ABSTRACT & POWERPOINT PRESENTATION

Design, Construction, and Use of Instrumented Boreholes and DC Resistivity Surveys to Measure Artificial Recharge in Thick Unsaturated Zones, Antelope Valley, California

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Managed Aquifer Recharge Symposium
January 25-26, 2011
Irvine, California

Symposium Organizers:

- National Water Research Institute
- Orange County Water District
- Water Research Foundation

www.nwri-usa.org/rechargesymposium2011.htm

Design, Construction, and Use of Instrumented Boreholes and DC Resistivity Surveys to Measure Artificial Recharge in Thick Unsaturated Zones

By: David O'Leary, John Izbicki, Carole Johnson, Michael Mondanos, Russell Johnson, and Tom Barnes

The Antelope Valley-East Kern Water Agency is proposing infiltration of imported water by flooding of agricultural fields to recharge and bank as much as 30,000 acre-feet of water per year in the western portion of Antelope Valley, California. When imported water is available, it would be ponded and infiltrated over a period of 3-4 months while the fields are fallow; agricultural production would continue during the remainder of the year. As part of a pilot test to determine the suitability of a proposed 1,430-acre site, a berm enclosing a half-acre field was constructed in an area shown by previous studies to have high infiltration potential. Three instrumented boreholes were installed near the site to monitor the vertical and lateral movement of water as it moves through the unsaturated zone. One borehole was drilled adjacent to the site to the depth of the water table (about 265 feet below land surface) using the Overburden Drilling and Exploration (ODEX) technique. The two remaining boreholes were drilled at distances of 25 and 50 ft from the bermed site to depths of about 80 feet using mud-rotary methods. The deeper borehole is used to monitor vertical movement of infiltrated water to the top of the saturated zone, and the shallower holes are used to monitor near-surface lateral movement of infiltrated water. Instruments installed within the deep borehole include advanced tensiometers, thermistors, dielectric permittivity sensors, suction-cup lysimeters, and a piezometer. Fiber-optic cables were installed all three boreholes to monitor temperature changes in the subsurface associated with the movement of the wetting front using Raman spectroscopy. All boreholes contain a 2-in diameter PVC pipe access point for the repeated collection of electromagnetic (EM) resistivity logs, which are sensitive to changes in water content in the unsaturated zone. Electrodes spaced at 3.3 foot intervals were installed in the shallower boreholes to measure relative changes in electrical resistivity between the two shallow boreholes; changes in resistivity are related to changes in water content. In addition, sequential surficial DC-resistivity data are being collected along transects adjacent to the site to monitor changes in subsurface resistivity resulting from the lateral spreading of infiltrated water. The surficial DC-resistivity data will be correlated with electrical resistivity data collected from the boreholes to assess the movement of the wetting front in three dimensions.

Water was applied to the bermed area beginning on June 15, 2010, and the monitoring of the movement of the wetting front is ongoing. Data from the pilot test will be used to develop a model of unsaturated-zone flow that will be used to assess the potential for full-scale development of groundwater recharge and banking at the proposed site. As part of this study, an existing model of saturated-zone flow will be updated and used to simulate the fate of recharge from a full-scale banking program at the site.

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NWRI Managed Aquifer Recharge Symposium
January 26, 2011

Presented by: David O'Leary

U.S. Department of the Interior
U.S. Geological Survey

Presentation Outline

- Project Objectives
- Site Location
- Infiltration Potential of Recharge Sites
- Instrumented Boreholes (ODEX)
  - Installation
  - Monitoring
- DC Resistivity
  - Borehole
  - Surficial
- Application of Recharge Water
- Results


Area of map
CALIFORNIA
Pacific Ocean
Tehachapi Mts
Cottonwood Creek
Mojave
Fremont Valley
MUROC FAULT
Boron
SPRING FAULT
Bissell Hills
Main Base
Rogers Lake (dry)
Westside study area
WILLOW SPRINGS FAULT
RANDSBURG - MOJAVE FAULT
Rosamond Hills
Rosamond
Buckhorn Lake (dry)
Rosamond Lake (dry)
NEENACH FAULT
BLAKE RANCH FAULT
EL MIRAGE FAULT
ANTELOPE VALLEY FAULT ZONE
Little Buttes
Antelope Buttes
North Buttes study area
Lancaster
Quartz Hill
Little Rock Wash
Alpine Buttes
Amargosa Creek
Palmdale
Big Rock Wash
Lovejoy Buttes
Littlerock
Amargosa Creek study area
San Gabriel Mts
USGS

Primary Project Objectives

- Determine if the North Buttes site is suitable for artificial recharge and storage
- Determine background water-level and water-quality conditions
- Determine the effects of artificial recharge on water levels and water quality
- Develop modeling tools to facilitate better management of the proposed full-scale artificial-recharge and storage project

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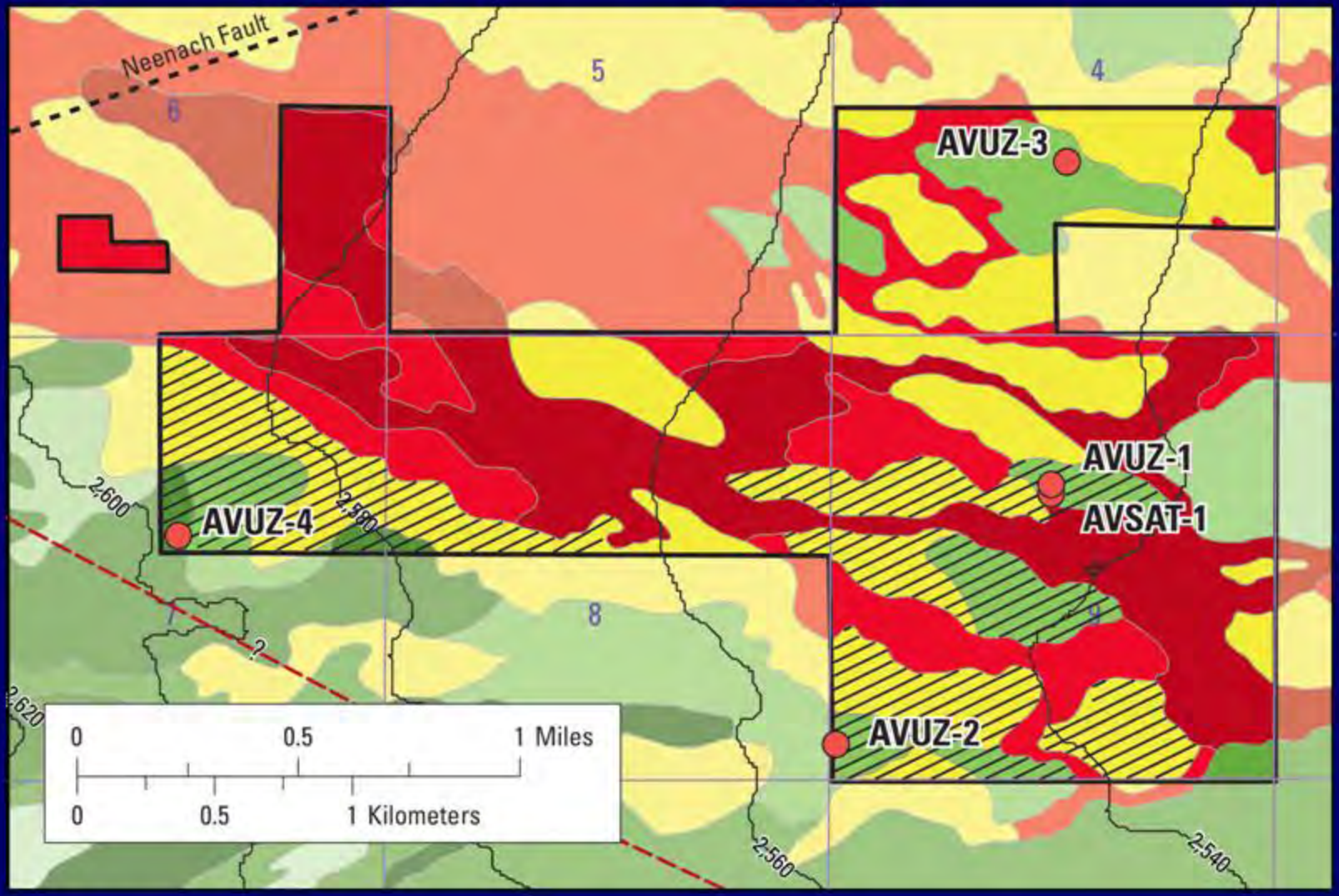
Monitoring network



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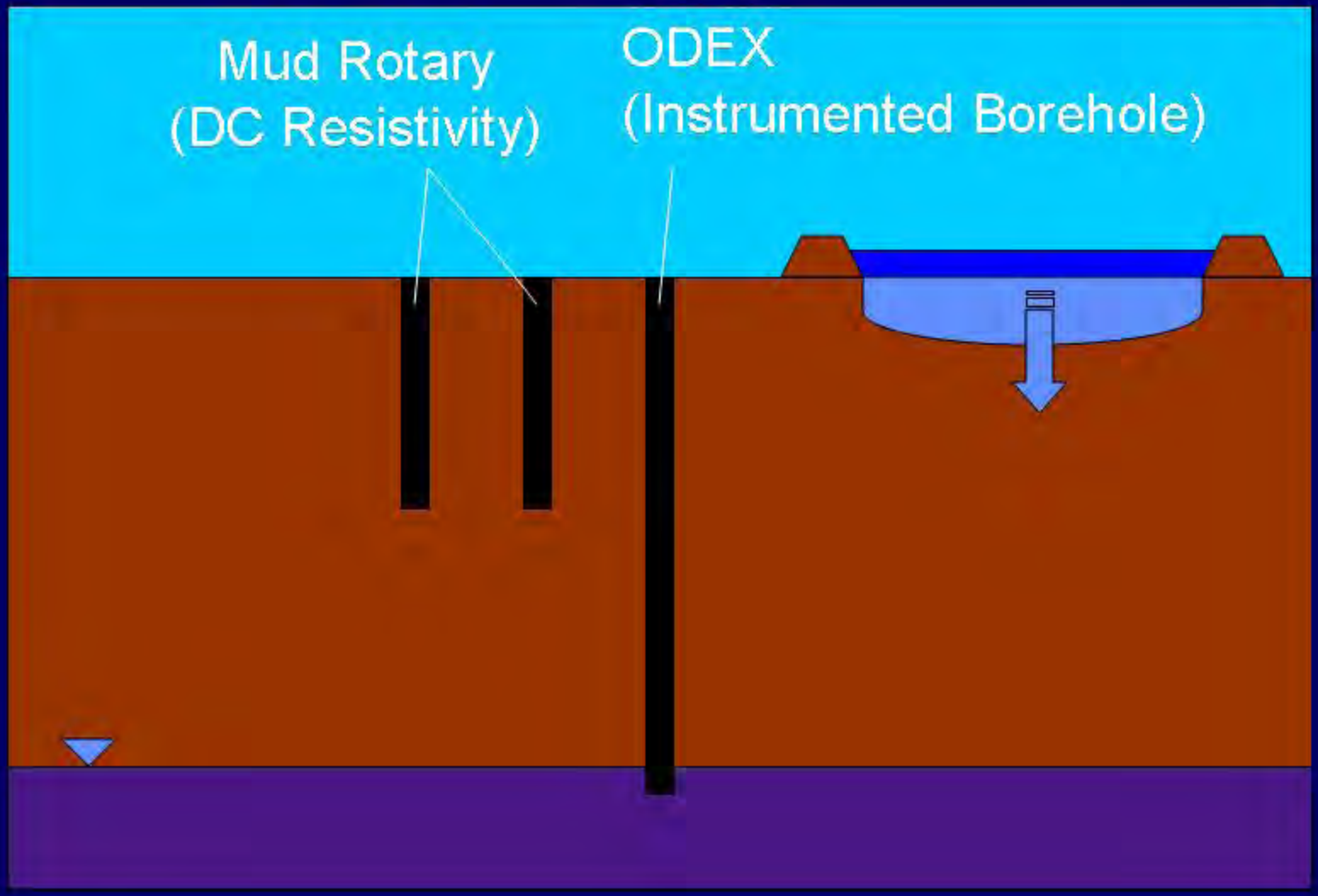
AVUZ-2 Recharge Pond

USGS



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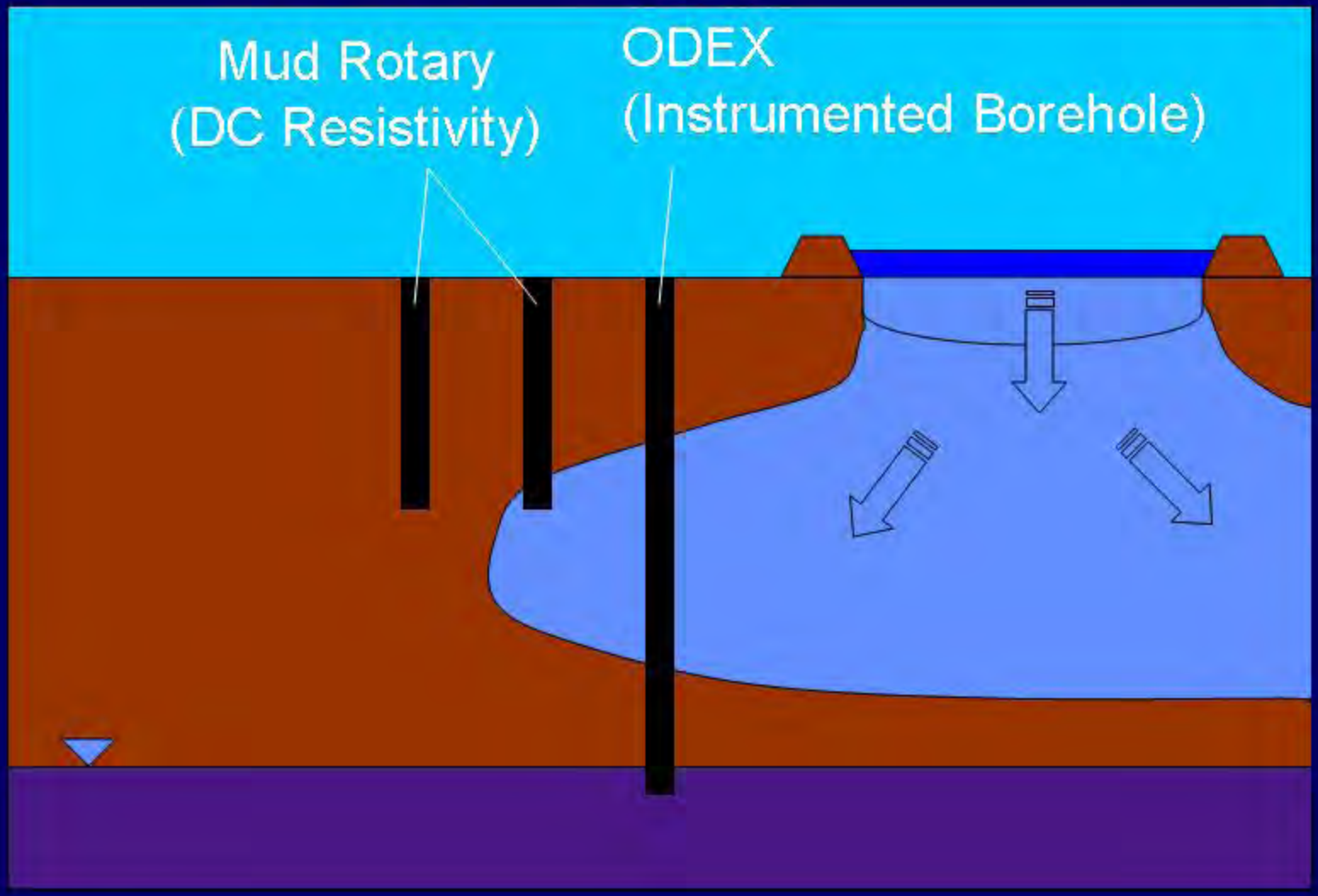

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ODEX DRILLING

ODEX DRILLING TECHNOLOGY

DETAILED LOGGING OF CUTTINGS AND LIMITED REAL-TIME ANALYSIS AT ONE-FOOT INTERVALS

CORE SAMPLES COLLECTED FOR HYDRAULIC AND ISOTOPIC ANALYSIS

Instrumentation

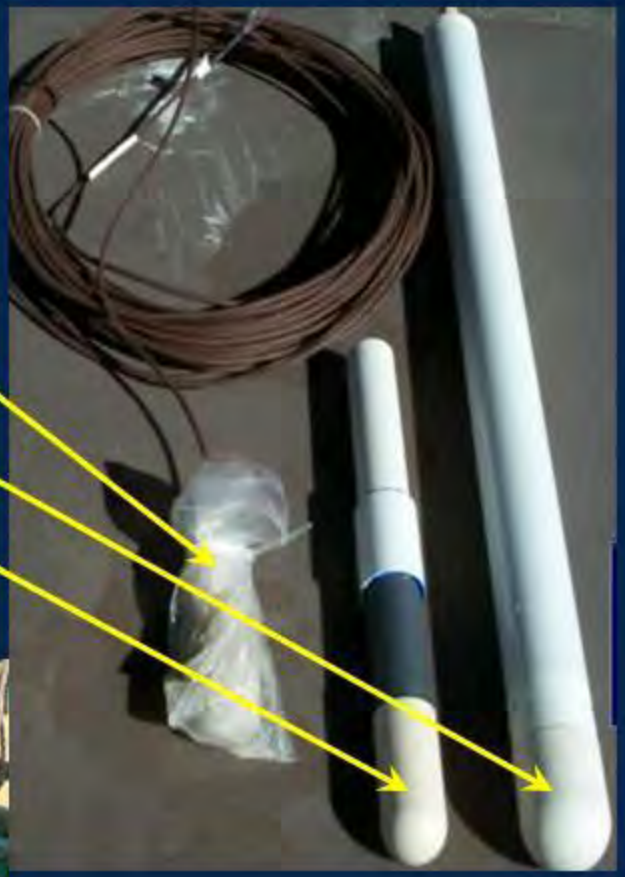
Dielectric Permittivity Sensor

Heat Dissipation Probe

Suction Cup Lysimeter

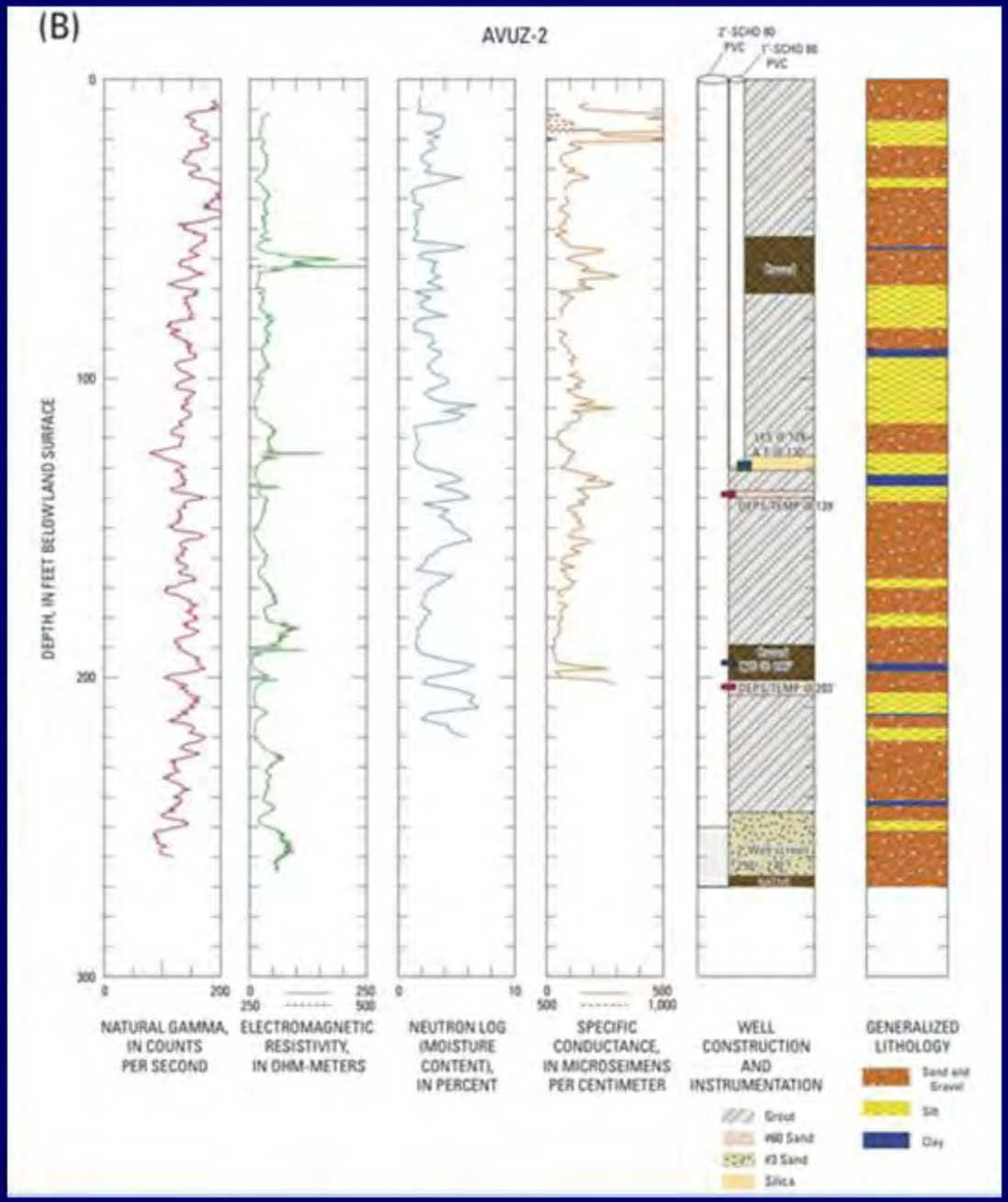
Advanced Tensiometer

Temperature Sensor



Instrument Installation

Instrumented Borehole Completion



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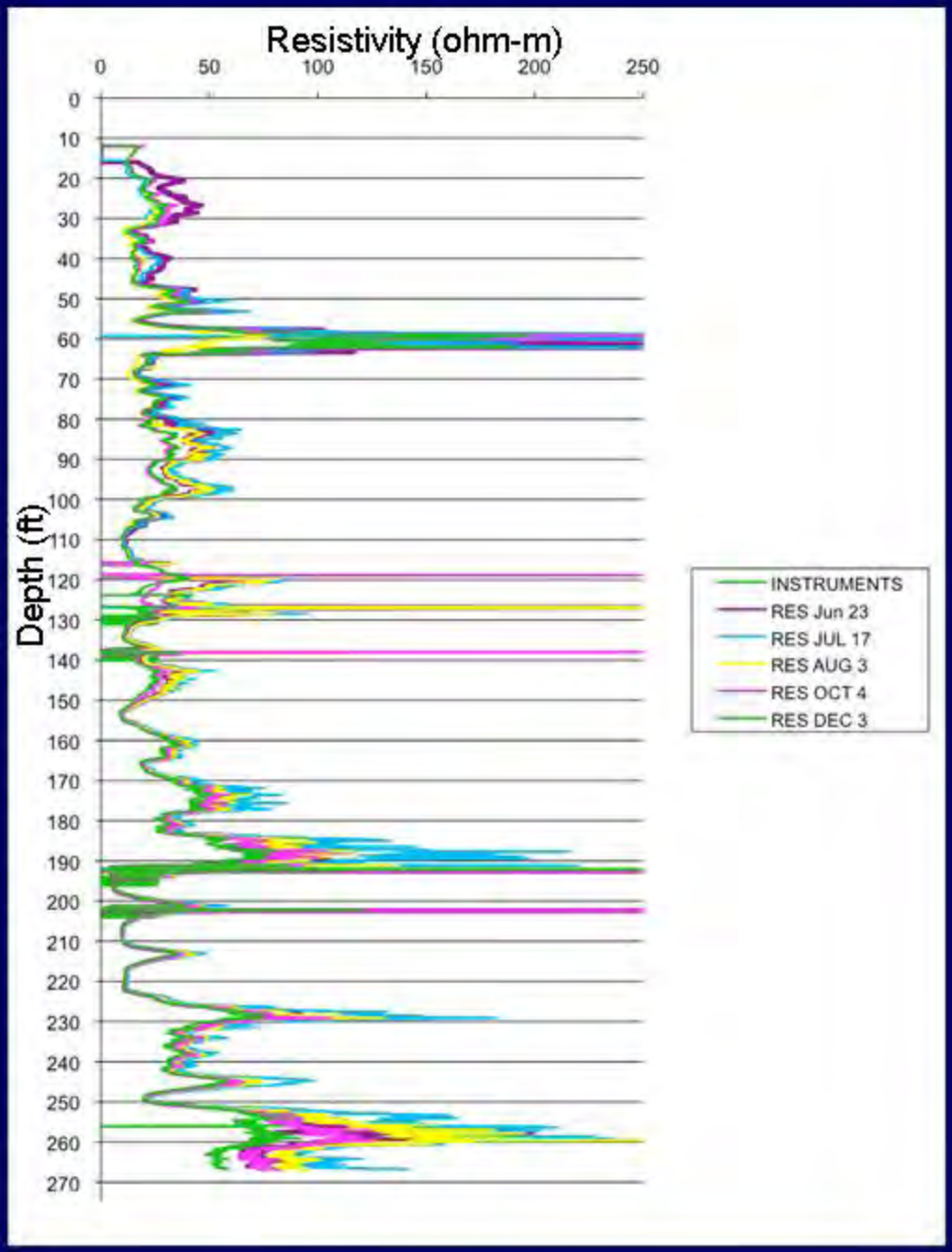
AVUZ-2 Resistivity Profiles



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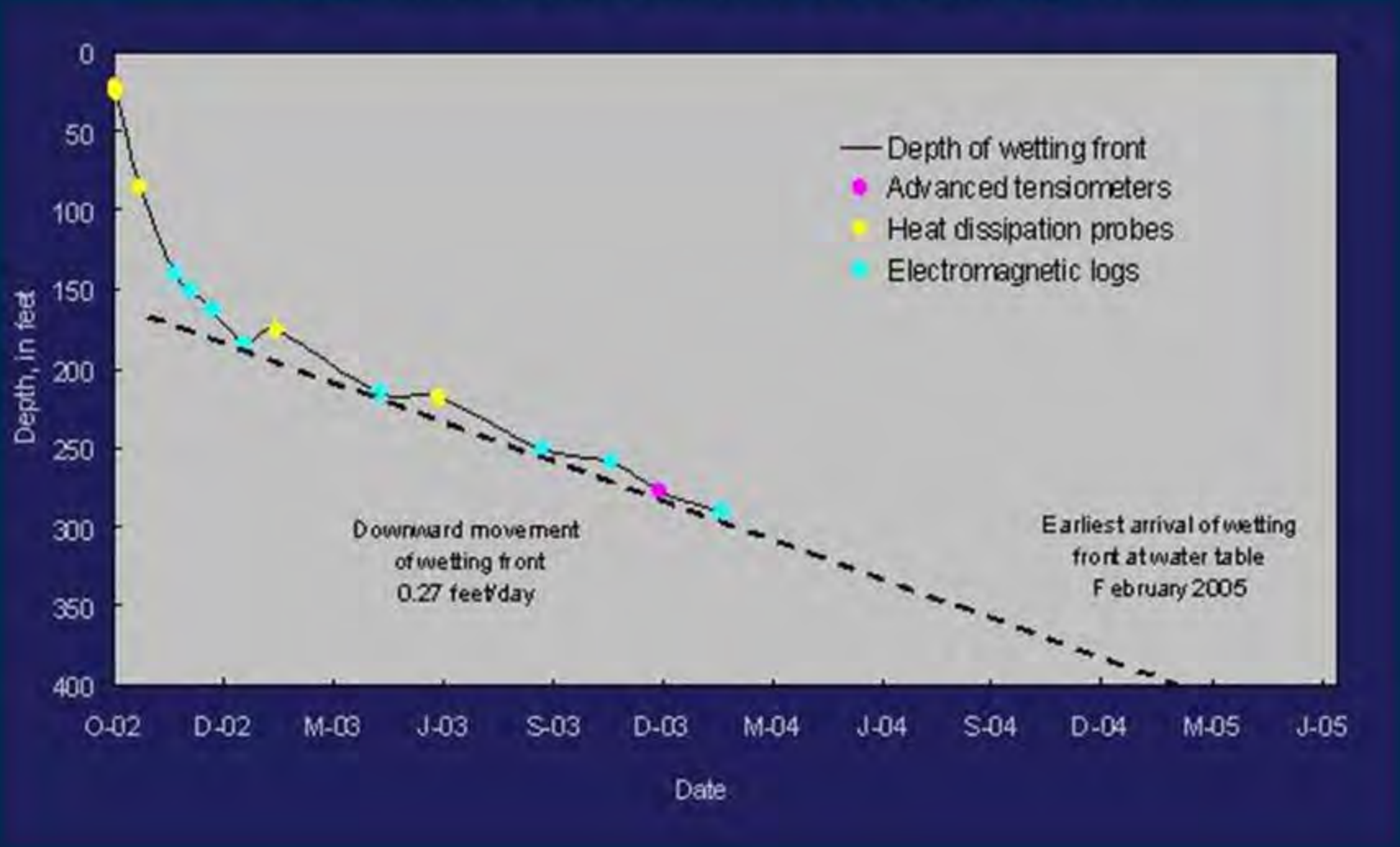
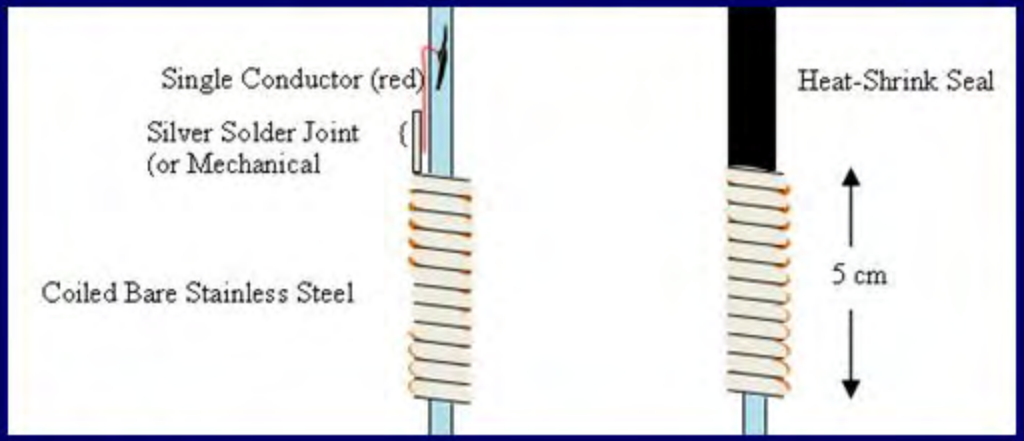
Downward movement of wetting front



DC Resistivity Array Install



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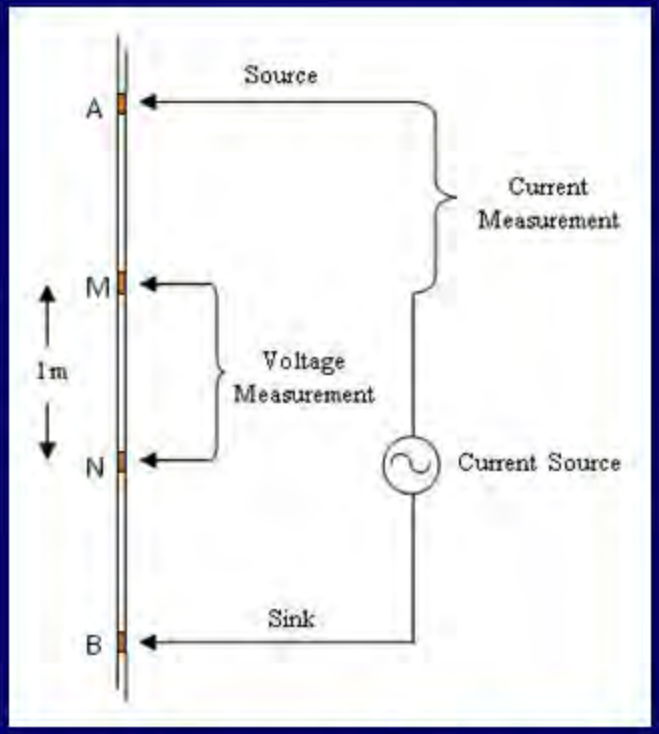
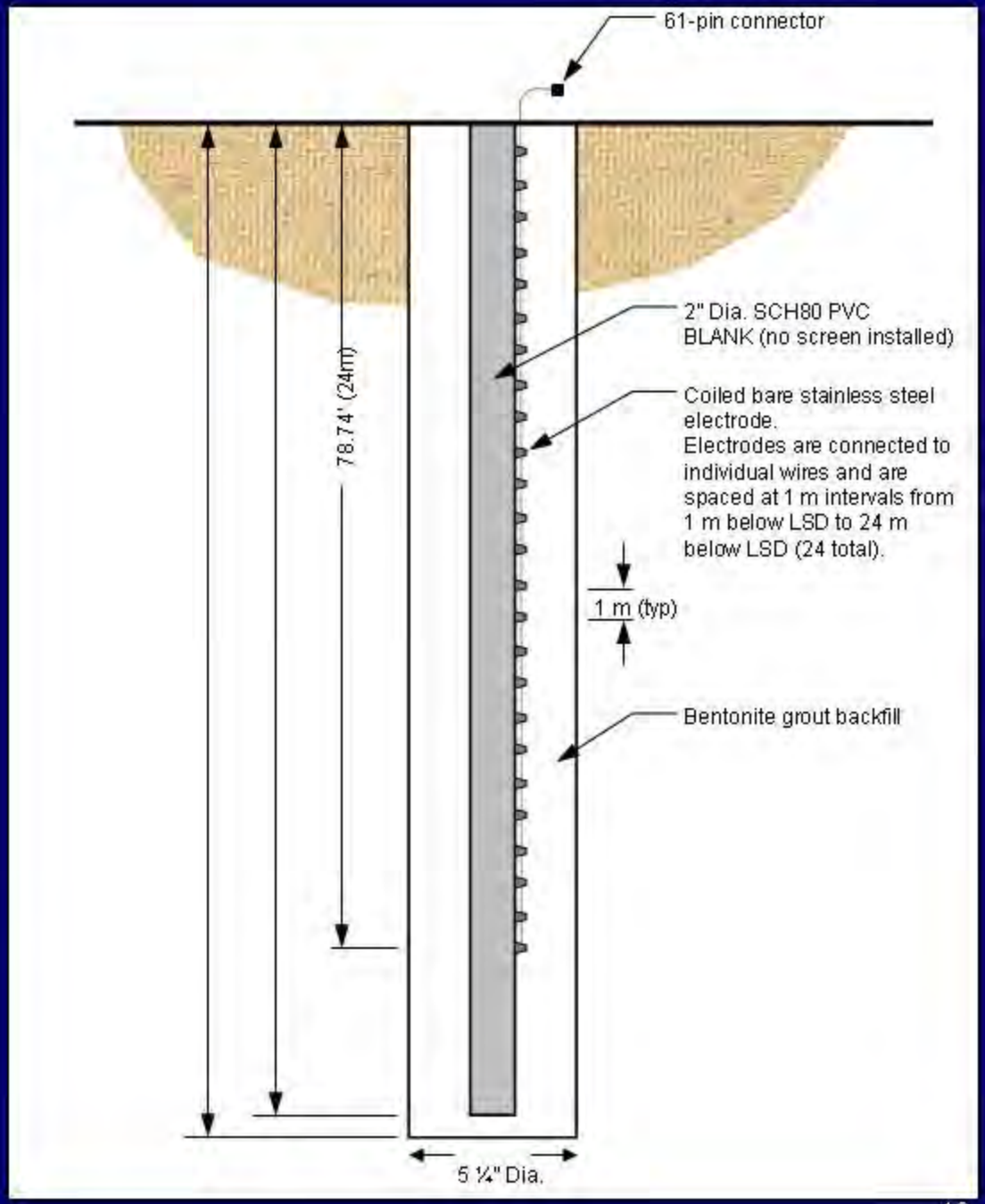
DC Resistivity Array

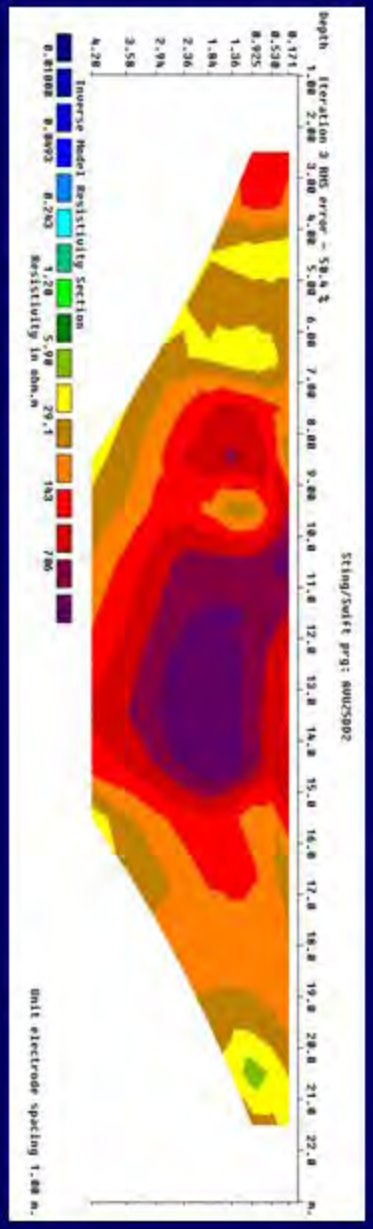


Wenner Array

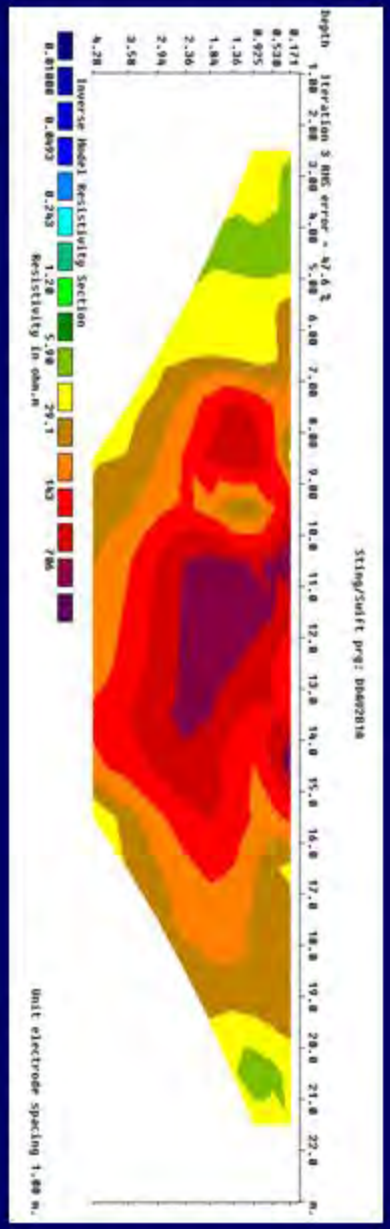


Borehole 2A

May 26th, 2010



November 5th, 2010



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Borehole 2B

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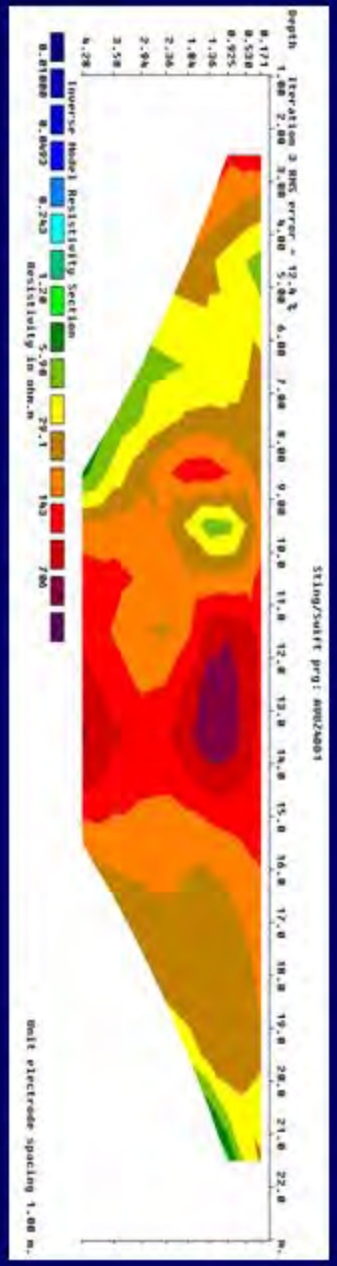

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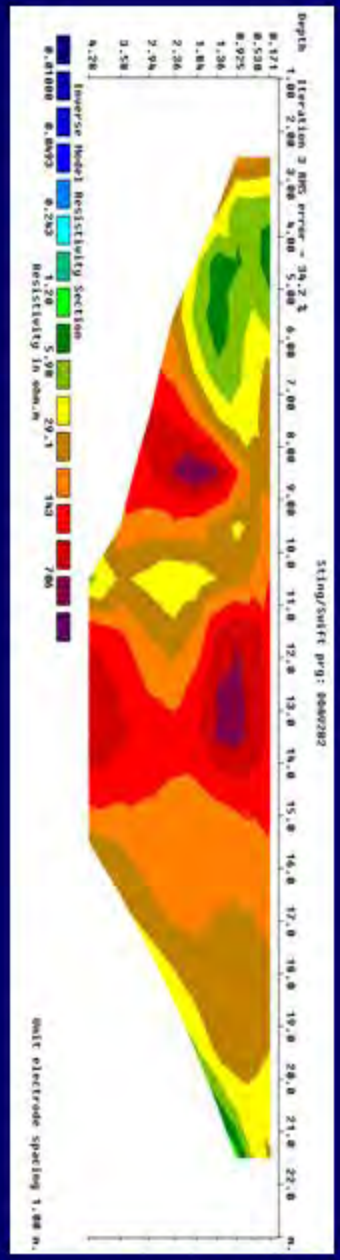

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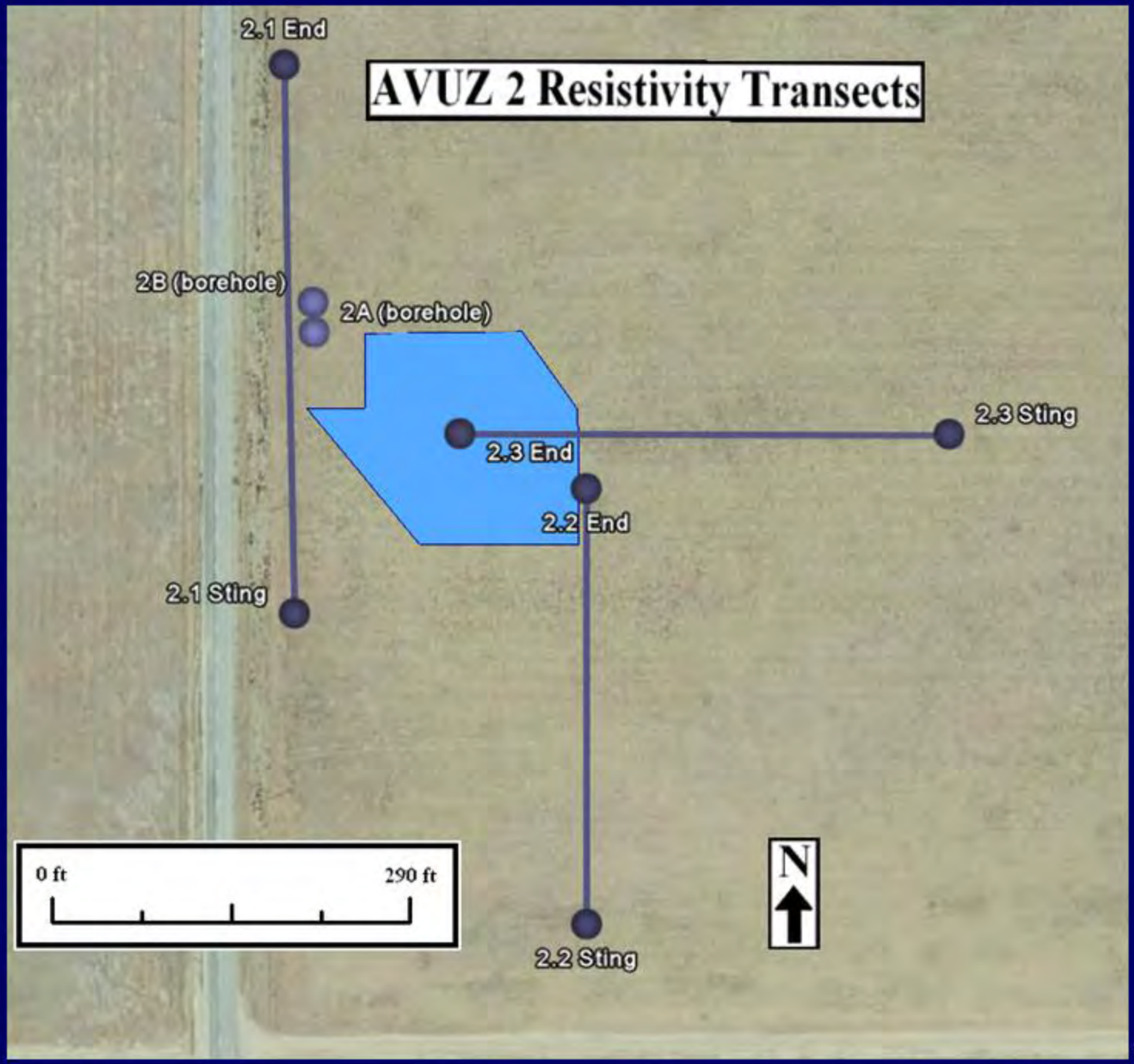
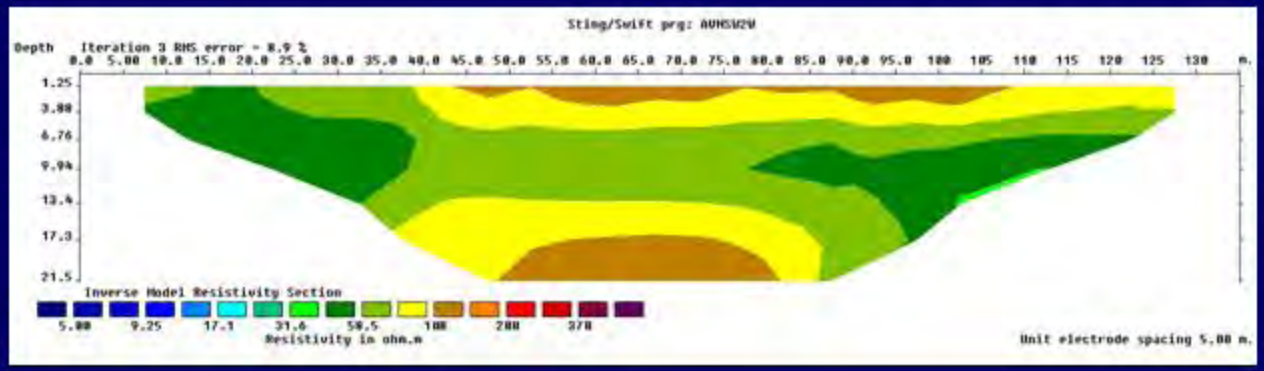

AVUZ 2 Resistivity Transects
2.1 End
2B (borehole)
2A (borehole)
2.3 Sting
2.3 End
2.2 End
2.1 Sting
2.2 Sting
0 ft
290 ft
N

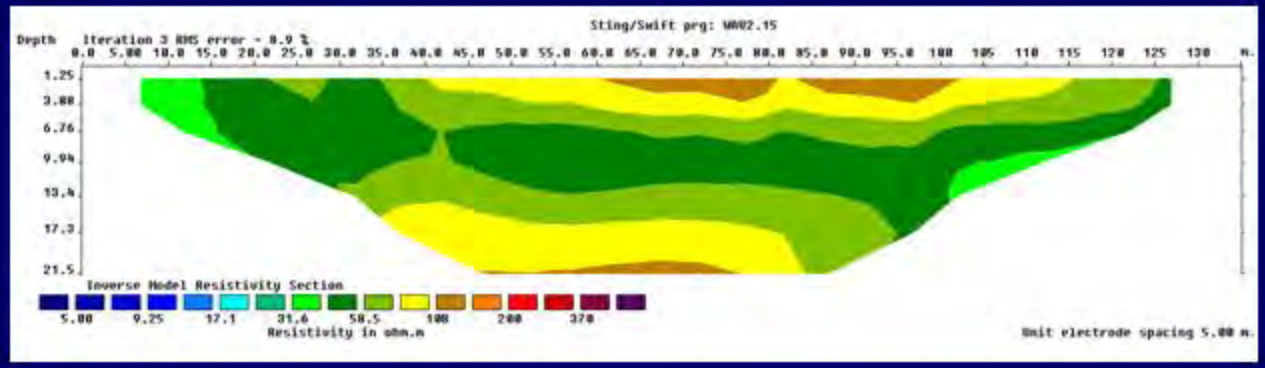
USGS

Transect 2.1

June 9th, 2010



November 4th, 2010



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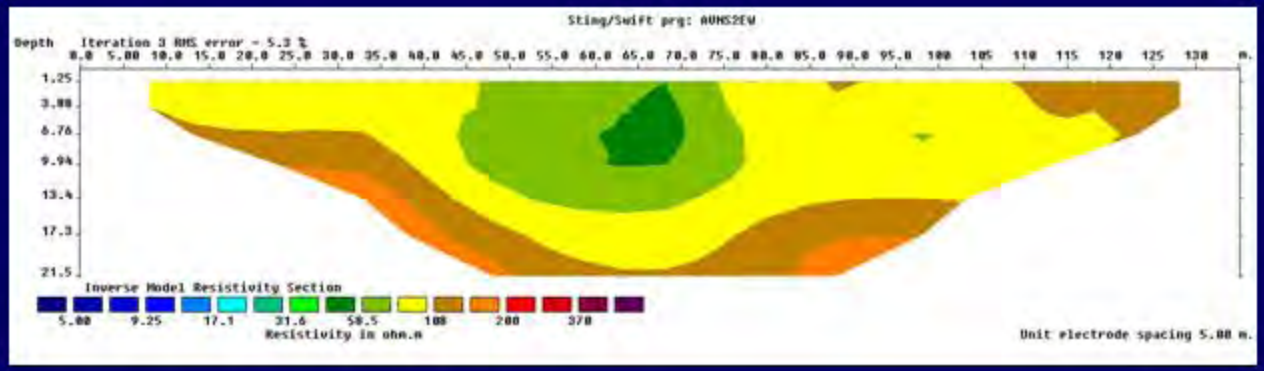
Transect 2.2

June 9th, 2010



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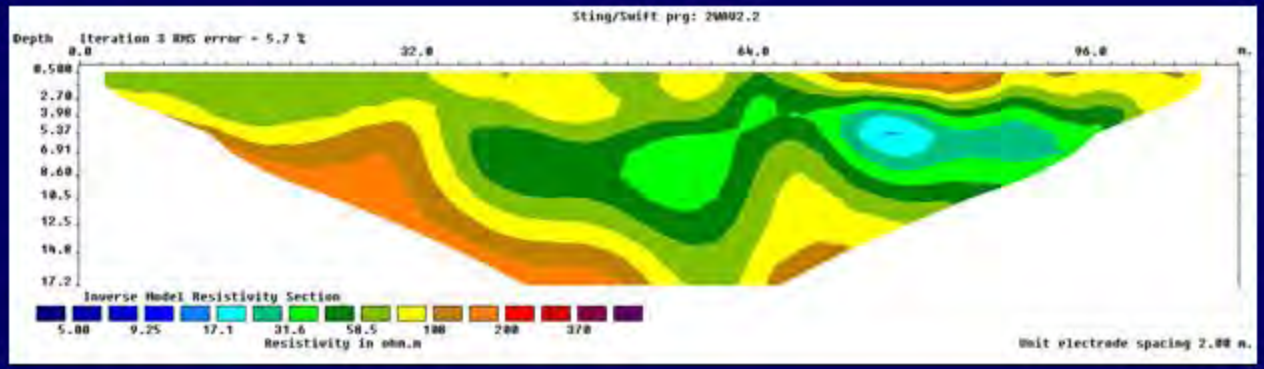

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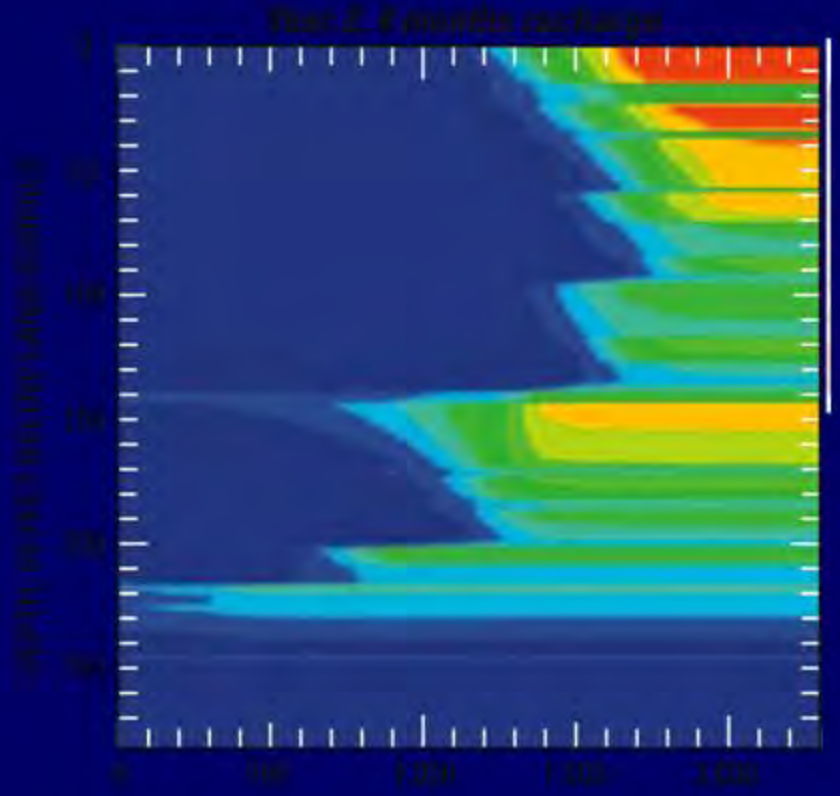
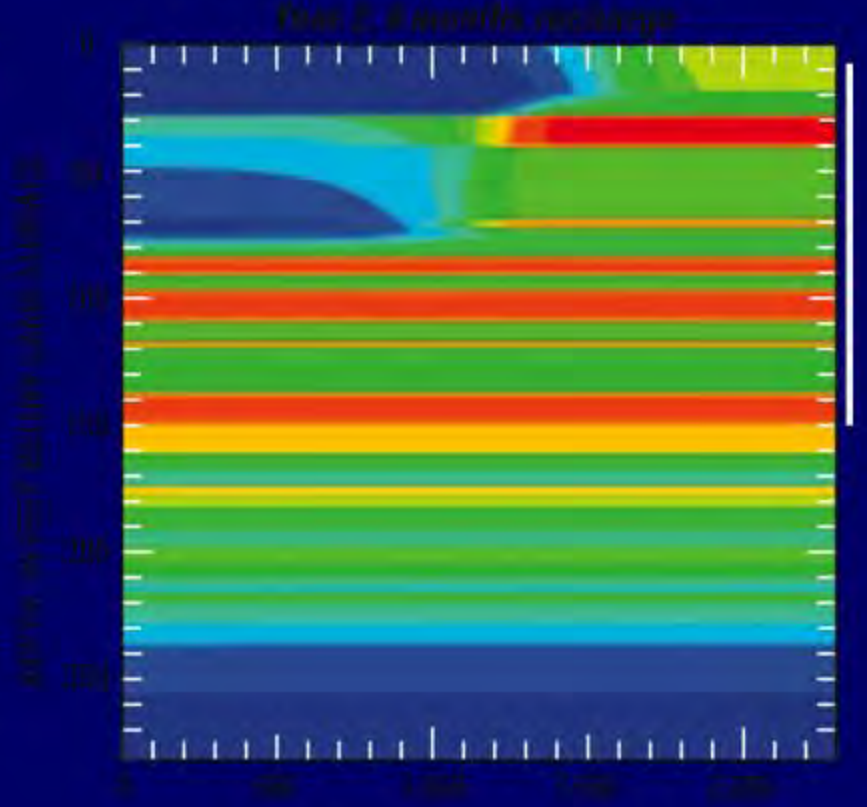
Simulated infiltration (2 years of recharge)

AVUZ-2 (south)



0.5 ft/d

AVUZ-3 (north)



0.07 ft/d

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Questions?
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