Drilling Methods

Used by the Western Region Research Drilling Program

Wireline Coring
Air Drilling
Mud Drilling
Logging and Construction
Monitoring

Three-dimensional geohydrologic and geochemical framework analyses require reliable subsurface data. This includes collecting Geologic, Geophysical, Hydrologic, and Geochemical data. The Western Region Research Drilling Program (WRRDP) collects these data in all types of geologic environments using multiple drilling methods, geophysical logging of holes, and installation of wells and other instruments.

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Wireline Coring

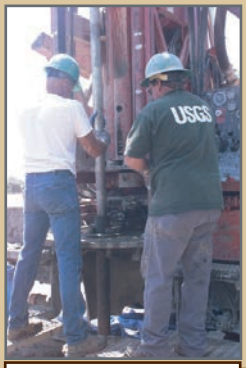
Western Region Research Drilling Program drill rig

Wireline coring is the most efficient method for collecting cores. Cores collected using this method greatly enhance subsurface data. Using the wireline system, cores can be taken continuously, or the drill-ahead system can be used if cores are taken intermittently. The **WRRDP** drill rig is capable of continuous coring a hole, then switching over to traditional drill pipe to ream the hole for instrumentation.

Latching up to core barrel

5-foot barrel attached to 5-foot spring retract

Hoisting core barrel up to line up over wireline casing



Core barrel being tripped down hole

Note: Spring retract allows core barrel to protrude beyond cutting bit in soft zones. This protects the core from mud or air invasion.

Core barrel retrieved → Barrel broken down → Liner with core removed from barrel

Proper handling and recording of core is critical prior to lab analysis.

Extraction of liner containing core material

Liner is cut and core is described

Coring sample

Scale: In feet below land surface

Scale in centimeters

Air Drilling

Drilling site using air-hammer drilling method

Air-hammer drilling is used in hard rock and unconsolidated-unsaturated studies. Unsaturated studies use an air-hammer/under-reamer system that pulls casing down as the hole is drilled. This allows wells and instrumentation to be installed inside the casing before the casing is pulled out of the hole. **Reverse air circulation** is also a method offered by the WRRDP.

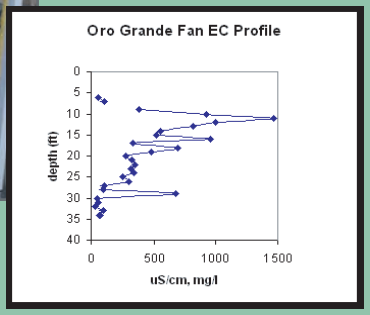
Air swivel diverter directs cuttings to **cyclone**

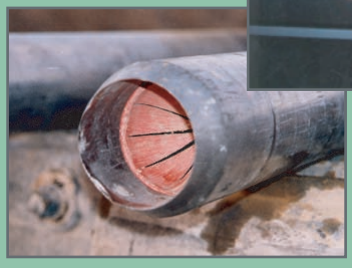
The rig's **900 cfm/350 psi air compressor** forces the cuttings to the surface through the diverter to the **cyclone**. The cyclone allows air to escape upwards while cuttings drop out through the bottom. For larger diameter holes, a backup unit can be piggy backed to the rig's compressor for additional air volume.

Foot interval samples show dramatic changes on small scale.

Measuring EC and Cl

Simple onsite measurements plotting chloride profile

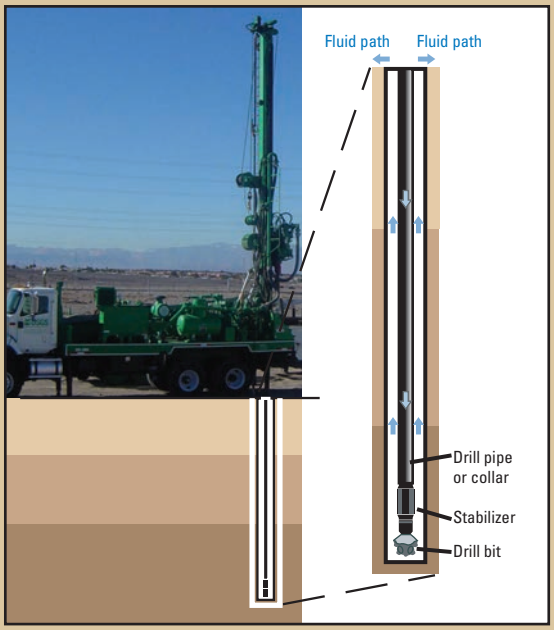




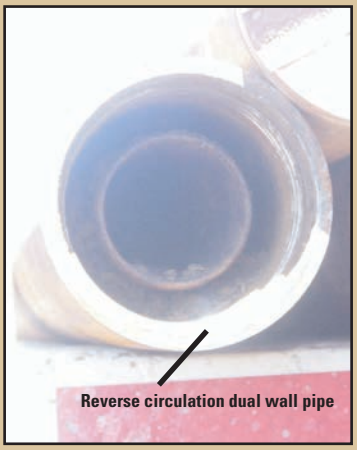
Cores can be immediately sealed airtight. Chemical and physical properties of the core material can then be analyzed in the lab.

Cores in saturated and unsaturated zones can be taken using the **push-core barrel**. Two-foot cores can be analyzed for both physical and chemical properties.

Mud Drilling



Both **Direct and Reverse mud circulation methods** are offered by the WRRDP. **Direct** mud circulation allows the scientist to collect both sieve and shaker samples. Spot coring is also possible. This method allows for rapid drilling of larger diameter holes and reaming of pilot holes. Flooded **Reverse** circulation uses either mud or water + polymers and air. Samples obtained using this method are very clean and accurate.



The **pickup pump** "vacuums" mud and cuttings from the borehole and diverts them to the shaker or mud-filtering system.

Reliable grout seals are set using a **high-pressure positive displacement piston grouter**.

The **shaker tank** serves as the mud filtration system. Once filtered the mud is then pumped back down the borehole.

The **shaker screen** separates drilling mud from coarser cuttings.

The **desilter cones** or **desander** separate the finer sands from drilling mud.

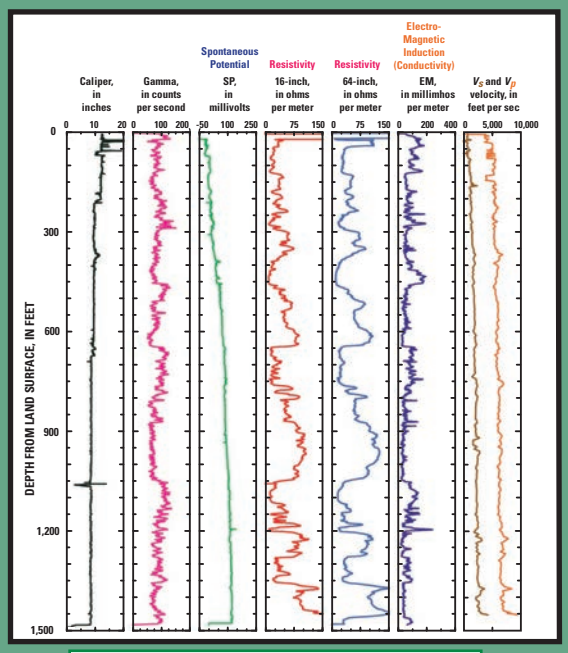
Dual positive displacement (piston) mud pumps force the drilling fluid down the borehole when the rig's centrifugal pump is over pressured. These pumps are used at deeper depths.

Typical cuttings collected by sieving mud and/or sampling from the shaker screen and cones.

Logging and Construction

Borehole Geophysical Logging

Geophysical logging services are included in all holes the WRRDP drills. Logs are printed onsite and digital files can be *e-mailed* to project managers. Standard logging tools which accompany the van include the following: resistivity tool (16-inch, 64-inch, lateral gamma, SP, temp., fluid resistivity), electromagnetic induction tool (conductivity, gamma, in open or fluid-filled hole), caliper tool, and deviation tool or inclinometer. Special tools can also be also run such as the acoustic televiewer, sonic (density), spectral gamma, and the borehole camera.



Geophysical logs and lithologic information
Well site 4S/12W-25G 1-6 (Long Beach water 1)

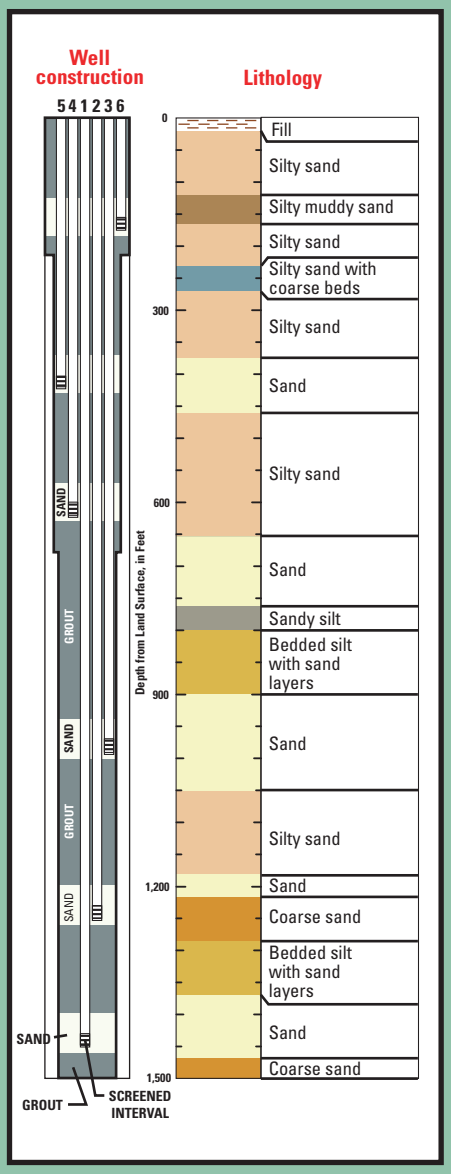
Geophysical tools used

Drawworks comes with 2500 feet of cable

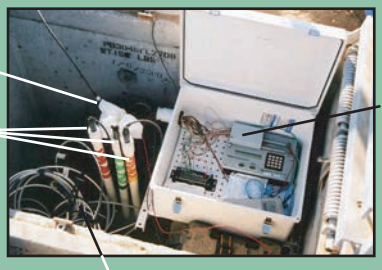
Inside of van showing computer used to run logging and plotting software

Well Construction

Well construction and instrumentation is performed by the WRRDP. For ground-water studies, typical construction well nests include five to six individual monitoring wells. The screened interval of each well is surrounded by a sand pack. Seals are pressure grouted into place between screened zones.



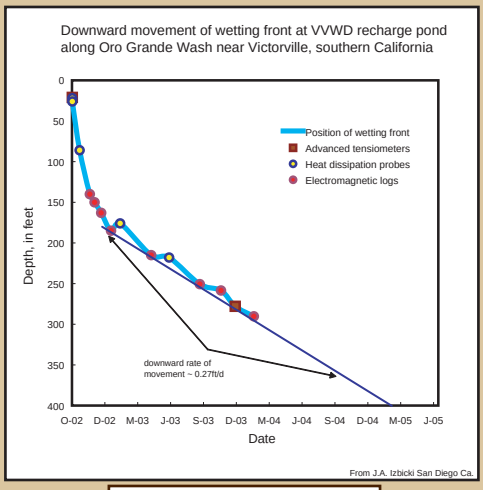
Installation of unsaturated zone study instrumentation, such as neutron logging access tubes, gas-sampling tubes, psychrometers, temperature probes, and lysimeters, are standard procedure for the **WRRDP**. Seismometers and strain meters can also be installed for earthquake studies.



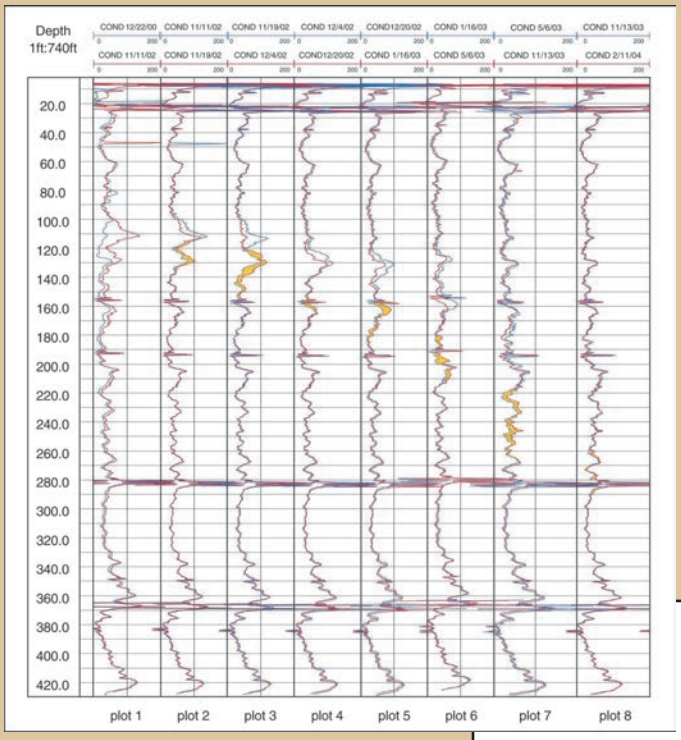
Instrumentation installed in borehole at Artificial Recharge Pond tracks downward migration of recharge through an unsaturated zone.

Monitoring

The WRRDP has experience in monitoring via geophysical logging. Two examples below demonstrate the ability of Electromagnetic Induction logs (EM logs) to track both fresh water recharge through the unsaturated zone in a desert environment and seawater intrusion in coastal environments. Temperature and flow metering are other very useful logs that can be run repeatedly over time.



EM data are proven with data from instruments installed in the borehole.



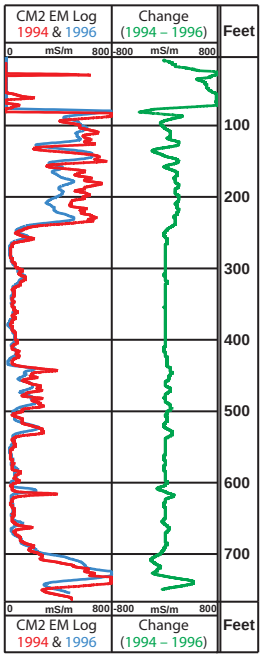
Changes in EM logs over time show the downward movement of the wetting front

A comparison of EM logs done in 1994 (red) and 1996 (blue) shows the changes that occurred during the 2-year period.

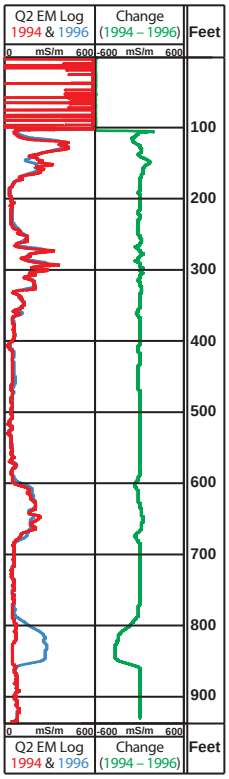
The EM log conductivity decreased in well CM2 at 150 to 240 feet below land surface, indicating a retreat of the seawater front.

The EM log conductivity increased in well Q2 at 800 to 850 feet below land surface, reflecting continued water-quality degradation in the lower aquifer system in this area.

EM Logs for Well CM2



EM Logs for Well Q2



For more information on this USGS program contact:
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