Boreholes	300	800	200	**1200**
1.3	Laboratory Analyses	200	300	200	**700**
1.4	Pre- and Post-Test Modeling	300	400	400	**1100**
1.5	Follow on Tests		100	400	**500**
1.6	International Collaborations	100	100	100	**300**
Total		1200	1700	1300	**4200**

3.4 Baseline Change Control

This project will be managed using the Project Information Collection System: Nuclear Energy (PICS:NE). The Baseline Change Proposal (BCP) process is managed within PICS:NE.

4. PROJECT MANAGEMENT

4.1 Project Reporting

The SNL Project Manager will report periodically to DOE-NE to provide updates on project progress and to discuss and resolve issues. Monthly status reports will be entered into the PICS:NE system as required. Each partner's financial system will provide required information related to project budget and costs to the PICS:NE system.

4.1.1 Earned Value Management System (EVMS)

SNL corporate EVMS, consistent with the PICS:NE EVMS guide, will be used, as necessary, to manage, control, analyze and report on the project. EVMS is not required for acquisition of commercial products that are designed and built from commercial off-the-shelf technology.

4.2 Risk Management

Risk Management is an essential element of this project. Risk assessments will be started early in the project lifecycle and will identify critical technical scope, cost, and schedule risks. Many risks can impact multiple aspects of the project. As risks are identified, they will be assessed, prioritized, and monitored by all the technical partners participating in the Project. Where necessary, risk mitigation strategies and actions will be developed, documented, and implemented to mitigate and disposition risks. Some general areas of risk that will be considered are listed below:

- **Technical Scope Risk** – The project includes significant research and development and thus has a high level of technical uncertainty. Independent technical reviews will be performed as appropriate, to minimize technical risks.
- **Cost/Budget Risk** – The funding and budgeting of a federal activity are subject to changes (e.g., availability of funds, continuing resolutions (CRs), congressional action, changes in Administration).
- **Schedule Risk** – As the project proceeds, delays can occur (e.g., equipment failure and technical development). There may also be schedule delays involved in the procurement process or impacts associated with changes in schedule driven by WIPP's disposal operations role.

4.3 Environmental and Regulatory Compliance

This work will operate under existing National Environmental Policy Act framework in place at WIPP and each of the participating laboratories. Additional permitting is not expected, beyond internal environmental safety and health requirements at WIPP.

4.3.1 Integrated Safety Management

Integrated Safety Management is addressed through the each participating partners' "Integrated Safety Management System." These activities will follow the guidelines and principles of integrated safety management. Section 2.2 discusses safety and training that is required by WIPP and will be coordinated through the TCO.

4.4 Configuration Management

A configuration management process will be established that controls changes to the physical configuration of project equipment, structures, and systems in compliance with DOE standards. This process ensures that the configuration is in agreement with the performance objectives identified in the technical baseline and the approved Quality Assurance (QA) plan.

A configuration management system will identify and document the configuration of the end products (e.g., samples and equipment) and control configuration changes during the life cycle.

4.5 Records Management/Document Control

Existing partner corporate processes will be utilized to control preparation, review, comment resolution, approval, issuance, use, and revision of documents that establish policies, prescribe work, and specify requirements.

The principle project controlled documents include contract documents, the Project Plan, Milestone reports, work authorizations, design specifications, compliance documents, QA and Environment, Safety, and Health Plans, and the BCP log including disposition.

4.6 Quality Assurance

QA is an integral part of effective project management and will be employed throughout the design, procurement, and construction of the project. The Project QA Plan will be based on each partner's corporate QA plan and the Spent Fuel Waste Science & Technology (SFWST) Program QA Plan (SNL 2018) and QA program document (DOE 2017). QA requirements will apply to all team members performing work on the project. A graded approach based on importance and significance of activities will be utilized in the application of standards.

In addition, national codes and standards will be followed throughout as applicable. Quality control will be required for the purchase, construction, and/or fabrication of essential components.

4.7 Project Closeout

When the project nears completion, project closeout activities will be identified and implemented. The following activities will be considered for project close out:

- Completion of contract obligations, products, services, and deliverables;
- Proper dispositioning of excess equipment and associated components;
- Determination for long-term use of boreholes; and
- Documentation of project lessons learned.

5. REFERENCES

DOE Carlsbad Field Office (CBFO), 2011. *A Management Proposal for Salt Disposal Investigations with a Field Scale Heater Test at WIPP*. DOE/CBFO-11-3470. Carlsbad, NM: U.S. Department of Energy Office of Environmental Management.

DOE Carlsbad Field Office (CBFO), 2013. *Test Specification for the Salt Defense Disposal Investigations Thermal Test in WIPP*. DOE/CBFO-13-3510. Carlsbad, NM: U.S. Department of Energy Office of Environmental Management.

DOE Carlsbad Field Office (CBFO), 2016. *Interim Charge Notice #1 to DOE/CBFO-13-3515, Science and Testing Activities in the Waste Isolation Pilot Plant Underground Underground Integarated Project Team Charter*. DOE/CBFO-13-3515. Carlsbad, NM: U.S. Department of Energy Office of Environmental Management.

DOE Office of Nuclear Energy (DOE-NE), 2017. Nuclear Technology Research and Development (NTRD) Quality Assurance Program Document, Rev. 4 (Effective Date: 07/05/2017). U.S. Department of Energy Office of Nuclear Energy.

Johnson, P.J., S.M. Bourret, H. Boukhalfa, F.A. Caporuscio, G.A. Zyvoloski, D.J. Weaver, S.Otto, & P.H. Stauffer, 2017a. *Experiments and Modeling to Support Field Test Design.* SFWD-SFWST-2017-000102, LA-UR-17-27759. Los Alamos National Laboratory.

Johnson, P.J., H. Boukhalfa, D.J. Weaver, S. Otto, B.L. Dozier, P.H. Stauffer, M.M. Millis, E.N. Matteo, K.L. Kuhlman, J. Rutqvist & Y. Wu, 2017. *Test Plan Document for Thermal Testing in Salt*. SFWD-SFWST-2017-000043, LA-UR-17-30762. Los Alamos National Laboratory.

Kuhlman, K.L., M.M. Mills & E.N. Matteo, 2017. *Consensus on Intermediate Scale Salt Field Test Design*. SFWD-SFWST-2017-000099, SAND2017-3179R. Sandia National Laboratories.

Rutqvist, J., M. Hu, L. Blanco-Martin & J. Birkholzer, 2017. *Coupled THM Modeling in Support of a Phased Salt Field Test Plan*. SFWD-SFWST-2017-000103, LBNL-2001023. Lawrence Berkeley National Laboratory.

Sandia National Laboratories (SNL), 2018. *Sandia National Laboratories QA Program Interface Document for NTRD/SFWD Activities.* FCRD-TIO-2011-000032 Rev. 7 (Effective Date: 02/28/2018). Sandia National Laboratories, Albuquerque, NM.

Stauffer, P.H., A.B. Jordan, D.J. Weaver, F.A. Caporuscio, J.A. Tencate, H. Boukhalfa, B.A. Robinson, D.C. Sassani, K.L. Kuhlman, E.L. Hardin, S.D. Sevougian, R.J. MacKinnon, Y. Wu, T.A. Daley, B.M. Freifield, P.J. Cook, J Rutqvuist & J.T. Birkholzer, 2015. *Test Proposal Document for Phased Field Testing in Salt*, FCRD-UFD-2015-000077, LA-UR-15-23154. Los Alamos National Laboratory.