Nye County Department
of Natural Resources and Federal Facilities

Drilling Program and Ventilation Studies Update

Nuclear Waste Technical Review Board Meeting
September 11, 2001

Drilling Program Topics

- Program objectives
- Program status
  - Three phases
- Phase III well types and locations
- Drilling and completion objectives/methods
- Geologic sampling and testing objectives/methods
- Preliminary results from Phase III
- Proposed additional wells

Related Drilling Activities Not Discussed Today

- Borehole geophysical logging
- Borehole completion details
- Aquifer testing
- Westbay® instrumentation of monitor wells
- Groundwater chemistry monitoring
- Water level monitoring

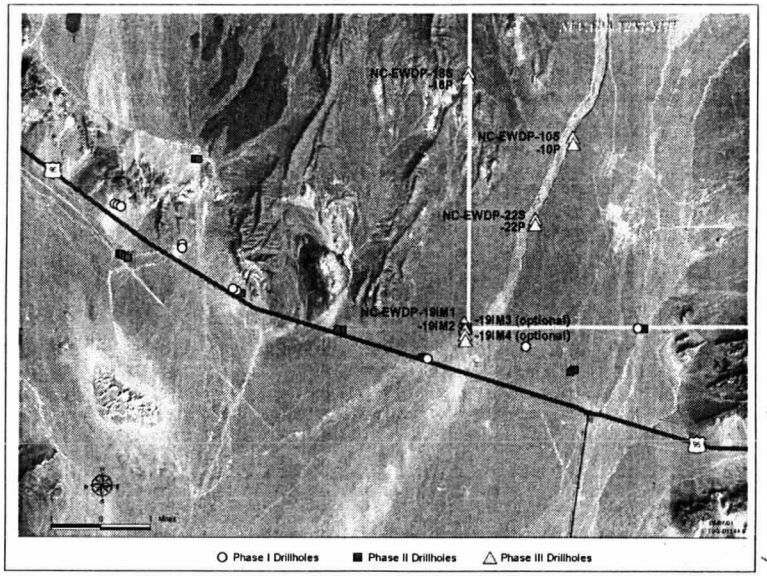
Drilling Program Objectives

- Develop capability for early warning groundwater monitoring network
  - Between Yucca Mountain and Amargosa Valley
- Establish baseline water quality information
- Fill in hydrogeologic data gaps
  - Flow path(s) between tuff and alluvium
  - ***Nature and continuity of alluvial textural layers***
  - Hydrogeologic units underlying the alluvium
  - Hydraulic gradients within and between units
  - Flow and transport parameters

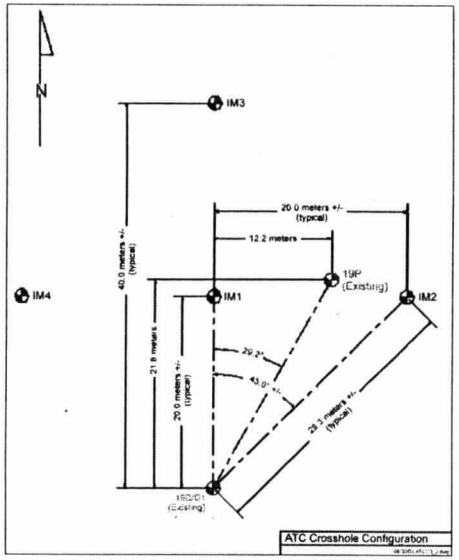
Drilling Program Status

- Phases I and II complete
  - Late 1998 to early 2001
  - Two dozen wells
  - 20,000 feet drilled
  - Eight aquifer tests
  - Extensive water level and water quality data
- Phase III in progress
  - July 2001 to December 2001
  - Focus on filling data gaps in zone of uncertainty

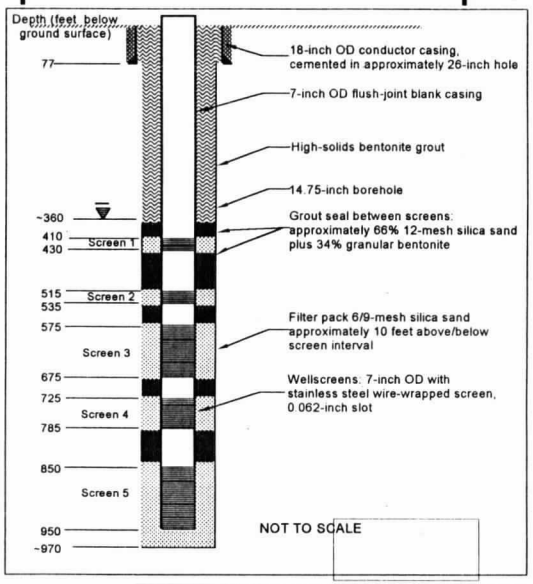
Phase III Early Warning Drilling Program 7/[illegible]-12/01



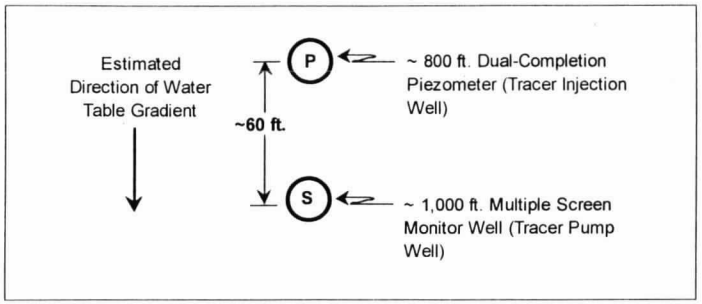
Alluvial Testing Complex (ATC) Diagram



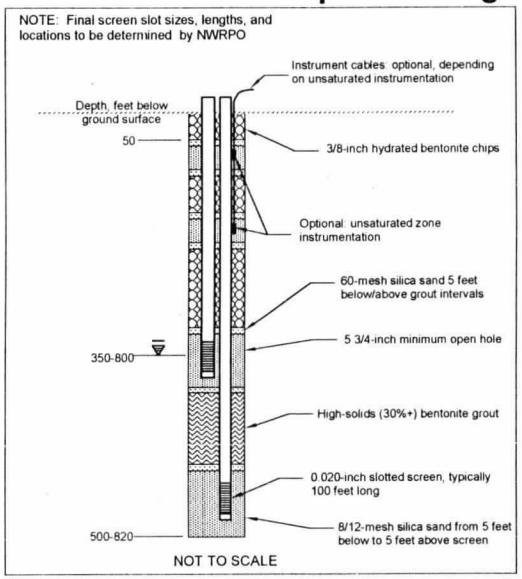
Typical Multiple Screen Monitor Well Completion Diagram



Schematic of Well Layout at Locations 10, 18, and 22 (Designed for Cross-Hole Tracer Tests)



Typical Piezometer Completion Diagram



Phase III Well Types and Locations

- Multiple-screen monitor wells (up to seven wells)
  - Approximately 1,000 feet deep
  - 7-inch outside diameter casing/screen
  - Can be instrumented with Westbay® equipment
  - Two to four wells at the Alluvial Testing Complex (ATC) site
  - Three wells in the zone of uncertainty south of Yucca Mountain
- Dual completion piezometers (three wells)
  - Approximately 800 feet deep
  - 2-inch inside diameter PVC casing/screen
  - Near monitor wells in zone of uncertainty

Phase III Drilling/ Completion Objectives

- Piezometers and monitor wells
  - Design/construct to support tracer tests
  - Collect representative drill cuttings and core
  - Obtain in situ density data where possible
- Monitor wells
  - Produce straight and stable boreholes for Westbay® installation

Phase III Drilling Methods

- Monitor wells
  - Dual-wall reverse-circulation (RC)
  - Flooded mud (FM)
- Piezometers
  - Casing-advance air-percussion hammer (CA)
- Details in backup slides

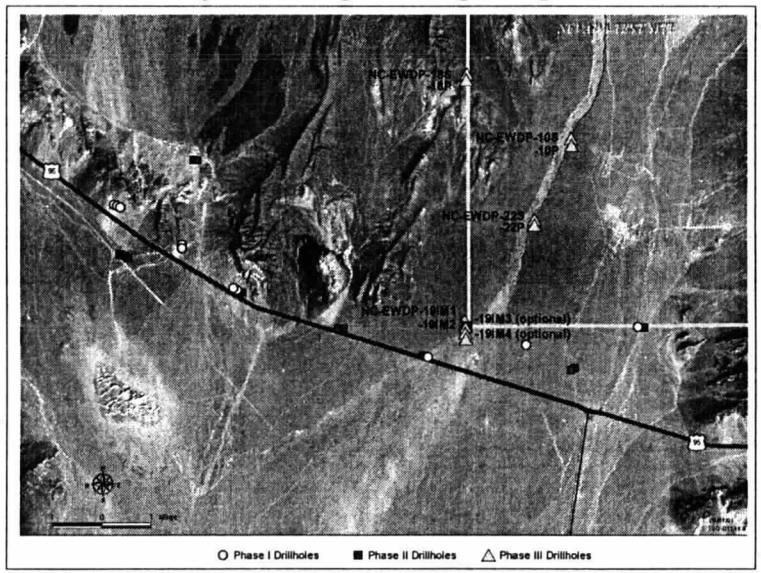
Drill Cuttings Sampling, Logging, and Testing Objectives/Methods

- Maximize information about textural layers
  - Minimize sample contamination from drilling fluids and uphole caving
  - Sample frequently
  - Capture the fines fraction in saturated alluvium
  - Produce detailed log descriptions of each sample
  - Make measurements to calculate in situ bulk densities
  - Conduct texture and flow-related laboratory tests
- Methods described in backup slides

Coring Objectives/Methods

- Obtain limited amount of minimally disturbed core from alluvium during CA drilling of piezometers
  - Potential saturated zone well screen intervals
  - Representative units in unsaturated zone
- Demonstrate feasibility for future drilling programs
- Methods described in backup slides

Phase III Early Warning Drilling Program 7/01-12/01



Phase III Progress to Date

- Drilled, sampled, logged, and abandoned four RC exploratory boreholes
  - Wells 19IM1A, 19IM2A, 10SA, and 22SA
- Drilled/completed ATC Monitor Well 19IM1
- Drilled ATC Monitor Well 19IM2
  - Completion is ongoing
- Drilling/coring of Piezometer Well 10P has begun

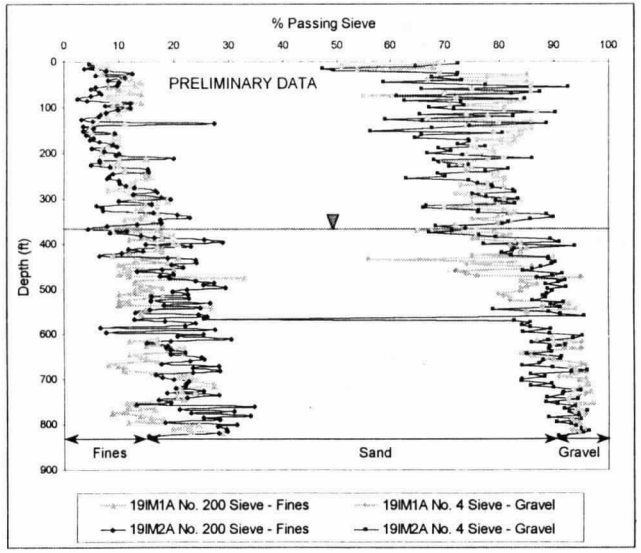
Summary of Preliminary Laboratory Testing and Field Logging Results

- RC borehole drill cuttings samples
  - Particle size distribution depth profiles
  - Cementation and HCl reaction depth profiles
  - Electrical conductivity (EC) depth profiles
- Laboratory data not yet available
  - Silt and clay percentages
  - In situ bulk density values

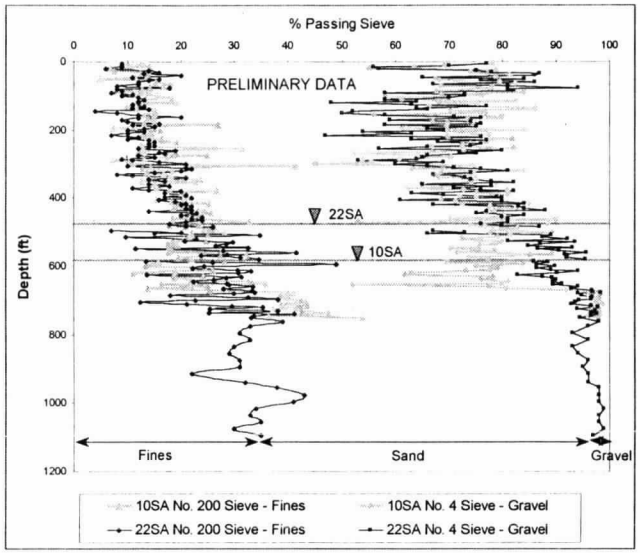
Preliminary Particle Size Distribution Observations

- Possible errors
  - Fines created/lost by drilling process
  - Contamination from uphole sediments
  - Homogenization of unsaturated alluvium samples
  - Splitting of saturated zone alluvium samples
- Data uses
  - To identify major trends within and between boreholes
  - To provide an indication of the thickness and textural variation between layers

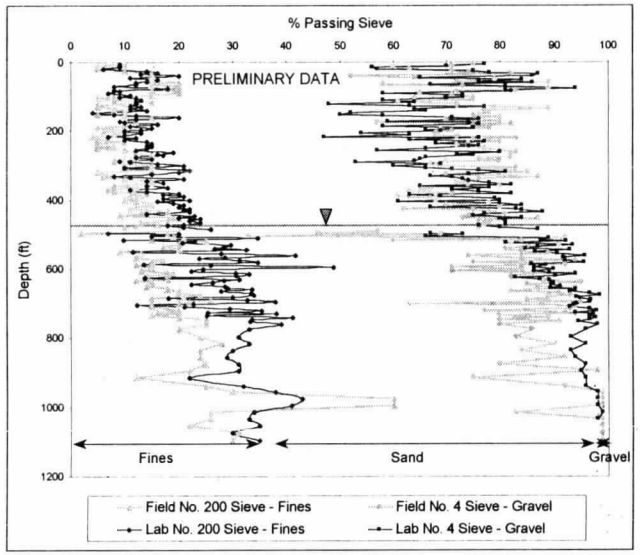
Particle Size Distribution for Wells 19IM1A and 19IM2A



Particle Size Distribution for Wells 10SA and 22SA



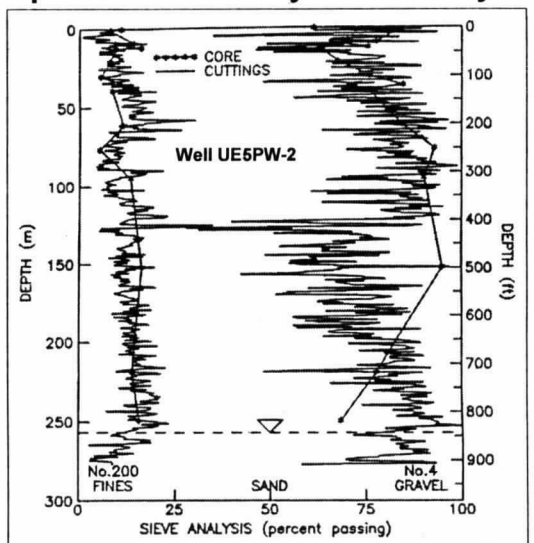
Particle Size Distribution for Well 22SA (Lab vs. Field)



Results from Alluvium in Frenchman Flat (For Comparison)

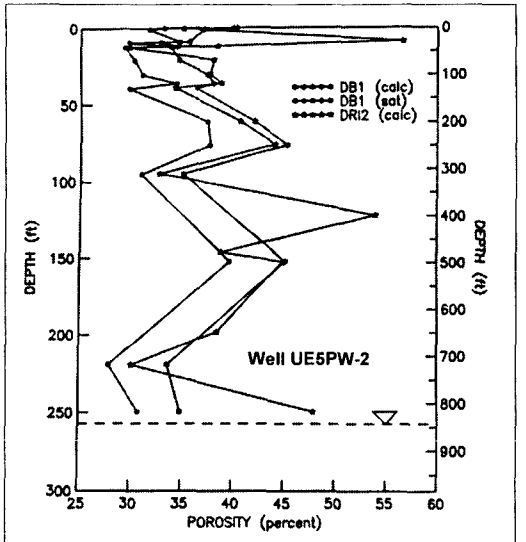
- Frenchman Flat also filled with volcanic sediments
- CA boreholes drilled to approximately 1,000 feet to support low-level and mixed waste disposal
- Depth profiles generated
  - Particle size distribution
  - Porosity
  - Hydraulic conductivity

Depth Profiles of Dry Sieve Analyses



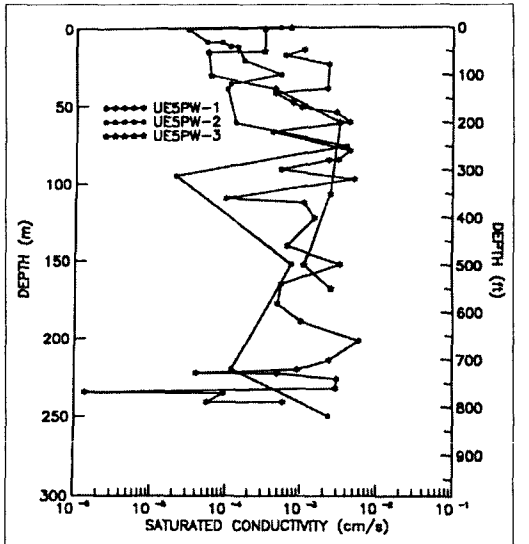
Source: Figure 3-5, *Site Characterization and Monitoring Data from Area 5 Pilot Wells*, DOE/NV/11432-74, Reynolds Electrical and Engineering Co., February 1994, p. 3-27.

Depth Profiles of Calculated and Water-Saturated Porosity



Source: Figure 3-9, *Site Characterization and Monitoring Data from Area 5 Pilot Wells*, DOE/NV/11432-74, Reynolds Electrical and Engineering Co., February 1994, p. 3-32

Depth Profiles of Saturated Hydraulic Conductivity



Source: Figure 3-11, *Site Characterization and Monitoring Data from Area 5 Pilot Wells*, DOE/NV/11432-74, Reynolds Electrical and Engineering Co., February 1994, p. 3-35

Preliminary Particle Size Distribution Observations (cont.)

- Generally increasing fines and decreasing gravel with depth in all boreholes
- Average fines percentage
  - From 14% in Well 19IM1A to 21% in Wells 22SA and 10SA
- Thick, fine-textured layers not observed
  - Except in lower portions of Wells 10SA and 22SA
- Large variation in particle size fractions observed between adjacent 2.5-foot depth intervals

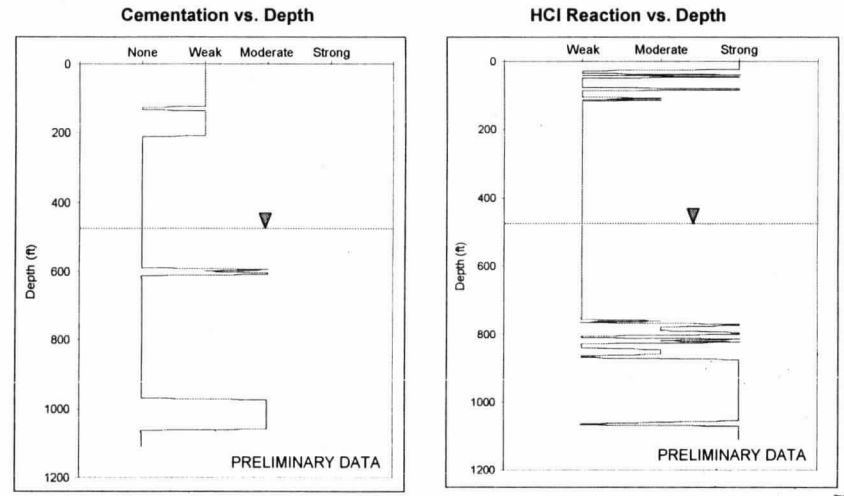
Preliminary Particle Size Distribution Observations (cont.)

- Some correlation between layers in closely spaced Wells 19IM1A and 19IM2A
- Average fines percentage in Frenchman Flat
  - From 7% in Well UE5PW-1 to 13% in Well UE5PW-2
- Differences between Fortymile Wash and Frenchman Flat may be due in part to
  - Differences in drilling and sieving methods, source rock, and depositional environment, among others

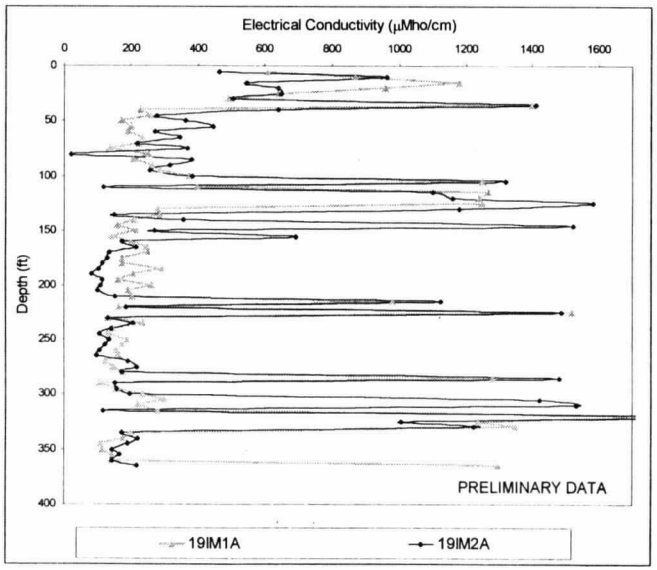
Preliminary Cementation and EC Observations/Measurements

- Visual estimate of degree of cementation
  - Evidence of grains cemented together
  - Evidence of cement on individual particles
- Estimate of degree of HCl reaction
  - Estimates presence of calcium carbonate
- Laboratory EC measurement of 1:1 soil water extract
  - Estimates presence of soluble salts

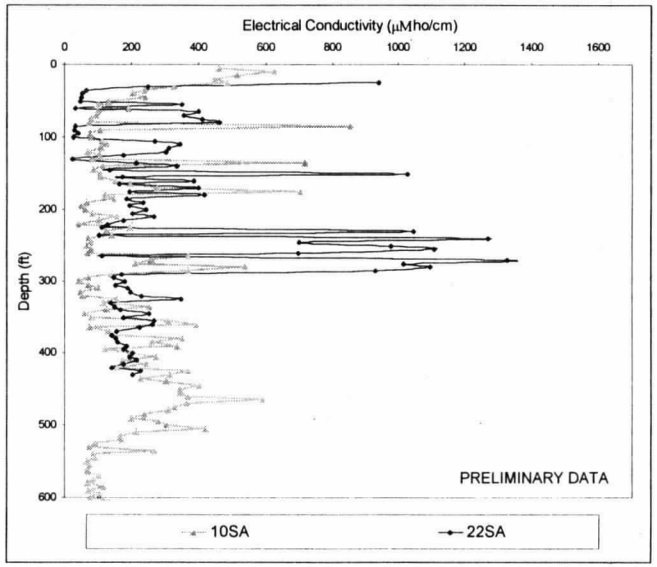
Comparison of Cementation and HCl Reaction for Well 22SA



EC Depth Profile for Wells 19IM1A and 19IM2A



EC Depth Profile for Wells 10SA and 22SA



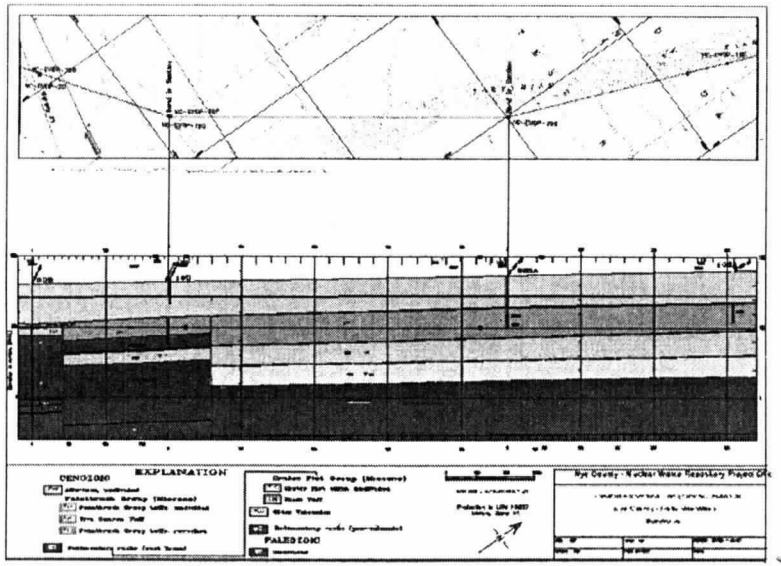
Preliminary Cementation and EC Observations

- Some weak cementation in upper 100 feet of boreholes.
- Little evidence of cementation except in the lower portion of Well 22SA
- Good correlation in EC data between Wells 19IM1A and 19IM2A
- EC peaks and valleys may reflect
  - Periodic salt accumulation during sediment deposition and/or
  - Periodic major infiltration events not great enough to flush the profile of soluble salts

Preliminary Lower Fortymile Wash Long Section

- Incorporates borehole data from deep Well 2DB and data from shallower Wells 19D, 22SA, and 10SA
- Incorporates USGS regional geologic framework units in northern portion of the section

Preliminary Lower Fortymile Wash Long Section



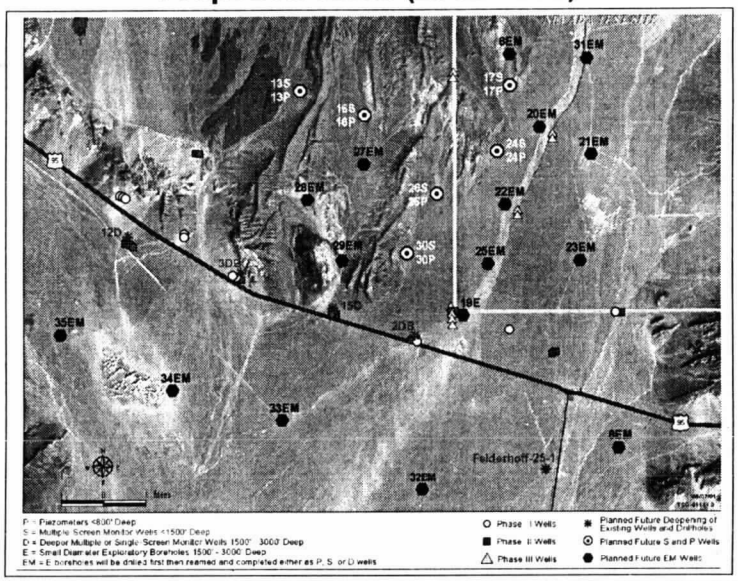
Summary of Preliminary Lower Fortymile Wash Long Section

- Major structural features
  - Highway 95 fault interpreted from surface geophysics
  - Aeromagnetic lineament X1 (possibly a deep feature)
- Rapid change from volcanic to sedimentary facies
  - Volcanic units north of X1 identified in USGS regional geologic framework model
  - Sedimentary facies below tertiary volcanics identified in Wells 2DB and 19D

Summary of Preliminary Lower Fortymile Wash Long Section (cont.)

- Major uncertainties
  - A second, deeper Qal (or lower Miocene conglomerate) unit in Well 22SA (and possibly in Well 10SA)
  - Paintbrush Group tuff unit underlying the lower Qal unit
  - Paintbrush Group tuff unit encountered in Wells 19D and 2DB
  - Depth to Paleozoics in Well 2DB
- Proposed work to reduce uncertainties
  - Drill deeper boreholes at Wells 19D, 22S, and 10S
  - Clean out Well 2DB and conduct video logging

Proposed Wells (2002-2006)



Proposed Monitor Wells

- Fill data gaps in alluvial Fortymile Wash pathway(s)
- Begin to characterize fractured volcanic rock Crater Flat pathway(s)
- Identify points of connection between fractured rock and alluvial pathway(s)
- Investigate the fluxes along east boundary of site-scale model
- Complete a "fence line" of deep wells along Highway 95 fault
- Complete a second fence line of downgradient wells to define flow system closer to potential receptors

Ventilation Studies Update

- Background
- Summary of past work
- Summary of present work
  - Details to be presented in January 2002
- Proposed work
  - More details in January 2002

Ventilation Studies Background

- DOE models predict high temperatures and humidity after backfill and closure
- Increased uncertainty in
  - Corrosion
  - Flow and transport simulations
  - Performance assessment
  - Safety demonstrations
- Since 1995, Nye County has studied natural ventilation as a means to lower temperatures and humidity and to reduce uncertainty

Summary of Previous Work

- Monitoring of pressure, temperature, and humidity in ESF and ECRB during construction
  - Suggests that ventilation could remove large amounts of heat and moisture
- Preliminary modeling of highly simplified repository and ventilation shaft(s)
  - Indicates that natural ventilation can keep host rock conditions cool (i.e., less than 30° C) and dry for first 1,000 years

Summary of Previous Modeling

- Simplified axisymmetric modeling completed in 1996
- Simplified three-dimensional site-scale modeling completed in 1998
- Results presented in Nye County Annual Reports and at ventilation workshop in 1998
- A-TOUGH code used to simulate heat and vapor flow in both rock and tunnels/shafts
  - Heat and vapor flow transfer between rock and tunnels accomplished by using eddy diffusivity.
- Results highly dependent on eddy diffusivity

Summary of Ongoing Work

- Activities to develop a more realistic natural ventilation design and model simulations
  - Identify a range in realistic design parameters for a natural ventilation repository design
  - Develop a more realistic conceptual design and model mesh
  - Refine estimates of eddy diffusivity
  - Conduct simulations to demonstrate the performance of the more realistic naturally ventilated repository design
- Results to be presented in January 2002

Summary of Ongoing Work (cont.)

- Comparison of computer codes
  - Funded by UNR
  - A-TOUGH vs. MULTIFLUX plus NUFT
  - Large difference in temperature predictions
  - Possibly due to differences in heat and vapor transfer coefficients

Rationale for Future Work

- No heater experiment has been conducted in the repository block where heat and vapor flow have been monitored between fractured rock and the tunnel ventilation system
  - Heat and vapor flow processes in rock are being validated in the ESF
  - Heat and vapor flow processes in the tunnel ventilation system are being validated at the Atlas Facility
  - However, tests have not been conducted to validate heat and vapor transfer mechanism/coefficients used in Nye County and DOE models under repository conditions

Proposed Future Work

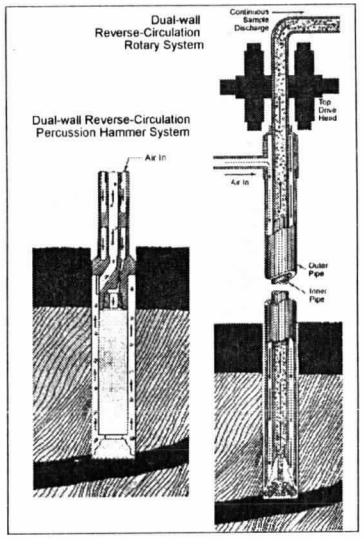
- Low temperature heater/ventilation experiment
  - Proposed by Nye County to meet model validation needs
- Validated models used to evaluate various natural and forced-air-ventilation scenarios and their potential to reduce
  - Uncertainties
  - Footprint size
  - Costs

Backup Slides: Drilling Methods

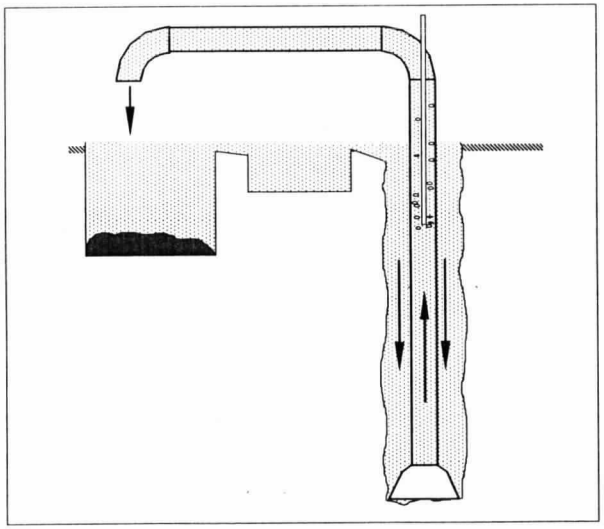
Monitor Well Drilling Methods

- Small-diameter dual-wall reverse-circulation (RC)
  - Representative drill cuttings
  - Fast and inexpensive
- Flooded mud (FM)
  - Produces straight, stable boreholes for instrumentation
  - Mud contaminates alluvium samples

Dual-Wall Reverse-Circulation Rotary and Percussion Hammer Drilling Systems



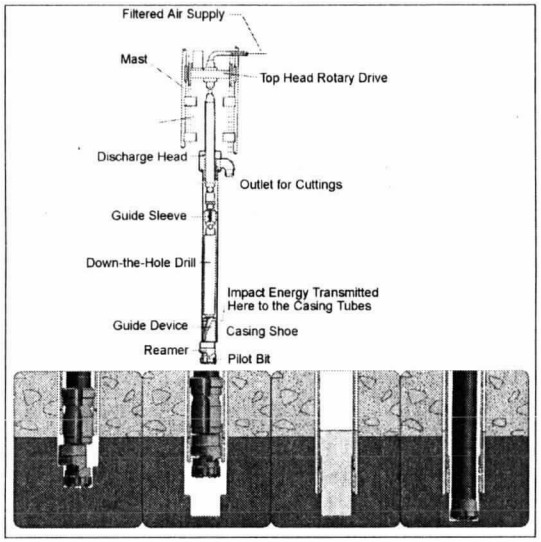
Flooded-Reverse-Circulation Mud-Rotary Drilling System



Piezometer Drilling Methods

- Casing-advance air-percussion hammer (CA)
  - Minimizes formation disturbance
  - Maximizes cuttings return
  - Permits core collection ahead of drill casing
  - Facilitates well completion

Odex®-Type Drilling System



Backup Slides: Sampling/Logging/Lab Testing

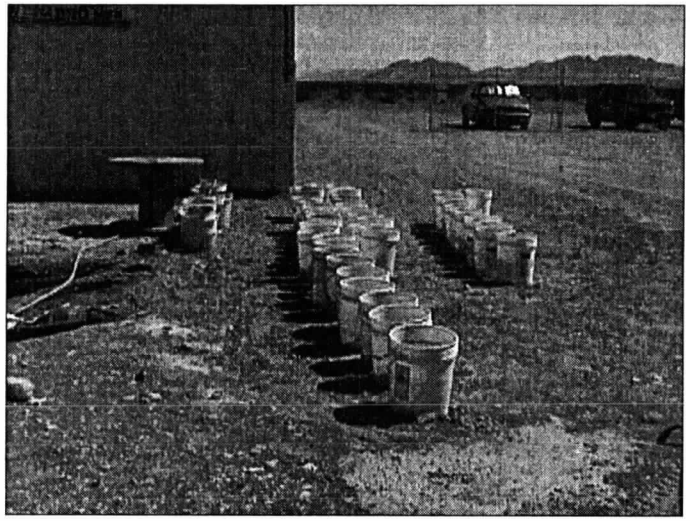
Drill Cuttings Sampling/Logging Frequency

- CA and RC drilling
  - Every 2.5 feet in unsaturated alluvium and saturated alluvium producing no water
  - Every 5 feet in saturated alluvium producing water and consolidated rock
- FM drilling
  - Where RC sample quality is poor

Sampling Method for Saturated Zone Alluvium Drill Cuttings

- For intervals producing significant amounts of water
  - Collect representative sample in 5-gallon bucket
  - Let solids settle out
  - Siphon off water
  - Homogenize sample
  - Split for logging, laboratory testing, and archiving

Processing Saturated Zone Drill Cuttings Samples



In Situ Density Measurements

- Calculated from
  - Field weight of drill cuttings/core
  - Calculated volume
  - Laboratory gravimetric water content
- Limited to
  - CA and RC drilling and drive core
  - 100-percent recovery intervals, excluding wash-out zones
  - All unsaturated zone samples
  - Saturated zone samples with low or no water production intervals

Weighing Samples for Bulk Density Calculations

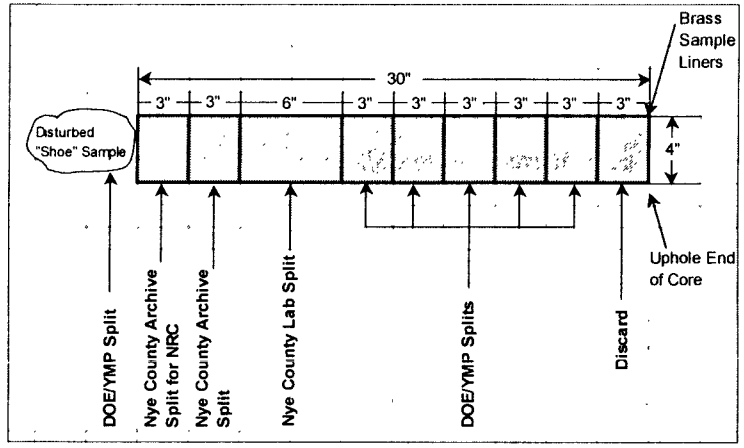
Drill Cuttings Laboratory Tests

- For samples spaced 5 feet apart
- Gravel/sand/fines (wet sieve)
  - Saturated and unsaturated alluvium samples
- Silt/clay (hydrometer)
  - Selected alluvium samples
- Electrical conductivity (1:1 water extract)
  - Unsaturated alluvium samples
- Gravimetric water content (oven dry)
  - Unsaturated rocks of all types
  - Saturated rocks producing little or no water

Coring Method/Approach in Piezometer Wells

- Use solid tube sampler with liner
  - 2.5 feet long by 4 inch diameter
- Drive with downhole percussion hammer
- Make ten core runs in each piezometer
  - Three runs in unsaturated alluvium
  - Seven runs in saturated alluvium

Proposed Drive-Core Brass Liner Segment Division



Core Sample Laboratory Testing

- Tests conducted on one 6-inch-long segment from each core run
  - Same tests as drill cuttings plus the following
  - Saturated hydraulic conductivity
  - Volumetric water content
  - Bulk and grain density
  - Porosity
- Remaining core segments
  - Available to other laboratories or archived at the Sample Management Facility (SMF)