# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

**TRIP REPORT**

**SUBJECT:** Devils Hole Workshop
Project No. 20.06002.01.272
AI No. 20.06002.01.272.603

**DATE/PLACE:** April 26–28, 2006
Death Valley National Park, California

**AUTHORS:** A. Sun, S. Colton, and J. Winterle

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**PERSONS PRESENT:**

James Winterle, Alexander Sun, and Shannon Colton of the Center for Nuclear Waste Regulatory Analyses (CNWRA); Neil Coleman and Eugene Peters of Nuclear Regulatory Commission (NRC); and approximately 100 other attendees with interest in the Death Valley ecology and regional groundwater flow system.

**BACKGROUND AND PURPOSE OF TRIP:**

The Devils Hole Workshop is an annual event that provides a forum for scientists and natural resource managers to exchange information on issues related to the Death Valley regional groundwater flow system. Posters and presentations for this particular workshop covered a variety of recent ecological and hydrologic studies in the area, water rights issues, environmental programs and policies, and information about the endangered Devils Hole Pupfish (*Cyprinodon diabolis*).

**SUMMARY OF PERTINENT POINTS AND ACTIVITIES:**

On the morning of April 26, 2006, prior to the start of the Devils Hole Workshop, the Nye County Nuclear Waste Repository Project Office held a meeting entitled Determination of the First Horizontal Well Location for Improved Aquifer Characterization and Monitoring Near Yucca Mountain. It was attended by many of the same people who would attend the Devils Hole Workshop. John Campanella and Jamie Walker described the project and showed potential locations for the first horizontal well, then solicited comments from the audience. The goals for the horizontal wells are to reduce uncertainty in geologic and hydrologic properties of the faulted volcanic tuffs by intersecting faults in the saturated zone, quantifying faults and fractures, obtaining geophysical measurements, obtaining hydrogeologic properties, and allowing for future access and long-term monitoring. According to the current plan, a top-drive single drilling rig will drill a 31.11 cm [12.25 in] hole to 30 m [100 ft] below the water table, and use the Nye County standard geophysical logging suite. Instruments will include a fullbore formation micro-imager, dipole shear imager, elemental capture spectrometer, natural gamma spectroscope, and an advanced nuclear-resistivity logging string. No core samples will be obtained, only cuttings. Several participants at the meeting seemed to agree that a preferred location for the horizontal borehole would be in the vicinity of the intersection of the Dune Wash, Bow Ridge, and Paintbrush Canyon faults, but an exact location was not chosen.

Among presentations at the Devils Hole Workshop itself, Neil Coleman discussed NUREG–1710. This is a three volume series that described (1) the chronology of population growth and agricultural development in the Amargosa Desert area of Nye County during the past 150 years; (2) events affecting water resources development within the Nevada Testing Site; and (3) the timing and rate of well-drilling activity in the Amargosa Desert, Crater Flat, and Jackass Flats. The first sources of fresh water that were used by humans in the area were the Ash Meadows springs. More than 1,200 boreholes have been drilled in the Amargosa Desert area since 1906. Sustained drilling has occurred from the 1950s to present for domestic purposes, irrigation and stock use, testing and monitoring, commercial, industrial, and other uses.

Thomas Buqo, a consulting hydrogeologist, presented Regional Versus Local Groundwater Conditions in the Yucca Mountain Region. Buqo remarked that published potentiometric maps of the Yucca Mountain region were unsuitable for identifying the extent of capture zones associated with public water supply wells in the Pahrump Valley and all county-operated systems in the Amargosa Desert. To determine drawdown at the local scale for developing wellhead protection plans, potentiometric maps were developed based on hand-drawn contours. Buqo noted that these local-scale potentiometric maps are consistent with the U.S. Geological Survey transient simulations of groundwater withdrawals in the Death Valley regional groundwater flow system.

Barry Freifeld of the Lawrence Berkeley National Laboratory presented A Novel Installation for Geochemical and Hydrological Monitoring at NC–EWDP–24PB. Borehole NC–EWDP–24PB is located within Amargosa Valley, west of Fortymile Wash and south of Highway 95, along potential flow paths where the Bullfrog and Tram tuffs are shallow. The borehole is the subject of a two-year intensive sampling project by the U.S. Department of Energy (DOE) Office of Scientific and Technical Information for a reactive transport study aimed at characterizing radionuclide sorption in the Bullfrog and Tram tuffs. It will be monitored by the Nye County Early Warning Drilling Program for decades. It is drilled to a total depth of 376.4 m [1,235 ft], and contains multilevel U-tube samplers, a fiber-optic distributed temperature sensor, and a continuous wellbore heater for measuring fluid flux. U-tube sampling is a novel method for high-purity geochemical sampling in which fluid samples are collected at *in-situ* pressure with no degassing. This is important at Yucca Mountain for determining redox conditions which strongly effect sorption of radionuclides. The fiber-optic distributed temperature sensor shows greater temperature differences under high flow conditions. The borehole temperature profile was interpreted to suggest mainly upward flow. However, negative (cooler) temperature perturbations suggesting a downward flow were also seen, possibly due to fracture flow. An optical televiewer showed calcite-filled fractures in the Bullfrog tuff. Completed tasks for NC–EWDP–24PB included a lithologic description, well log, pumping test, and electrical conductivity measurements. Reactive transport studies are expected to start by Fall 2006, pending approval of the proposed radionuclide surrogate tracer.

Barry Freifeld also presented flowing fluid electrical conductivity logging results from Boreholes NC–EWDP–24PB and NC–EWDP–32PB, which targeted volcanic tuffs and alluvium, respectively. The borehole locations may be along groundwater transport pathways from the potential repository. In addition to obtaining standard borehole logs (including caliper, gamma, self-potential, resistivity, and downhole video), flowing electrical conductivity logging was performed under ambient and forced gradient conditions. Preliminary interpretation, based on analysis with BORE II software, identified groundwater flow paths and intraborehole hydraulic

gradients. Further analysis is needed to estimate regional groundwater discharge and transport velocities at these sites.

John Campanella of Questa Engineering presented preliminary results from Nye County alluvium tracer tests at NC–EWDP–22S in lower Fortymile Wash. Halide and fluorinated benzoates, with diffusion coefficients that differ by an order of magnitude, were used as sorbing solute tracers for two consecutive single-well, push-pull tracer tests. Two-well, cross-hole tracer tests were also conducted. Data were obtained for estimating porosity, dispersivity, and possible diffusion into immobile water in the system. Preliminary analysis indicated that dispersivity is scale-dependent and diffusion into immobile water was minimal or nonexistent. Additionally, slower response time east-to-west compared to north-to-south suggested that a fast flow path existed between injection Well 22PA and pumping Well 22S in the shallow alluvial aquifer. A fortuitous long pumping interruption between the two cross-hole tests provided information about the natural gradient magnitude and azimuth. The response curve from perrhenate tracer suggested that technetium, by analogy, would not sorb or precipitate in the alluvium, consistent with the DOE performance calculations.

John Walton of the University of Texas at El Paso presented Vapor Transport, Performance Assessment, and Design. He challenged the assumption that repository heat-driven vapor transport is primarily into the rock. Instead, his analysis and three-dimensional models indicated that the predominant direction of vapor migration during the thermal period is into the drifts. Walton suggested that this would lead to cyclical changes in relative humidity and salt accumulation in large amounts, to a maximum of ~10 tons per drift at 1,000–1,500 years. He suggested that such amounts of salts could result in a corrosive environment for drip shields and waste packages. Walton advocated a below-boiling repository design, using a permanent natural ventilation system, to decrease the likelihood of localized corrosion.

Gregory Roberson of the University of Colorado discussed the effects of tectonic deformation on the water level in Devils Hole. Tectonic deformation was examined using the volumetric strain field of the Great Basin. Extension at Devils Hole was found to be N65°W, and, according to Brian Wernicke, is 8 nanostrain per year. Although not the dominant influence on water levels at Devils Hole, strain simulations showed that tectonic deformation can cause the water level to decline up to 2 mm [0.08 in] over 11 years. Future work will involve a historical tectonic deformation study using a strongly coupled geomechanical simulator. It would include current slip rates on faults, preferably in three dimensions.

Wayne Belcher of the U.S. Geological Survey presented Evaluation of Ground-Water Flow in the Southern Part of the Amargosa Desert, Nevada and California. By developing and using a numerical ground-water flow model, the U.S. Geological Survey plans to evaluate potential impacts from pumping on water levels and discharge within areas of concern in the southern Amargosa Desert. The model will consist of the Death Valley regional groundwater flow system, which has 1.5 km [0.93 mi] grid cells, embedded with a higher resolution 300 m [0.19 mi] grid. The regional hydrologic flow model will be updated to MODFLOW–2005, and direct embedding, rather than a telescoping mesh, along with a local grid refinement package will be used. In response to questions by Neil Coleman, Belcher did not believe that the model is being developed under the quality assurance program that the DOE has established for the Yucca Mountain Project. It has not yet been calibrated with Inyo County wells. The timeframe for completion is ~3.5 years.

Steffen Mehl of the U.S. Geological Survey described a project that sought a better understanding of the estimated parameters in regional models with locally refined grids. A shared-node method of local grid refinement with two child fluxes per parent flux was used. CPU time was found to be ~15–30 minutes for one-way coupling and ~8–10 hours for fully coupled models. Mehl noted that hydraulic conductivity dominated the response of the system and mentioned potential future developments. These developments included irregular-shaped areas, better integration of refinement, and hierarchies of refinement (e.g. grandchildren nodes) that would allow a high level of resolution near pumping wells.

Al Aziz Eddebbarh of the Los Alamos National Laboratory described a similar ghost-node method for linking models with varied grid refinement. This is a viable method to couple distinct models that has error nearly equal to that when coupling two MODFLOW models. This method was recently developed by the U.S. Geological Survey, Los Alamos National Laboratory, and Sandia National Laboratories.

Michael King of The Hydrodynamics Group explored the geochemistry at 40 springs throughout Death Valley National Park. He found that water sampled from small, local springs in mountain ranges in that vicinity have major ion signatures that group water nicely by mountain range. This study showed local recharge to be less than 10 percent of the regional spring discharge in the Furnace Creek area—evidence that the major springs in the Furnace Creek area discharge from the regional carbonate aquifer.

John Jansen of Aquifer Science & Technology presented results of a geophysical survey in Ash Meadows. Approximately 31 km [19 mi] of gravity and magnetic data along four profile lines was collected and modeled. Eleven deep Transmission Electron Microscopy soundings were also collected on three profile lines. Gravity data modeling suggested a bedrock high near the California–Nevada state line and a large trough between the bedrock high and the Devils Hole area, consistent with the earlier gravity inversions.

Michael King of The Hydrodynamics Group presented results of a study which evaluated the Lower Carbonate aquifer as a barrier to radionuclide transport into the major Furnace Creek springs. A MODFLOW groundwater model was created to simulate flow through the Funeral Mountains, which was based on data from monitoring wells in the Southern Funeral Mountain Range, geologic mapping, water chemistry analysis, and water budget analysis of the Furnace Creek spring system.

During the poster session, John Walton of the University of Texas at El Paso presented a poster on Infiltration Rates Derived from Chloride Mass Balance. Chloride mass balance was used to determine infiltration rates for five Early Warning Drilling Project boreholes, using the annual chloride deposition rates obtained from literature. Their results indicated the infiltration rates differ at most by a factor of 3.5 among the five boreholes.

Alexander Sun presented a poster entitled Continuous Updating of Groundwater Flow Models Using Ensemble Kalman Filter. A sequential data-assimilation scheme was described and demonstrated for simultaneously identifying the values and patterns of hydraulic conductivity distribution.

Field trip excursions included visits to a gravel bar deposited by Lake Manly, and springs discharging near the Keane Wonder Mine, Upper Monarch Canyon, and Grapevine Canyon.

**CONCLUSIONS:**

The Devils Hole Workshop provided an excellent opportunity to learn about ongoing field and numerical investigations characterizing regional- and local-scale flow systems in the Death Valley area. The opportunity to interact with key personnel working for Nye County Nuclear Waste Repository Project Office and for Inyo County Regional Water Program should prove valuable.

**PROBLEMS ENCOUNTERED:**

None.

**PENDING ACTIONS:**

None.

**RECOMMENDATIONS:**

Attendance at future Devils Hole Workshops is highly recommended.

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