

**Office of Nuclear Material Safety and Safeguards, Region IV  
And Center for Nuclear Waste Regulatory Analyses  
Joint Trip Report**

**SUBJECT:** Participation in Field Geological Overview of Yucca Mountain Site and Vicinity,  
Nevada and California

**DATE:** April 27-29, 2006

**PLACE:** Overnight in Las Vegas and Amargosa Valley, Nevada

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**SENSITIVITY**

Non-sensitive

**BACKGROUND/PURPOSE/OUTLINE OF TRIP**

The Nuclear Regulatory Commission (NRC) and Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs are preparing to review a License Application for a high-level waste repository at Yucca Mountain, Nevada that the U.S. Department of Energy (DOE) indicated it will submit. NRC and CNWRA staffs have been making direct observations and measurements of rocks, soils, and water properties through field and lab investigations and from air photos,

Enclosure

satellite imagery, and geophysical surveys for two decades and are familiar with the geologic and hydrologic setting. However, there were no scheduled field visits to the Yucca Mountain area for at least five months for the approximately two dozen new and experienced employees who need a regional perspective. The participants will benefit from an integrated understanding of the geologic, hydrologic, and tectonic features of the Yucca Mountain region and their relevance to specific aspects of potential repository performance.

The purpose of this field geologic overview was to introduce the staff reviewers of the potential license application to the geology, hydrology, geophysics, volcanic history, erosion and deposition processes, land uses, cultural setting, underground operations, and the local environment. The objective was to facilitate the staff's pre-licensing preparation for review of a license application using personal observations in the field to discuss the evolution of DOE's assessments and NRC's evaluations of selected issues.

The trip was attended by ten staff members from NMSS, one from Region IV and eight from CNWRA. Larry McKague, who developed the draft field guidebook, arranged for the accommodations, DOE briefings and escorts for the Nevada Test Site segment, and led the three-day trip. Because of constraints on travel, only half of the eligible staff were selected to participate. The size of the group was appropriate for the field conditions.

Our stops at geologic, hydrologic, and cultural locations of interest and are relevant to licensing considerations and requirements (all within the scope of the Yucca Mountain Review Plan, Revision 2, July 2003) were selected to provide staff with both a broad overview and detailed information concerning the actual surface and underground features of the region surrounding the DOE's Yucca Mountain site. To provide this background, the trip focused on stops that illustrated the following: (i) local and regional surface and subsurface hydrologic settings and evidence for both the paleohydrologic and current flow systems; (ii) geologic history of the Yucca Mountain Region, including geologic structures and stratigraphy that explain site characteristics; (iii) volcanology of both the tuffs at Yucca Mountain and the basalts in Crater Flat and the Amargosa desert that bear on volcanic hazard analysis; and (iv) modern tectonics that bear on seismic hazards. In addition, stops were made near the 18-km compliance boundary to discuss aspects of the Reasonably Maximally Exposed Individual and accessible environment, at several low level waste storage areas, at the Spent Fuel Test - Climax Mine in Yucca Flat, and at the sites of previous nuclear tests with discussions of the containment of radioactivity emitted by the tests. Participants also visited the Exploratory Studies Facility at Yucca Mountain and the DOE Science Center in Las Vegas.

DOE staff supported the trip on the first day at Yucca Mountain and at Frenchman and Yucca Flats. Their roles were to provide information briefings and serve as required escorts while in both areas. At Yucca Mountain, they ensured our safety as well as provided technical briefings in Alcoves 1 and 2. They also ensured our safety and security while visiting various historic nuclear test sites and the nuclear waste management facilities on the Nevada Test Site (NTS). DOE staff were immensely helpful in expediting badging and entry and briefing participants in the Exploratory Site Facility. Their briefing at the NTS waste management site was particularly instructional because of their work experience there. The NRC On-Site Representatives' Office ensured the completeness and timeliness of our badging request forms and provided field safety and logistical support.

The draft Field Trip Guidebook provided maps, mileage, diagrams, photographs, descriptions of

the sites, and references. Dr. McKague requested that each participant send critiques and comments on the guidebook and itinerary to improve the next edition and subsequent trips. Future participants and visitors to Yucca Mountain will have the guidebook in advance of the trip. The guidebook was arranged by days and covered the following sites and topics.

## **DAY 1: YUCCA MOUNTAIN AND NEVADA TEST SITE; PALEOZOIC CARBONATE AQUIFER.**

### Stop 1: Fran Ridge Large Block Test, Yucca Mtn Project (YMP), Nevada Test Site

Topics: History of site characterization; emphasis here is on fractures, thermal and mechanical properties of DOE's early-choice principal host rock, Topopah Spring middle nonlithophysal unit; prototype heater-block test; volcanic stratigraphy, mineralogy, welding and other textures; layering and thickness of units; extrusive processes that controlled Topopah Spring pyroclastic flow and fall deposits; sample representativeness and sample management; fracture networks; surface runoff and rock weathering.

### Stop 2: Yucca Crest, YMP, NV

Topics: This stop was the 'high point' of the trip - a panorama from the crest of Yucca Mountain repository block from Timber Mountain clockwise to the Calico Hills, Jackass Flat, Fortymile Wash, Little Skull and Skull Mountains, Busted Butte, Grapevine and Funeral Mountains of California, Lathrop Wells volcano, Big Dune, Crater Flat with Black, Red and Little Cones, Steve's Pass, Bare Mountain and the Sterling gold mine on Bare Mountain, Jet Ridge across from the Solitario Canyon fault and the other ridges that constitute "Yucca Mountain," an opportunity to reflect on and discuss the concepts of vertical movement, lateral extension across Crater Flat, potential sources of earthquakes and volcanism, rates of erosion and deposition by running water, sense of the hydraulic gradient. Opportunity to discuss local geography, political entities, demographics, land use, natural resources.

### Stop 3: Exploratory Study Facility (ESF), North Portal, Alcoves 1 and 2, YMP, NTS

Topics: Observe potential future surface operations area at North Portal; underground safety briefing and donning safety equipment; ESF tunnel construction, operation and testing; we observed two test alcoves that had been used by DOE for various measurements and infiltration tests some of which were still being conducted; we observed: ground support systems including steel sets, wire mesh, rock bolts and shotcrete, examples of open and instrumented boreholes; fractured, welded tuff forming angular rock faces as a result of the drill and blast method of excavation; difference between drill and blasting and tunnel boring machine tunnel construction. Sense of scale and nature of tunnel and drifts and underground operations. On the North Portal pad, we observed buildings and support facilities, including the visitors center, and the drainage ditch above the portal designed to divert runoff from the tunnel entrance. Examination of Bow Ridge fault in the ESF.

### Stop 4: Trench 14, Bow Ridge Fault, Exile Hill, YMP, NTS

Topics: Studies of calcite and opal veins to distinguish downward infiltrating water from upward-moving water along faults and fractures; significance to a repository of both processes; evidence and significance of faults regarding groundwater flow and geologic stability.

### Stop 5: Sedan Crater, NTS

Topics: Peaceful uses of atomic energy; effects of blast on alluvium and rock; rate of erosion of

crater wall and deposition in crater floor; rate of revegetation and environmental effects of invasive grass susceptible to lightning-induced fires.

Stop 6: Spent Fuel Test-Climax, and Environmental Protection Agency's (EPA's) Experimental Farm, NTS

Topics: Granitic rock and tungsten mining; evidence of kilometers of uplift and erosion; history of early (1978-1983) project to demonstrate the emplacement, storage and retrieval of spent nuclear fuel in an underground drift in granitic rocks using remote-handling methods; repackaging of fuel in a hot-cell (Engine Maintenance and Disassembly Building is still an operational hot-cell in Jackass Flat); history of EPA's radiological-uptake monitoring on a simulated irrigation dairy farm (1965-1981).

Stop 7: Carpetbag Fault, Yucca Flat, NTS

Topics: Underground nuclear explosions generated vibratory ground motion that caused faulting of alluvium; history of the containment of underground nuclear explosions, including technical basis of successful containments; effects of interacting engineering systems and the natural systems on containment, geologic and hydrologic bases for selecting sites for underground tests; overview of geology and hydrology of Yucca Flat with emphasis on how the alluvium reflects the geologic history of the basin.

Stops 8, 9: DOE Low Level Waste Sites (operational) and Overview of NTS

Topics: Current NTS operations, including waste management history at Area 3 and 5 sites; fracture-controlled drainage in Yucca Lake/Playa; U.S. Geologic Survey geologic mapping of NTS; and early recommendation of HLW disposal sites in the U.S., including Yucca Mountain.

Stop 10: "Bonanza King Formation" Paleozoic Carbonate Rock Formation, Nye County.

Topics: Faulting and fracturing of carbonate rocks; ubiquitous fault breccia; the significance of faults as barriers or conduits for fracture-flow of groundwater; stability of fractured rock, and Bonanza King as an analog to fractured Paleozoic aquifer along Yucca Mountain saturated zone flow path.

**Day 2: POTENTIAL RMEI VICINITY, ANCIENT SPRINGS, YOUNG AND OLD VOLCANOES, BARE MOUNTAIN, NYE COUNTY, NV**

Stop 1: Panorama at town of Amargosa Valley (formerly Lathrop Wells), Nye County

Topics: Largest surface mine in the world nearby; significance of position-measurements by California Institute of Technology Global Positioning Satellite monitoring stations and level-line surveys that suggest continuing tectonic activity in the area; geographic landmarks in surrounding mountains; University of Nevada-Reno seismic stations; significance of predominantly volcanic rocks to the north and sedimentary rocks to the south of Yucca Mountain; significance of wind erosion as evidenced from large sand dunes; origin of Yucca Mountain by volcanism and tectonism; recap volcanic stratigraphy of Yucca Mountain.

Stop 2: General RMEI Location At Distributary Channel Deposits In Fortymile Wash, Nye County

Topics: Evidence and significance of Fortymile Wash as a potential surface transport system for radionuclides; evidence and significance of rates and sizes of transportable particles; discussion of volcanic ash re-distribution studies; observations of rock types accumulated from

the upstream sources; and the perspective at approximate location of the RMEI.

Stop 3: Lathrop Wells Volcano, Nye County

Topics: Basaltic volcanic eruptions at and near Yucca Mountain; geology of Lathrop Wells 76,000-year old volcano; characteristics of the eruption products; evidence of periodic basalt volcanism in the area; consideration of effects of subsurface plumbing of magma and extrusion of lava flows and tephra (scoria, cinders and ash); evidence of wind and water erosion of the volcanic cone and surrounding deposits; the CNWRA study to estimate the transport and redistribution rates of tephra; volcanic hazard and risk analysis, eolian deposits on lava flows.

Stop 4: Raven Canyon - Direct Observations of Welded Cliff-forming, Non-Welded Slope-forming and Vitric (Glassy) Volcanic Tuffs, Nye County

Topics: Discussion of groundwater flow through layers of tilted, fractured tuffs of alternating thicknesses and textures and widely ranging permeabilities upon close examination of tuffs that actually underlie Yucca Mountain.

Stop 5: Diatomite Paleo-Spring Deposit, "Sinkhole," and a Nye County monitoring well

Topics: Significance of spring deposits; evidence and significance of past wetter climate in Crater Flat; evidence and significance of dissolution in alluvium; evidence and significance of subsidence of southern Crater Flat greater than northern part; evidence and significance of giant slide blocks and breccia; Affected Units of Local Governments' opportunities to conduct research and investigations (Nye County Early Warning Drilling Program, Well 1DX) about technical, safety and environmental considerations of a HLW repository.

Stop 6: Crater Flat Formation Tuff, Nye County

Topics: Review of tuff stratigraphy and significance of welding, non-welding regarding vertical and lateral groundwater flow.

Stop 7: Steve's Pass Near Bare Mountain Fault and Crater Flat Volcanic Cones, Nye County.

Topics: evidence and significance of Bare Mountain tectonics influencing faulting and earthquakes at Yucca Mountain (results of 15 years of CNWRA investigations); erosion and alluvial fan deposition on Bare Mountain; uneven subsidence and in-filling of Crater Flat; evidence and significance of vertical-axis rotation of Yucca Mountain; Bare Mountain fault; history of basalt volcanoes in Crater Flat; factors regarding the probability of future volcanism; significance of gold mines in Bare Mountain for future human intrusion.

Stop 8: View of West Face of Yucca Mountain, Nye County

Topics: Geology and stratigraphy of the west flank of Yucca Mountain; significance of infiltration into Yucca Mountain by way of Solitario Canyon; role of various hydrostratigraphic units in diversion and distribution of infiltrating water; significance of Solitario Canyon fault and its earthquake potential; U.S. Geological Survey runoff and groundwater-monitoring programs; confluence of Bureau of Land Management, Nellis Air Force Base and NTS political boundaries; alternative tectonic models of Crater Flat; land withdrawal requirement.

Stop 9: U.S. Ecology Low Level Waste Site (not operating), Beatty, Nye County

Topics: History of this Low Level Waste site; on-going studies of tritium and C-14 transport through alluvium at this site by USGS.

Stop 10: Carrara Marble Quarry Canyon, Bare Mountain, Nye County

Topics: Discuss Bare Mountain style of deformation by listric faulting, exposed in canyon wall,

as analog for large scale detachment faulting hypothesis that links Bare Mountain fault with Crater Flat and Yucca Mountain faults; Bare Mountain as analog of buried Paleozoic rocks such as postulated by DOE occur beneath Yucca Mountain.

**DAY 3: ASH MEADOWS, NYE COUNTY, NV; MONITORING WELL, INYO COUNTY, CA; DEATH VALLEY NATIONAL PARK, CA; LAS VEGAS VALLEY, CLARK COUNTY, NV**

Stop 1: Inyo County, CA Research Well BLM #1

Topics: Affected Units of Local Governments' contributions to the Yucca Mountain Project database; discussion of Center's independent review of Inyo County drill core seeking to correlate Inyo County rocks with similar types around the Amargosa basin; flow of groundwater into Death Valley or Franklin Playa (Yucca Mtn discharge zone).

2: Devil's Hole (Death Valley National Park), Nye County

Topics: Structural control of groundwater flow in Paleozoic limestones that underlie the Yucca Mountain saturated zone flowpath; 500,000-year climate record of Amargosa Desert area applied to future climate; persistence of water table in this location projected to future conditions; significant quantity of groundwater in Amargosa Desert accounts for irrigation-type agricultural development; relationship of Devil's Hole pupfish's endangered status to the water level in Devil's Hole; and the control of future use of groundwater in the valley.

Stop 3: Clinoptilolite (Zeolite) Outcrop, Nye County

Topics: Occurrence of clinoptilolite in rocks beneath Yucca Mountain; the potential radionuclide sorption benefit of zeolites in Calico Hills formation beneath the repository and along the hydrologic flowpath; chemical properties of clinoptilolite; genesis of clinoptilolite.

Stop 4: Calcite Vein Deposits in Faults and Fractures, Inyo County

Topics: Evidence and significance of calcite veins that represent multiple episodes of spring deposition emanating from below ground surface, compared to Trench 14 deposits; evidence of geologic structural control of groundwater pathways; direct observation and other evidence of water transport of boulders; further discussion of running water as dominant agent of erosion, transportation and deposition in the desert.

Stop 5: Travertine Point, Inyo County

Topic: Discussion of vertical fluctuations of hydraulic systems as evidenced from veins leading to spring deposits at the top of the cliff.

Stop 6: Zabriskie Point, Death Valley N.P.

Topics: Erosion and deposition characteristics of a fine-grained tuff deposit; discussion of human-induced accelerated erosion.

Stop 7: Badwater (Low-Point of the Trip), Fault Scarp in Alluvial Fan, Death Valley N.P.

Topics: Evidence for and significance of the Death Valley-Furnace Creek tectonism for Yucca Mountain seismotectonic hazard; further evidence that running water is a significant agent of erosion and deposition in this desert environment; regional discharge point for groundwater flow system; sense of geodynamism of this region.

Stop 8: Artists Pallet, Death Valley N.P.

Topics: Chemical variation in volcanic ash; discussion of western U.S. Tertiary volcanic history;

aesthetic sense of volcanic ash deposits.

Stop 9: Corn Creek Spring and Paleo-Lake Deposits, Clark County, NV

Topics: Playa evidence of former dry climate and near-surface water discharge, Basin and Range general geology, thrust faults, Lee Canyon and Kyle Canyon alluvial fans, tectonic history from 65 million years ago to present, movement on Las Vegas Valley shear zone.

**SUMMARY OF PERTINENT POINTS:**

The theme of the field overview was the interrelationship of geological features, events and processes that affect the potential Yucca Mountain repository at the drift, site, and regional scales. The approach was to provide opportunities for staff members to make observations of natural features and processes in the Exploratory Studies Facilities tunnel, at the Yucca Mountain site, and in the regional settings, directly - in the field, with knowledgeable colleagues available to address questions and keep the focus on potential license application issues.

The topics purposefully raised at the field overview stops, enumerated above, enabled discussion of the evolution of thinking by DOE and NRC on various licensing issues and on review methods in the Yucca Mountain Review Plan. The opportunity to comprehend issues regarding the interaction of the natural systems with engineered systems at different scales when the evidence is in view, and the relative scales of the systems are in sight, as opposed to visualizing them from photographs and scaled drawings in documents, is unique to the field observation approach. The trip and evenings together provided an opportunity for NRC and CNWRA staffs to work as a team, discuss a variety of topics and develop mutual respect for each others' skills and backgrounds. Camaraderie and sharing of knowledge and experience were enhanced by having participants rotate among vehicles on a daily basis.

**SUMMARY OF ACTIVITIES:**

L. McKague led a three-vehicle, three-day field geologic overview to Yucca Mountain and vicinity. He provided a prototype field guide and requested each participant to contribute written observations and comments for his consideration for the next trip. Each NRC and Center participant was directly exposed to the rocks, sediments, soils, vegetation, topography, weather, natural and cultural environments, geologic and hydrologic features (e.g., strata, faults, fractures, volcanoes, spring deposits, playas, washes) and processes (e.g., weathering, surface-mass-movement by erosion, deposition and transport of sediment by water, wind and gravity) potentially relevant to the review and evaluation of a potential license application (LA) for a Yucca Mountain, Nevada high-level waste repository. Discussions among participants at each stop were encouraged and continued in the vehicles.

**CONCLUSIONS:**

NRC and CNWRA staff visits to the site help ensure and improve the effectiveness of their role in the Yucca Mountain project. The NRC and Center staffs benefitted from the experience of directly observing the natural and operational environments in and around Yucca Mountain and

discussing geologic, tectonic and hydrologic models and interpretations associated with their preparations for a LA review. Potential LA reviewers gained a sense of the scale of the test facility, Yucca Mountain, and vicinity. The perspective obtained from such visits is invaluable and may only be obtained from specialized trips emphasizing specific features or processes. This site visit to the Yucca Mountain region provided participants with an integrated perspective and understanding of the geologic, hydrologic and tectonic features of the region and the potential impact of regional processes on long-term performance of a potential repository at Yucca Mountain.

**PROBLEMS ENCOUNTERED:**

None.

**PENDING ACTIONS:**

Finalization of Field Trip Guidebook, summer 2006.

**RECOMMENDATIONS:**

All HLWRS staff (and other NRC and CNWRA staff members who will be significantly involved in Yucca Mountain activities) should be required to make at least one trip to the Yucca Mountain area that includes many of the attributes of this trip.

**POINTS FOR COMMISSION CONSIDERATION:**

No specific Commission consideration is needed.

**ATTACHMENTS:**

None. [The Field Trip Guidebook was pre-decisional. A copy of the final version will be available in the summer, 2006.]

**REFERENCES:**

None.



**SIGNATURES:**

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