APRIL 2003

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Memorandum

Risk Reduction & Environmental Stewardship (RRES)
Groundwater Protection Program (GPP), MS M992

To/MS: Distribution
From/MS: Charles Nylander, RRES-GPP, MS M992
Phone/FAX: 5-4681/5-4747
Symbol: RRES-GPP-03-053
Date: April 24, 2003

SUBJECT: MINUTES FROM THE HYDROGEOLOGIC CHARACTERIZATION PROGRAM ANNUAL MEETING HELD MARCH 18, 2003

Enclosed please find the Los Alamos National Laboratory' (LANL) Hydrogeologic Characterization Program March 18, 2003, Annual Meeting minutes, a list of poster presentations displayed at the public meeting, an updated list of publications associated with the program, and a copy of the Groundwater Annual Status Report for FY02.

The discussions and presentations at the annual meeting resulted in the following highlights:

- There continues to be significant funding uncertainty for FY03. Installation of wells and other non-field work on the program depends on receiving additional funding from the facility landlord, the National Nuclear Security Administration (NNSA), and on receiving funds for the accelerated cleanup program from Environmental Management. The current level of funding is sufficient only complete the construction, reporting, and site restoration for the wells drilled in FY02.

- The well completion reports for the five FY02 wells will be distributed when completed, but all may not be completed by April 30, 2003, due to funding issues.

- New Mexico Environmental Department (NMED) was consulted about plans to plug and abandon Mortandad Canyon intermediate well MCOBT-4.4 and a separate meeting to discuss the subject was requested.

Please review the minutes for accuracy. If you identify substantive changes that should be made, please submit your comments to me in writing or via e-mail at nylander@lanl.gov.

Enclosure: Groundwater Annual Status Report for FY02
LANL Hydrogeologic Characterization Program March 18, 2003 Annual Meeting Minutes

CN/th

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J. Arends, CCNS
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M. Bates, Los Alamos Study Group
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C. Borchert, City of Santa Fe, Santa Fe, NM
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D. Duffy, Jemez Pueblo, Jemez, NM
M. Everett, Kleinfelder, Inc.
J. Fries, Santa Fe, NM w/enc
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T. Glasco, Los Alamos County, Los Alamos, NM
M. Goldberg, Lamy, NM
D. Gonzalez, Cochiti Pueblo
J. T. Grubesic, Assistant Attorney General
R. Gutierrez, Santa Clara Pueblo, Espanola, NM
K. Hull, Neptune & Co., Albuquerque, NM
B. Jacobs, Bandelier, NM
B. Johnson, Westbay, N. Vancouver
J. Kelsey, DB Stephens & Assoc.
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G. Lewis, NMED/HRMB, Santa Fe, NM
R. Lewis, Schlumberger, Englewood, CO
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M. Manzanares, NNMCAB, (2 copies)
V. Maranville, NMED/HWB
R. Mayer, EPA, Dallas, TX
D. Larrsen, Westbay, N. Vancouver
C. McLane, EAG, Princeton, NJ
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C. Mechels
D. Miotla, NNSA, Germantown, MD, MS C146
K. Nasser, Revision, Denver, CO
P. Padilla, Los Alamos County, Los Alamos, NM
J. Parker, NMED/DOE/OB, Santa Fe,
J. Pecos, Cochiti Pueblo, Cochiti, NM
R. Powell, EAG, Powell & Associates, Las Vegas, NV
J. Powers, EAG, Bloomington, MN
J. Powers, EAG, Murray, UT
G. Rice, San Antonio, TX
P. Ritzma, NMED Deptury Secretary, Santa Fe, NM
D. Schafer, EAG, Stillwater, MN
R. Snodgrass, Los Alamos Monitor, Los Alamos, NM
J. Stomp, City of Albuquerque
G. Valdo, Pueblo Cochiti
N. Weber, San Ildefonso Pueblo, Santa Fe, NM
J. Young, NMED/HRMB, Santa Fe, NM
D. Youngberg, DOE/HQ/DP-13, Germantown, MD
J. Aldrich, EES-6, MS D462
T. Antan, EES-13, MS M992
S. Baldridge, EES-11, MS D462
C. Bare, RRES-ECO, MS M887, (3 copies)
A. Barr, RRES-SWRC, MS K498
B. Beers, RRES-WQH, MS K497
K. Birdsell, EES-6, MS T003
S. Bolivar, RRES-R, MS H865
D. Broxton, EES-6, MS J462
W. Carey, EES-6, MS D462
G. Cole, EES-6, MS D462
A. Crowder, MK/PMC, MS M327
M. Dale, NMED/DOE/OB, MS J993
A. Dorries, RRES-ECR, MS M992
C. Echohawk, EES-9, MS C323
D. Edwards, NMT-5, MS E506
B. Enz, DOE/OLASO, MS A316
D. Erickson, ADWP, MS A106
D. Farley, RRES-ECR, MS H865
B. Gallaher, RRES-WQH, MS K497
A. Gallegos, EES-15, MS J495
S. Gibbs, ADO, MS A104

MAY 2003

L. Goen, ADO/IF&C, MS F627
F. Goff, EES-6, MS D462
P. Gomez, RRES-WQH, MS K497
GPP File, MS M992
H. Granzow, RRES-GPP, MS M992
K. Granzow, NMED/DOE/OB, MS J993
B. Grimes, CER-30, MS A117
K. Hargis, RRES-DO, MS J591
D. Hickmott, EES-6, MS D462
D. Hollis, RRES-R, MS M992
J. Holt, ADO, MS A104
R. Hull, LATA, MS M321
IM-5, MS A150
M. Johansen, DOE/OLASO, MS A316
E. Keating, EES-6, MS T003
S. Kinkead, IM-8, MS M310
R. Koch, SAIC, MS J521
C. LaDelfe, EES-11, MS D462
LANL Reading Room, MS A117
A. Lavine, EES-9, MS D462
A. Lee, RRES-R, MS M992
C. Lewis, EES-9, MS D462
P. Longmire, EES-6, MS D469
L. Maassen, RRES-R, MS M992
S. Maez, LATA, MS M321
L. McAtee, HSR-DO, MS K491
J. McCann, RRES- WQH, MS M992
D. McInroy, RRES-R, MS M992
S. McLin, RRES-WQH, MS K497
K. Mullen, RRES-WQH, MS K497
S. Natalie, PM-PPC, MS M992
B. Newman, EES-15, MS J495
M. Nilsson, EES-6, MS T003
C. Nylander, RRES-GPP, MS M992
S. Pearson, RRES-R, MS M992
A. Pratt, EES-13, MS M992
N. Quintana, RRES-R, MS 992
S. Rae, RRES-WQH, MS K497
G. Rael, DOE/ABQ, MS A906
B. Ramsey, RRES-DO, MS J591
P. Reneau, PeaKTCI, MS K490
B. Robinson, EES-6, MS T003
D. Rogers, RRES-WQH, MS K497
P. Sanchez, ADO-IF&C, MS F627
P. Schumann, RRES-R, MS M992
J. Sisneros, FWO-MSE, MS P908

J. Sisneros, FWO-SEM, MS P908
J. Skalski, EES-17, MS H865
E. Springer, EES-15, MS J495
P. Stauffer, EES-6, MS T003
D. Stavert, RRES-EP, MS J591
B. Stone, EES-6, MS T003
N. Tapia, RRES-WQH, MS K497
T. Taylor, LAAME, DOE/OLASO, MS A316
C. Thayer, LC-GL, MS A187
B. Turney, RRES-WQH, MS K497
G. Valentine, EES-6. MS D462
D. Vaniman, EES-6, MS D462
S. Veenis, RRES-WQH, MS K497
M. Vesselinov, EES-6, MS T003
R. Vocke, RRES-DO, MS J591
J. Vozella, DOE/OLASO, MS A316
P. Wardwell, LC-GL, MS A187
R. Warren, EES-6, MS D462
P. Weber, EES-DO, MS D446
T. Whitacre, DOE/OLASO, MS A316
M. Witkowski, EES-DO, MS C306
D. Woitte, LC-GL, MS A187
S. Yanicak, NMED/DOE/OB, MS J993
C. Zerkle, ADO-IF&C, MS F627
RRES-GPP File, MS M992
RPF, MS M707

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

MEETING PURPOSE, ATTENDEES, AND AGENDA

The Los Alamos National Laboratory Groundwater Integration Team (LANL GIT) met with the New Mexico Environment Department (NMED), the Department of Energy (DOE), and stakeholders on March 18, 2003 for the Annual Groundwater Protection Program Meeting. The meeting was held at the Courtyard by Marriott in Santa Fe, New Mexico. Charlie Nylander (Groundwater Protection Program Manager) facilitated the meeting.

The following groups and stakeholders were represented (see List of Attendees for specific information):

NMED-Hazardous and Radioactive Materials Bureau
NMED-DOE Oversight Bureau
New Mexico Attorney General
DOE-Office of Los Alamos Operations
New Mexico Office of the Natural Resource Trustee
San Ildefonso Pueblo
University of California
LANL-Groundwater Integration Team (GIT)

The purpose of the Annual Meeting was to provide NMED, DOE, and stakeholders with information on LANL's groundwater protection efforts and present planned activities for the upcoming fiscal year. The meeting agenda was as follows:

Welcome and Introductions
Well Drilling Summary
Geology in Latest Wells- stratigraphy and water-bearing zones
Geochemistry Update – latest contaminant data and effects of residual drilling mud on contaminant analysis
MCOBT 4.4 – what is known/suspected and decisions that have to be made
Low-Head Weir – results from contaminant sampling
Regional Aquifer Water Level Map
PM-2 Aquifer Test
Hydrogeologic Workplan Data Overview
Well Drilling Schedule/Plan

SUMMARY OF PRESENTATIONS AND DISCUSSIONS

Welcome and Introductions

Charlie Nylander (LANL) welcomed the participants to the sixth annual meeting for the Groundwater Protection Program. A brief history of the program was provided. In 1998 the Hydrogeologic Workplan prepared by LANL was approved by NMED. The Hydrogeologic Workplan laid out the scope and schedule for a seven-year characterization effort intended to refine the understanding of the hydrogeologic setting beneath the Pajarito Plateau. The purpose of the annual meetings is to provide a status of what has been learned over the past year for NMED and interested stakeholders. There are also three quarterly meetings per year that are intended to apprise NMED and stakeholders of program progress during the year. This year the format of the annual meeting has changed to encourage open dialogue. The evening session, between 5:00 and 8:00, will be a public forum with poster presentations on several different topics. The format of the public meeting is intended to promote dialogue, interaction, and questions. The "Groundwater Annual Status Report for FY02" is available for all participants.

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

Well Drilling Summary

John McCann (LANL) provided a summary of well drilling over the past year. The drilling accomplishments include the installation of six wells:

- R-14 located within Mortandad Canyon watershed, in Ten Site Canyon – total depth of 1330 ft, completed with two screened intervals
- R-16 located within Mortandad Canyon watershed, in White Rock – total depth of 1287 ft, completed with four screened intervals
- R-20 located within Pajarito Canyon watershed, on the Pajarito Canyon bottom near TA-18 and water supply well PM-2 – total depth of 1365 ft, completed with three screened intervals
- R-21 located within Cañada del Buey watershed, on the north side of TA-54 – total depth 995 ft, completed with one screened interval
- R-23 located within Pajarito Canyon watershed, on the Pajarito Canyon bottom close to State Road 4 – total depth 935 ft, completed with one screened interval
- R-32 located within Pajarito Canyon watershed, on the Pajarito Canyon bottom mid-way between R-20 and R-23 – total depth 1008 ft, completed with three screened intervals

All work on the above wells is now complete.

Well development challenges were encountered because wells were drilled using fluids – mud, foam, lost circulation materials. The challenge was to remove the materials from the wells so that the wells yield water that is representative of the formation water. Chemical additives were used to break down lost circulation materials. Developing the wells required removing large volume of water as indicated below.

Well	Volume of Water Removed during Development (gallons)
R-14	205, 010
R-16	100,120
R-23	25,900
R-32	144,670

The water removed during development was contained in tanks and sampled and analyzed for contaminants. When the analytical results indicated no contaminants present and NMED gave approval, the water was sprinkled on roads and other areas for dust control.

Sampling activity in FY02:

- R-13: first screening sample and three characterization sampling rounds
- MCOBT-4.4: first screening sample and three characterization sampling rounds
- R-7, R-9, R-9i, R-12, R-15, R-19, R-22, and R-25: one round of sampling where the characterization sampling has been completed:
- Two CdV-R wells associated with the 260 Outfall Corrective Measures Study investigation: quarterly sampling

Reports completed in FY02:

- Fact sheets for wells R-14, R-16, R-20, R-23, and R-32
- Geochemistry Reports for R-7, R-12, R-19, and R-22
- Well Completion Reports for MCOBT-4.4, MCOBT–8.5, and R-7
- Remaining well completion reports are expected to be complete by March 31.

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

Questions, Comments, Answers, and Responses

Q: When will the fact sheet and well completion report for R-21 be done?

A: The fact sheet will be done today and the well completion report is expected to be complete by March 31.

Q: Will the wells planned for this year be drilled with fluids?

A: Many of the wells planned this year are in wet canyons where perched intermediate zones and possibly contamination are anticipated, so the wells will be started with dry (air) drilling methods and minimal fluids. However, fluids may be used, particularly below the regional water table. We must be able to have the flexibility to use the methods that will work in the geologic conditions encountered. Also, measures will be taken to circulate as much of the fluids out of the borehole before constructing the well to reduce the time and effort for development.

Geology in Latest Wells- Stratigraphy and Water-Bearing Zones

David Broxton (LANL) described the geology encountered in the FY02 wells. R-14 is located in Ten Site Canyon. Ten Site Canyon received effluents from one of the earliest wastewater treatment plants at the Lab, located in TA-35 (now decommissioned). It is also cross gradient from the discharge of the TA-50 liquid radioactive wastewater treatment plant. The purpose of R-14 is to look for contaminants from the TA-35 wastewater treatment plant and possibly the TA-50 plant. The depth of the well is 1330 ft. Core was collected from 0 to 306 ft and analyzed for anions and moisture content. Logs from the well include: natural gamma, borehole video, lithologic, and Schlumberger geophysical logs. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model is a good match with what was encountered. Cerros del Rio basalt was expected, but found dacite instead. However, this is not a big surprise because dacites are also present in a Seismic Hazards Borehole nearby. The regional aquifer was predicted at 1164 ft, and the water level in the open borehole (composite head) of R-14 is 1181 ft deep. R-14 was completed with two screens in the regional aquifer: screen one between 1200 and 1233 ft and screen two between 1286 and 1293 ft.

Since R-14 is the last of the deep wells proposed for Mortandad Canyon in the Mortandad Canyon RFI Work Plan, a cross section summarizing the information from the boreholes was presented. The salient features of the cross-section are:

- Dacites are stratigraphically higher than the basalts.
- Cerros del Rio basalts thicken as the top of the unit rises eastward.
- There is a wedge of Puye Formation on top of the Cerros del Rio basalt that this eastward as the top of the basalts rise.
- A thick section of the Otowi member of the Bandelier Tuff, overlying the Guaje Pumice, is present.
- Alluvial groundwater extends probably to R-15 and possibly beyond; the down-canyon extent is not well defined.
- There are two intermediate perched zones – one within the Puye Formation above the Cerros del Rio basalt encountered in MCOBT-4.4 and one at the base of the Cerros del Rio basalt encountered in R-15. The extent of either zone is not defined.
- The regional aquifer is entirely within the Puye Formation below the Cerros del Rio basalt.

R-20 is located in Pajarito Canyon, near PM-2 water supply well and TA-18. Core was collected from the surface to a depth of 436 ft and analyzed for anions and moisture content. Logs from the well include natural gamma, borehole video, lithologic, and Schlumberger geophysical logs. There are two Schlumberger logs because the well was drilled open hole down to the regional aquifer and one set of logs was run at that time. The borehole was then cased and drilled with

mud. The second set of Schlumberger logs was run when the total depth was reached. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model (based largely on PM-2) is a very good match with the actual encountered. The unit encountered at the bottom of the borehole is Tertiary Sands, which was originally thought to be Santa Fe Group. The regional aquifer water level was predicted to be at 854 ft. The composite water level in the well was 842 ft. R-20 was completed with three screened intervals and the water level in each interval measured:

- Screen 1 (904 – 912 ft): water level at 826 ft
- Screen 2 (1147 – 1154 ft): water level at 830 ft
- Screen 3 (1328-1336 ft): water level at 850.2 ft

R-21 is located in Cañada del Buey, north of TA-54, mid-way between MDA-L and MDA-G. The total depth of the well is 995 ft. Core was collected from the surface to a depth of 250 ft and analyzed for anions and moisture content. Logs from the well include borehole video, lithologic, and Schlumberger geophysical logs. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model (based largely on PM-2) is a good match with the actual encountered. Although the 3-D geologic model shows undifferentiated Cerros del Rio Basalts, the actual encountered was a series of basalts intercalated with cinders, rubble, and many interfingering units, although the thickness of the Cerros del Rio is close to what was predicted. Puye Formation was encountered at the bottom of the borehole. The regional aquifer water level was predicted at 874 ft, and the water level in the completed well is 802 ft. The well is completed with a single screened interval between 889 and 907 ft.

R-32 is located in Pajarito Canyon, south of TA-54, mid-way between MDA-L and MDA-G. Total depth of the well is 1008 ft. Core was collected from the surface to a depth of 318 ft and analyzed for anions and moisture content. Logs from the well include natural gamma and induction, borehole video, lithologic, and Schlumberger geophysical logs. The borehole did not achieve the total planned depth due to drilling problems, therefore there are no Schlumberger geophysical logs to total depth. However, the LANL natural gamma and induction logs do go to total depth. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model is a good match with the actual encountered. Similar to R-21, the actual Cerros del Rio Basalts encountered were a series of basalts intercalated with cinders, rubble, and many interfingering units. Puye Formation was encountered at the bottom of the borehole. The regional aquifer water level was predicted at 856 ft and the composite water level in the borehole was 782.5 ft. R-32 was completed with three screened intervals and the water level in each interval has been measured. The initial Westbay water levels are (may equilibrate to different levels over time):

- Screen 1 (867 – 875 ft): water level at 775.8 ft
- Screen 2 (932 – 935 ft): water level at 786.8 ft
- Screen 3 (973-980 ft): water level at 786.5 ft

R-23 is located in Pajarito Canyon, near State Route 4. Total depth of the well is 935 ft. Logs from the well include natural gamma, caliper, borehole video, lithologic, and Schlumberger geophysical logs. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model is relatively close with the actual encountered. The predicted geology is from R-22, which is about one-quarter mile west. Cerros del Rio basalt is thinner in R-23 than expected based on predictions from R-22. Beneath the Cerros del Rio basalt are sands assumed to be part of the Santa Fe Group. The same sands are present in R-22 and the depth of the sands is consistent with the exposure of Santa Fe Group in the canyons. The

regional aquifer water level was predicted at 892 ft and the water level in the completed well is 828 ft. The well is completed with a single screened interval between 889 and 907 ft.

R-16 is located in the Mortandad Canyon watershed, on the mesa near the White Rock wastewater treatment plant and Overlook Park. The total depth of the well is 1287 ft. Logs from the well include natural gamma, lithologic, and Schlumberger geophysical logs. Geologic characterization samples were also collected. The stratigraphy predicted by the 3-D geologic model and from measured sections in the canyon was different than the actual stratigraphy encountered. The Cerros del Rio basalt was thinner than expected and the Totavi gravel was thicker than expected. However, the Totavi is not a time-stratigraphic marker, so it is not surprising to find it intercalated with the Puye Formation. There were diatomaceous and fossiliferous deposits in three units left from time periods when the Rio Grande was dammed and lakes formed. The regional aquifer water level was predicted at a depth of 783 ft, approximately the same elevation as the Rio Grande (5445 to 5425 ft mean sea level). However, the composite head in the completed well was 645 ft. The well was completed with four screened intervals. Screen one is behind casing that was stuck and could not be removed, therefore there is no access to screen one. The water level in each screened interval has been measured. Initial Westbay water levels are (may equilibrate to different level over time):

- Screen 2 (863 – 871 ft): water level at 613.8 ft
- Screen 3 (1015 – 1022 ft): water level at 669.5 ft
- Screen 4 (1237-1244 ft): water level at 709.5 ft

A cross-section down Pajarito Canyon summarizes geologic relationships based on the new wells. Salient features are:

- The Bandelier Tuff thins from west to east.
- The top of the Cerros del Rio basalt is rising, thickest below R-22. This could be the result of an old north-south trending topographic feature that the Cerros del Rio is draped over or thickens into.
- The Puye Formation wedges eastward, and pinches out before R-23, but is present again at R-16.
- There is an older fanglomerate deposit that is older than the Puye Formation, but looks very similar to it. It is composed of sediments shed from the Jemez highlands before the Tschicoma volcanic centers formed. The older fanglomerates follow the same pattern as the Puye Formation – thick in the west, thinning to the east, and abruptly pinching out between R-22 and R-23.

The cross-section is consistent with every well except R-20, where Santa Fe Group was tentatively identified at the bottom of the borehole. If the sandy unit at the bottom of R-20 is Puye Formation or the older fanglomerate, this cross-section would be consistent.

<u>Questions, Comments, Answers, and Responses</u>

Q: Were any of the core submitted for analysis of contaminants?

A: Most of the core was used to measure anions, stable isotopes, and moisture content. However, some samples were used to analyze for contaminants. The core was leached and the leachate analyzed. In Mortandad Canyon, the core had less than 2 pCi/L tritium, nitrate was less than 1 mg/L, other radionuclides were less than detection, and no perchlorate was detected.

Q: Have the Mortandad Canyon geophysics been overlaid on the geologic cross section?

A: The electromagnetic did not extend that far down the canyon and resistivity work continues.

Q: Have the different interflows in R-21 and R-32 or other boreholes been correlated?
A: This has not been carefully looked at yet. The interflows are quite variable and thet change over short distances, but it is planned to look for any units that are correlative.

Q: Why is there large relief on the Santa Fe Group surface?
A: There was probably a period of erosion, analogous to Black Mesa and Buckman Mesa erosional remnants.

Q: Where do the predicted stratigraphic contacts come from?
A: The 3-D geologic model.

Q: On the diagram for R-16, what is the lowermost unit on the "anticipated" column?
A: It should have been marked Tsf for Santa Fe Group.

Q: What is the location of R-16 with respect to the wastewater treatment plant?
A: R-16 is too close to the wastewater treatment plant to know where it is with respect to groundwater gradient. However, the effluent from the plant is released into a canyon down gradient from R-16.

Q: If the ponds at the wastewater treatment plant were leaking, would that show up in R-16?
A: If the ponds had been leaking, a perched water zone would be present. Also, the nitrate and chloride are low, which suggests that if there is leakage, it is not being picked up in R-16.

Q: What degree of uncertainty is there in the R-16 stratigraphic contacts?
A: It is believed they are close, but continue to work on correlating the lithologic log with the geophysical logs.

Q: Are lakebed deposits seen in R-16 also seen in exposures along the canyon?
A: None have been identified in canyon exposures.

Q: Are the older fanglomerates only encountered in boreholes or are there surface exposures of it?
A: The older fanglomerate has only been encountered in boreholes.

Q: Where would the river have been at the time the older fanglomerates were deposited?
A: It could have been about where R-22 is and that is why the Cerros del Rio basalts are so thick there. However, the R-22 location could also have been a tributary channel to the river.

Q: It appears that there may be a perched intermediate zone in R-23 at a depth of 400 ft; what are plans to install intermediate monitoring wells?
A: There is fairly clear evidence of perched water at R-23. No perched water was observed at other wells, although drilling with mud may have masked the presence of perched water at the other wells. The plans for future drilling based on the FY02 wells have not yet been formulated.

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

Geochemistry Update – Latest Contaminant Data and Effects of Residual Drilling Mud on Contaminant Analysis

Pat Longmire (LANL) stated the objectives of his presentation:

- Evaluate the hydrochemistry of wells R-9i, R-12, and MCOBT-4.4 during characterization sampling conducted from February 2000 through August 2002 at the Lab. The wells were installed as part of the hydrogeologic characterization of the Pajarito Plateau, Los Alamos, New Mexico.
- Analyze the effects of drilling fluids on chemistry.
- Address inorganic solutes, distribution of tritium, stable isotopes of hydrogen, nitrogen, and oxygen, and geochemical calculations.

The analytical methods used are as described in Environmental Protection Agency's SW-846:

- Metals – inductively coupled plasma optical emission spectroscopy and inductively coupled plasma mass spectrometry
- Anions – ion chromatography and titration (alkalinity)
- Organic compounds – gas chromatography and gas chromatography/mass spectrometry
- High explosive compounds – high-pressure liquid chromatography and diode array detector
- Radionuclides – alpha spectrometry, gas proportional counting, gamma spectroscopy, liquid scintillation, direct counting, and electrolytic enrichment
- Stable isotopes – isotope ratio mass spectrometry

Mortandad Canyon received treated effluents since the 1940s (from TA-35) and 1960s (from TA-50). MCOBT-4.4 is located in Mortandad Canyon. A pre-characterization sample was collected on April 22, 2002 and it contained tritium (12,797 ± 1,368 (3σ) pCi/L), nitrate (as N, 13.2 mg/L), and perchlorate (142 μg/L). The first characterization sample was collected on June 28, 2002 and a replicate set of samples was collected. The analytical results from the June sampling are:

- Tritium: 14,600 ± 759 (3σ) and 14,900 ± 768 (3σ) pCi/L (drinking water standard 20,000 pCi/L)
- Nitrate: (as N) 12.5 and 12.5 mg/L (drinking water standard 10 mg/L)
- Perchlorate: 178 and 179 μg/L (no standard has been set)

The second and third characterization samples have been collected and analyzed. The analytical results are essentially the same.

From Mortandad Canyon core was collected from the MCOBT-4.4, MCOBT-8.5, and R-15 boreholes and was analyzed for anions (reported in the well completion reports). The perchlorate distribution profile is shown on graphs. The data is not reliable below 400 ft because fluids were added for drilling. A perchlorate plume in the vadose zone can be seen. MCOBT-8.5 had the highest perchlorate concentration in core: 840 μg/L at 100 ft depth. Nitrate profiles are also useful for estimating rate of transport. The isotopes of nitrogen can help distinguish the source of nitrogen – either nitric acid or a sewage source. From 1986 to 1989, there was work at the Lab that used a source highly enriched in the nitrogen-14 isotope. In that three-year period the effluent discharged to Mortandad Canyon contained the highly enriched nitrogen-14 that provides a unique tracer. Nitrogen moves with water, so the distribution of the nitrogen-14 tracer can be used to estimate travel time. Since 1963, the nitrate in the TA-50 effluent was neutralized nitric acid, which has a very different isotopic profile than does the nitrogen-14. The nitrogen isotope profile at MCOBT-4.4 suggests that water is moving through the vadose zone at about 31 ft/year. The enriched nitrogen-14 is not present in MCOBT-8.5, suggesting that the nitrogen at this location is older.

Looking at Mortandad Canyon in cross section, R-15 has a perched zone that had tritium (3770 pCi/L) and no nitrate. However, the regional aquifer at R-15 had elevated nitrate (2.2 and 2.4 mg/L; background nitrate 0.3 to 0.5 mg/L) but no tritium. At MCOBT-4.4 there is a perched zone, stratigraphically higher than at R-15, which contains tritium, perchlorate, and nitrate. At MCOBT-8.5 there was no saturation in the vadose zone. There are perched zones in Mortandad Canyon, but it is not known if they are continuous or their extent. Contaminants have migrated to the perched zones and possibly to the regional aquifer (nitrate above background). Using the cores for anion and isotope analysis, contaminants in the vadose zone can be tracked.

Drilling fluids change the redox chemistry surrounding the borehole. A conceptual model for the changes that occur when drilling through basalt is:

- The iron-rich minerals in the basalt have altered by weathering into altered mineral assemblages
- Nickel is concentrated in the altered mineral assemblages
- The drilling fluids change the redox chemistry such that the iron is dissolved and the nickel that was co-located with the iron is also released
- This is a short-term geochemical change

In R-9i, elevated nickel in the first and second characterization sampling rounds was found, but nickel dropped of in the third sampling round to below the standard. If there were a nickel plume, it would be expected to be more consistent over time. The elevated nickel was not seen in R-9, which was drilled without fluids. Thus, drilling fluids may result in a temporary increase in metals such as nickel.

Another example of the effect of drilling fluids can be seen in R-12 located in Sandia Canyon. It was drilled without fluids and the perched zone had nitrate at 5 mg/L. The nitrate had a sewage signature, which is consistent with discharge from the sanitary wastewater treatment plant up canyon. Later, R-12 was deepened and drilling fluids were used to deepen the borehole. After the deeper well was completed, no nitrate was detected. EZMud drilling fluid might provide food for the microbes and the microbes, in turn, break down the nitrate. EZMud residuals are present, based on the absence of sulfate and the presence of increased iron and manganese. As the well re-equilibrates, increasing levels of nitrate should be seen over time.

Conclusions with respect to geochemistry:

- Aqueous chemistry of perched groundwater and the regional aquifer varies
- Characterization sampling provides decisions for monitoring (trends, contaminants, levels)
- Perchlorate, nitrate, and tritium were observed in MCOBT-4.4. Tritium was observed in R-9i, R-9, and R-12.
- Breakdown of drilling fluid results in release of natural nickel from ferric hydroxide in R-9i.
- Geochemical calculations using the computer program MINTEQA2 were performed to evaluate speciation, adsorption/desorption, and mineral equilibrium

<u>Questions, Comments, Answers, and Responses</u>

Q: Have anion profiles from the R-15 core been looked at?

A: The profiles from R-15 core show a pattern similar to MCOBT-4.4 and MCOBT-8.5. Also alluvial well 7.5 had perchlorate in the alluvium. There was one high (1600 µg/L) perchlorate value in the R-15 core.

C: Propose an alternative conceptual model: perchlorate in MCOBT-8.5 is stranded by evaporation in the vadose zone.
R: The stable isotopes show that evaporation is occurring in the vadose zone, but downward movement is also probably occurring. Conditions in Mortandad are drier now that the discharges have been reduced, but was wetter in the past. Perhaps it is not so much that the perchlorate is stranded, but that the faucet has been turned off and it is moving, but not as fast. It could be that the rate of movement is slowed by evaporation and the perchlorate front is building up.

Q: Is the Cerro Toledo interval saturated in Mortandad Canyon?
A: The Cerro Toledo was wet, but not saturated. The moisture content of the core confirms that the Cerro Toledo was not saturated.

Q: Was the Cerro Toledo interval present at MCOBT-8.5?
A: No, the Cerro Toledo interval was not present at MCOBT-8.5.

Q: Is there dilution of the nitrate down canyon?
A: There is more mixing of solutions than dilution occurring. The movement in the vadose zone may not be directly downward.

Q: What would the nitrogen isotope ratio of sewage be?
A: The nitrogen isotope ratio would be +7 or higher per mil due to denitrification.

Q: What is the source of water in the perched zones?
A: There are bar charts in the completion report for MCOBT-4.4 and –8.5 that show the water composition. The water does not match the alluvial water, so there may have been pre-existing native water. The isotopic signature is similar to the regional aquifer. Some background information: After MCOBT-4.4 and –8.5 were drilled, MCOBT-8.5 was plugged and abandoned because it was dry. A well was constructed in MCOBT-4.4. The well completion report is for both of the MCOBT wells. There have been three rounds of characterization sampling in MCOBT-4.4 to date. After four rounds of characterization sampling have been completed, a geochemistry report will be prepared.

Q: What are the water levels in MCOBT-4.4?
A: The water level dropped, but subsequently stabilized. There is a presentation on MCOBT-4.4 next.

Q: What is the expected time frame for the wells to re-equilibrate?
A: Three to ten years, but it is very site-specific and depends on flow rate and geology.

Q: How would air affect the re-equilibration? Drilling dry would introduce air into the system.
A: It would affect the iron, manganese, and microbial activity. It would not affect the nitrate. Drilling with air would not change the effects very much because the water is also aerobic.

Q: Was R-9i drilled with mud?
A: Yes, R-9i was drilled with mud. That would not affect the tritium, and uranium was not detected. At R-9 the nickel was less than detection, although at R-9i nickel was seen.

Q: Was there tritium in MCOBT-8.5?
A: There was no water at MCOBT-8.5, but the core is being analyzed for tritium. Only the core that was collected dry can be used because the addition of fluid confounds the tritium analysis.

MCOBT 4.4 – What is Known/Suspected and Decisions That Have to be Made
Charlie Nylander (LANL) explained that MCOBT-4.4 is an intermediate depth well located in Mortandad Canyon, near the confluence with Ten Site Canyon. The intermediate perched zone has contaminants (tritium, nitrate, and perchlorate), and there are questions about the integrity of the well.

What is known:

- The borehole was drilled into basalt and there was water coming into the borehole
- To determine what interval the water was coming from, a packer was put in the borehole and the water beneath the packer was removed by airlifting. The water level beneath the packer did not rise, indicating that the water was entering the borehole from a unit above the packer.
- With the packer in place, the perched water zone was sealed off, so the well design was based on the assumption that the location of the packer was the perching unit.
- The packer was removed, the well was constructed, and the water level rose to 493 ft, indicating that the well was adequately placed in a perching unit and water flowing into the well was not leaking out. The water level stayed static at 493 ft for three to four months.
- The well was then developed by swabbing, bailing, pumping etc., following well development protocols. After development was completed, the well sat for five to six months waiting for a pump to be installed.
- In preparation for installing the pump, the borehole video camera was used to inspect the inside of the well. The video showed that the water level had dropped to 519 ft and water could be seen entering the well at a depth of 497 ft. If the integrity of the well were intact, the water level would be expected to rise as water continues to enter the well.
- A transducer that was installed in the well shows that the water level has remained steady at 519 ft.
- The water in the intermediate perched zone is contaminated with:
    - Tritium: 14,900 ± 768 (3σ) pCi/L
    - Perchlorate: 178 µg/L
    - Nitrate: 12.5 mg/L
    - No drilling fluid residuals are present at MCOBT-4.4

What is suspected:

- The bottom of the screen was too close to the perching interval, so that the well development activities opened up previously closed fractures.
- The perched intermediate zone water was drained through the freshly opened fractures.

Decisions to be made:

- Whether to plug and abandon MCOBT-4.4
- Where to locate a replacement well
- How to target the perched intermediate zone without getting too close to the perching horizon

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

Questions, Comments, Answers, and Responses

Q: Where is the water going?
A: The water is entering the well from the Puye Formation and is flowing out through the Cerros del Rio basalt. It probably continues until it reaches another perching layer.

Q: Do we know the thickness of the layer that may be leaking?
A: If the perching horizon is the basalt flow interior, then it is about 14 ft thick. When the pump was put in, it did not look like there was enough water to place the pump. The silty sand may be the perching horizon rather than the basalt interior.

Q: The water could be flowing out of the filter pack and could be going anywhere.
A: That is true, the water could be moving laterally or vertically.

Q: What is the volume of water in the perched zone?
A: Cannot estimate the volume because there is only one well.

Q: Have you considered pumping in grout to see if you can stop the leak?
A: It is too difficult to assure that the grout is effectively placed.

C: This is the first time NMED has seen this data, and NMED wanted a proposal from you. It looks like it is leaking.
R: Another meeting with NMED needs to be convened to focus only on MCOBT-4.4 and a proposal will be presented at that meeting.

C: The new well should be drilled before abandoning this one.
R: That is right, it is hard to target the right depth.

Q: Is a replacement well necessary?
A: There is a concern that there are contaminants that should be monitored. Also, the water levels have to be examined in order to understand the connections. It is also important to understand to where the water is leaking.

C: The state is very interested in intermediate zones. There will be more intermediate wells in Mortandad Canyon.

Q: Has there been a comparison in down gradient wells since this happened?
A: R-15 is the closest down gradient well, and it is screened in the regional aquifer. It is not showing any effects, but the separation between the perched zone and the regional aquifer is large. The water could be flowing laterally. The work plan for Mortandad Canyon is being amended and the investigation of the leakage from MCOBT-4.4 will be addressed in the amendment.

Q: What does the stabilized water level mean – the water keeps coming in but the water level does not rise?
A: The pressure transducer stays the same.

Q: What about the perched zone in R-15?
A: The perched zone in R-15 was why the packer test was conducted - to find where the water was in MCOBT-4.4. R-15 changed perceptions about perched zones in Mortandad Canyon.

C: The Groundwater Integration Team has recommended that MCOBT-4.4 be plugged and abandoned.

R: What is the schedule?
R: The plugging and abandonment could be done under the Mortandad Canyon Work Plan amendment next year or under the Hydrogeologic Workplan this year.

Low-Head Weir –Results from Contaminant Sampling
Bill Stone (LANL) stated that the low-head weir project is not part of the Hydrogeologic Workplan. It is funded by Cerro Grande fire money and is part of Groundwater Protection at the Laboratory. After the Cerro Grande fire, it was expected that there would be enhanced runoff and potential movement of contaminants. The Corps of Engineers built the low-head weir, a low dam with openings that slowly drain the pond behind it. The intent of the weir is to slow down water and allow sediments to settle. However, within the ponded area there is fractured basalt at and near the surface. Monitoring wells around the weir had three primary objectives:

- Assess the impact of the fire water quality
- Observe the impact of the weir on hydrology
- Estimate contaminant travel times through the vadose zone

Three boreholes were drilled around the weir: two are angled beneath the weir and the third is a conventional vertical monitoring point for the saturated zone. There is a Laboratory report on the installation of the boreholes. Sampling is conducted in the vertical borehole only. It is constructed as a conventional monitoring well with four screened intervals. There are two perched zones (same zones as in R-9i) and one transient zone that seems to be associated with ponding of water behind the weir. The FLUTE system is used to sample. The FLUTE system is a liner that is like a sock. The liner is filled with water to keep it down in the borehole. The outside of the liner has ports that are connected to sampling tubes. Nitrogen is used to force the sample up to the surface. Each port has a transducer to measure pressure.

Sampling that is conducted at the weir consists of the following:

Location:	**Purpose:**	**Frequency:**
Pond	General water quality	When water is present
Los Alamos Weir Site – 01 (LAWS-01) vertical borehole	General water quality	Irregular (R-9i nearby)
	Background chemistry for tracer test (KBr)	Pre-test only
Los Alamos Weir Site – 01 (LAWS-01) vertical borehole	Arrival of tracer	Weekly

The analytical suite for general water chemistry is: silver (Ag), aluminum (Al), alkalinity (Alk) (lab), arsenic (As), boron (B), barium (Ba), beryllium (Be), bromine (Br), Tentatively Identified Compounds (TIC), total organic carbon (TOC), calcium (Ca), cadmium (Cd), chlorine (Cl), chlorate (ClO_3), perchlorate (ClO_4), cobalt (Co), carbonate (CO_3), chromium (Cr), cesium (Cs), copper (Cu), fluorine (F), iron (Fe), hardness, bicarbonate (HCO_3), mercury (Hg), potassium (K), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), ammonium (NH_4), nickel (Ni), nitrogen dioxide (NO_2), nitrate (NO_3), oxalate, lead (Pb), phosphate (PO_4), rubidium (Rb), antimony (Sb), selenium (Se), silica (Si), silica oxide (SiO_2), sulfate (SO_4), tin (Sn), strontium (Sr), total dissolved solids (TDS), thorium (Th), titanium (Ti), uranium (U), vanadium (V), and zinc (Zn).

The analytical results from sampling are:

Date	Source	Results (ppm)	
		Cs	Sr (total)
4/5/01	LAWS-01 screen 2 (163 ft)	<0.001	0.16
4/5/01	LAWS-01 screen 4 (275 ft)	<0.001	0.20
4/6/01	Pond	<0.001	0.11
12/17/01	LAWS-01 screen 2 (163 ft)	<0.001	0.25
12/17/01	LAWS-01 screen 3 (193 ft)	<0.001	0.24
12/17/01	LAWS-01 screen 4 (275 ft)	<0.001	0.25

Radiogenic constituents that have not been detected are: americium-241, cesium-137, plutonium-238, 239/240, and strontium-90. Tritium is less than 200 pCi/L. Fire-related water quality changes observed include elevated levels of: total organic carbon (330 ppm, background ~ 3 ppm), alkalinity (bicarbonate), calcium, and sodium (fire or road salt?) were observed in LAWS-01 from draining of the reservoir as storms not in burned area. At R-9i, similar water quality changes were noted, but not as much as at LAWS-01.

Surface to groundwater flux was estimated using a tracer test in April 2002. The tracer, KBr solution (16,000 ppm), was applied to the dry pond floor. Subsequent ponding events were expected to drive the tracer through. Moisture measurements in LAWS-01can detect the water front. The arrival times of moisture and tracer in well/boreholes gives the flux. There were three ponding events in 2002: June, August, and October. The biggest event was in June resulted in ponded water 3 ft deep. Wetting was detected at 89 ft after three days, suggesting the flux rate is 30 ft/day in the vadose zone. The water level in the perched zone rose in the vertical well. The bromide increased in 10 days, suggesting a flux rate of 12-18 ft/day if the fractures are vertical. If the fractures were not vertical, then the flux rate would be higher because the distance traveled is longer. The other two ponding events yielded similar results. Another tracer test with a different tracer is planned. The tracer was evident in the shallowest zone last, suggesting fracture flow, not matrix flow. By the third wetting event the reaction was the same in all zones.

<u>Questions, Comments, Answers, and Responses</u>

Q: Has elevated manganese after the fire been observed?
A: The manganese has been slightly elevated.

Q: There was water in the pond in December, was it sampled?
A: The water in the pond was not sampled until after December.

Q: Does seeing the wetting front in the shallowest zone last suggest that the water is moving so fast that the liner does not pick it up?
A: The more likely explanation is that the water is moving through heterogeneous fractures. Wetting is a function of local pathways.

Q: Have data been collected on both of the perched zones that are in R-9i; does it show the zones are connected?
A: There is a delay between the upper and lower, but they are connected. It is not known if the water being seen is from the pond or from water soaked in upstream above the pond.

Q: How long did the pond stay filled (associated with the June event)?
A: It drained within days. There was water on Friday and Saturday, but it was gone by Sunday.

Q: It appears that the fractures dried out between the first and second event, but stayed wet between the second and third event.
A: It appears that they were wetted between the second and third event. Now there is a lot of debris in the pond – wood and weeds—that are confounding the infiltration.

Q: Are there up- and down-stream gages and can it be determined how much water is infiltrated?
A: The gage below did not work during the first event, so it is not known how much water went by.

Q: If the ponding of water presents a problem with respect to water quality, couldn't the flow of water be increased through the weir?
A: The weir is designed to let water through.

Q: Has the other steam gage data been looked at – for example, Ralph Ford-Schmidt had a gage below the weir all last year.
A: The lower gage was just put in, so storm flow data has not been looked at yet. Ralph's data would be very helpful.

Regional Aquifer Water Level Map
Charlie Nylander (LANL) presented the latest rendition of the regional aquifer water table map. The black dots are regional aquifer characterization wells and test wells. The open circles are water supply wells that were not used in the contouring. This is the first regional aquifer water table map to use only short-screened interval wells on which to base the contours. The flow direction is primarily west to east. The cross section shows the gradient is downward in the west, flattened in the middle, and upward toward the discharge area at the Rio Grande.

Questions, Comments, Answers, and Responses
Q: The data table indicates a number after the well designation – what does that mean?
A: The screen that the water level was measured in.

Q: There should be a map with water levels measured all at the same time. The data on this table has some measurements years apart.
A: The elevation of the regional aquifer does not change very much, thus the contours at this scale would not be changed.

Q: Does flow in the regional aquifer extend beneath the Rio Grande?
A: The capture zone analysis suggests that the groundwater divide has been moved to the east side of the river by pumping in the Buckman well field.

C: There is a concern about what is happening beneath San Ildefonso and what the effect might be on domestic wells.
R: The capture zone analysis shows that when the pumping reaches steady state, the water beneath San Ildefonso may be captured partially by pumping at Buckman and partially by pumping at the Pajarito Mesa well field.

Q: Why is R-8 not on the map?
A: The surveyed location and elevation of R-8 was not available at the time the map was made.

PM-2 Aquifer Test

Stephen McLin (LANL) stated that the PM-2 aquifer test is on going. Why do aquifer testing:

- Physically measure aquifer parameters (transmissivity and storavity values) using alternative methods (e.g. single well tests, multi-well tests, and water level fluctuations).
- Compare predicted drawdown from the regional aquifer model against measured drawdown in individual monitoring wells.
- Compare observed and simulated vertical hydraulic gradients in canyons with and without municipal water supply wells.
- Simulate zones of capture around individual municipal water supply wells.
- Identify and better understand aquifer boundary influences, potential canyon recharge zones, or interconnection/isolation of perched aquifer zones with the regional aquifer.
- Design and evaluate optimal monitoring well locations and selected screen intervals (i.e., a three dimensional monitoring network).

A diagram of a text book aquifer test shows that when the observation well is located at a distance of 1.5 times the aquifer thickness from the pumping well, the partial penetration effects are negligible.

The test in PM-2 was proposed in late October because the wells are not in service during the winter. Production well PM-2 has a constant discharge of 1,248 gallons per minute. The shape of the cone of depression is an indication of transmissivity and storativity. If the cone of depression has a small radius, the transmissivity and storativity are low. If the cone of depression has a large radius, the transmissivity and storativity is high. The drawdown curve for the ideal confined aquifer is referred to as the Theis curve. The drawdown curve for other types of aquifer conditions (leaky, unconfined, bounded) are variations of the Theis curve. Running an aquifer test for a long time helps to understand the type of aquifer and boundary conditions.

The calculated idealized radius of pressure influence includes the following wells: PM-2, PM-4, R-20, R-21, R-32, R-19, R-13, and R-15. The test started with a 60-day static recovery period (12/3/02 – 2/3/03) where the water level in the well was monitored before any pumping began. The 25-day pumping interval (2/3/03 – 3/28/03) had a constant discharge of 1,248 gallons per minute. The radius of pumping influence was greater than 8,808 ft and an area of 8.74 miles. Eight well screens were affected. The pumping interval was followed by a 25-day recovery interval from 3/1/03 to 3/26/03. The maximum drawdown was 85 ft, measured in a peizometer located one foot away from PM-2. PM-4 had 10 ft of drawdown and PM-5 was drawn down two ft. Drawdown was also observed in R-20 (screens 1, 2, and 3) and in R-32 (screens 2 and 3). No drawdown was observed in R-21, R-19, R-22, R-14, R-23, or R-12. The water that was pumped went into the distribution system. The wells were shut down in early December and the County let the reservoirs drain down to accommodate the test water.

The screens in PM-5, PM-4, and PM-2 are about the same length and depth interval. The screens in R-20 are within the upper portion of the PM-2 screen. Screens in R-32 are higher than the PM-2 screen. One question is whether the vertical gradient in R-32 is the result of depressurizing the aquifer by pumping. The Jacob-Cooper plots show the boundary of a depressurizing zone that is radiating out. The storage coefficients of 10^{-3} to 10^{-4} suggest a confined aquifer. There is no drawdown seen at R-22 and it is not known if that is because the Puye Formation has pinched out or because it is too far away.

The observed and predicted drawdown curves show that the shape of the curves are similar, the order of the curves is the same, but the predicted maximum drawdown is lower than measured in

PM-4, PM-5, PM-2, and R-20 screen three. The predicted drawdown is higher than measured in R-20 screens one and two.

The preliminary conclusions from this aquifer test are:

- Observed recharge boundary effects propagate radially outward from the pumping well over time.
- Cone of depression extends radially outward more than 8,800 ft.
- Primary water production originates from highly transmissive units located below the water table and these are not evenly distributed over the entire screened interval.
- Observed and predicted drawdowns are in reasonable agreement, but further model improvements can be made.
- Model can be used to simulate areas of water "capture" around water supply wells using observed seasonal pumping patterns.

Questions, Comments, Answers, and Responses

Q: Was temperature and conductance data collected during the test?
A: No, some sampling was done for Safe Drinking Water Act.

Q: Is the recovery being measured?
A: Recovery is being measured over the same period of time as the pumping. As of one week ago, the water levels had recovered 90% in all wells. There has been rapid recovery suggesting high transmissivity. The cone of depression seems to be distorted (not a perfect circle) around PM-2. The drawdown is concentrated in different layers. This is important to know when designing a monitoring system – should monitoring be done at the water table or where the water is coming in?

Q: Did the spinner test in PM-4 show that most of the production is in the upper part of the screen?
A: Yes, it did and that is common on the plateau. It was the same in the Guaje replacement wells.

Q: Is the zone of influence the same as the zone of capture?
A: No, that is why the map in the handout says "zone of pressure influence". The zone of influence is not a circle; it is distorted. In R-32 there was no drawdown in screen one, so there is not a radius of influence that is the 8,800 ft everywhere.

Q: What is the typical operation of PM-2?
A: PM-2 will probably be turned on next month. When it is in operation, it is only pumped at night to avoid peak power charges. Only the PM-4 well is left on all the time because the pump runs on gas. The pumps can only pump at one rate, but the pumping is on a diurnal schedule.

Q: Have you looked at the water levels in R-12 or R-9 for water level variations due to pumping PM-1?
A: That data has not been evaluated, but there may not be any response in R-12 or R-9 because the screens are higher than in PM-1.

Q: What kinds of changes need to be made to the regional aquifer model to accommodate this data?
A: The regional aquifer model is not set up for this type of data, because it was not available. For example there was no constraint on storativity. However, the model captured the trends,

even though the absolute numbers were not. These data will be incorporated in the model and it will be recalibrated. It is important to do that in order to answer the question about the zone of capture versus the zone of influence, which is necessary to predict where plumes will move.

Q: Will this require tighter grid spacing in the regional aquifer model?
A: For the aquifer test data shown here, the resolution is adequate. For smaller features or tests, the spacing would have to be tightened up.

C: Water samples were collected during the test and they are being analyzed.

Hydrogeologic Workplan Data Overview
Charlie Nylander (LANL) gave the Hydrogeologic Workplan data overview. There will be changes in the way well completion reports are done. For the wells in FY02, the contractor started the reports, but LANL is finishing them. There have been some perturbations, so the reports may be later than March 31.

Hydrologic testing – A report on the first five wells has been completed, peer reviewed, comments incorporated, and another peer review. Copies of the report are available today. Future reports on hydrologic testing will be done on a well-by-well basis.

Geology – Working towards a routine cycle of updating the 3-D geologic model every year, so expect annual tune-ups. The poster session includes FY02 well data.

Hydrology – The FY02 and FY03 milestone reports that describe the regional aquifer modeling will be completed. The Groundwater Pathways Assessment Report to be complete in June. There will be a report on the Pajarito Plateau infiltration, which is also a poster session. There will also be a report on vadose zone anion profiles, which also has a poster this evening.

Geochemistry –The R-25 geochemistry report and the baseline groundwater report is expected to be finished this year.

Annual Report – Provides good information on geology, hydrology, and geochemistry and is available today.

This program has been installing wells for five years, 19 wells thus far. The interpretive work will be taking off. It is desirable to look at reports on a site wide, rather than well-by-well basis and anticipate writing a final report that synthesizes all of the data. The final form of the corrective action order will influence how the program comes to a close.

<u>Questions, Comments, Answers, and Responses</u>
No questions or comments on this presentation.

Well Drilling Schedule/Plan
Charlie Nylander (LANL) stated that if additional budget comes available, six wells will be installed this year. In January, draft Data Quality Objectives (DQOs) were transmitted to NMED. NMED has approved the DQOs for wells R-2, R-4, and R-11. The DQOs for wells R-6, R-18, and R-26 are still under discussion with NMED.

The DQOs for R-2 are:

- Subsurface distribution of contaminants in an area expected to contain the maximum groundwater contamination from Acid Canyon.

- Open borehole, using air with minimal fluids.
- Core the upper portion of the boring.
- Single screen just below the regional aquifer water table.
- Total depth of about 100 ft below the regional aquifer table.
- DQOs approved by NMED February 27, 2003.

The DQOs for R-4 are:

- Subsurface distribution of contaminants in an area down gradient of releases in Pueblo Canyon and up gradient of the treatment plant effluent.
- Open borehole, using air with minimal fluids.
- Core the upper portion of the boring.
- Completion is determined after analysis of R-5 data and particle-tracking simulation to determine how deep contaminants from Pueblo Canyon might be expected.
- DQOs approved by NMED February 27, 2003.

The DQOs for R-6 are:

- Water quality in an area up gradient of all releases in from Laboratory operations.
- Drilling method to be decided by driller.
- Two screened intervals in the regional aquifer, approximately matching the two upper regional aquifer screens in R-25.
- Total depth penetrates about 300 ft into the regional aquifer.
- DQOs still under discussion with NMED

The DQOs for R-11 are:

- Perched zones are anticipated to occur as a result of infiltration of surface water; opportunity to assess pathways.
- Open borehole using air with minimal fluids.
- Core the upper portion of the borehole, to auger refusal or 250 ft max.
- One screened interval in the regional aquifer.
- DQOs approved by NMED February 27, 2003.

The DQOs for R-18 are:

- Propose relocation to Potrillo Canyon, where R-23 was originally planned.
- Drill an open borehole, using air with minimal fluids to 500 ft below the top of the regional aquifer.
- Complete with up to four screens in the regional aquifer, placed in different geologic units.
- DQOs still under discussion with NMED

The DQOs for R-26 are:

- Water quality in an area up gradient of all releases from Laboratory operations and effect of the Pajarito fault on groundwater flow air with minimal fluids.
- Core the upper 200-foot portion of the borehole.
- Two screened intervals: one in the perched zone (if present) and one in the regional aquifer.
- Total depth will be about 1,500 ft and will penetrate about 100 ft into the regional aquifer.
- DQOs under discussion with NMED .

The planned non-field activities are:

- Information Management – continuing to provide data on wqdbworld@lanl.gov.
- Groundwater Pathways Assessment – focusing on Mortandad Canyon and wet canyons.
- Regional aquifer modeling – continuing capture zone analysis.
- Geologic Model – annual update.
- Quarterly and annual Meetings.
- Annual report.

It is not certain how the final negotiations on the corrective action order will affect the program. The Hydrogeologic Workplan will transition and come to a close. Anticipate negotiations to be wrapped up in mid-April.

Regarding the budget: the continuing resolution was decided in February, so the FY03 budget is now in place. The PMP accelerated clean up funding from EM should be coming in. On the NNSA side, the Lab is trying to identify and plus up the FY03 money. Continue to plan to have sufficient budget in place for the planned wells and non-field activities. The drilling services will be contracted through DOE, expecting a May 1 award to a contractor.

Due to security issues, there is a program to evaluate well security and retrofit wells with secure caps. Bollards are also being placed around well pads to protect them from vehicular collision. At the same time, GIS is being used to locate all the wells.

Questions, Comments, Answers, and Responses

C: The accelerated cleanup money is held until the State of New Mexico endorses the Project Management Plan.

Q: What is the status of locating a well on the Pueblo of San Ildefonso?
A: It has been discussed and a number of potential locations proposed. However, installing that well this year depends on receiving the accelerated cleanup funding. If the funding comes through, a cooperative agreement will be established and work with San Ildefonso will commence to develop DQOs for the well.

Q: If the accelerated cleanup funding becomes available, what is the next step that should be taken towards installing a well?
A: The Governor is very interested and an agreement could be made very quickly.

C: In wet canyons with known contamination, more coring may be warranted, perhaps as far as the regional aquifer.
R: That suggestion will be considered. The current planning is to core the upper 200-300 ft. Part of the dilemma is that the contaminant profiles seem to indicate that the contaminants trail off below that depth. The physical process of coring below that depth requires the addition of fluids. Coring the upper 200 – 300 ft can be done with an auger, but below that fluids are necessary. The addition of fluids can mask the presence of perched zones.

Q: Is there an updated list of publications?
A: An updated list of publications will go out with the minutes of this meeting.

Q: What is the schedule for drilling and geophysics?
A: Looking at expanding the geophysics and putting in intermediate wells in TA-16 to serve as control points for the geophysics.

Q: Why not use Mortandad Canyon, which already has control points, as a pilot for expanding the geophysics?
A: Both canyons will be used.

Q: Was any of the data from the flyover electromagnetic survey used in decisions?
A: The data is still being processed; it is expected to be done at the end of the fiscal year. The CMS for the 260 outfall will have three intermediate wells and these will go in first this summer.

Q: Will the data from the 260 outfall CMS investigation be reported here?
A: Yes, the wells are part of the 260 CMS, placed around the boundaries of the plume. But the data from those wells will be part of the hydrogeologic characterization and reported on here.

Los Alamos National Laboratory
Groundwater Protection Program
Annual Meeting
March 18, 2003
Minutes

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Los Alamos Groundwater Protection Program Geology Subcommittee Report: Data Collection and New Results from Drilling Activities in the Latter Part of FY-02

D. Broxton, D. Vaniman, R. Lawerence, G. Cole, B. Carey

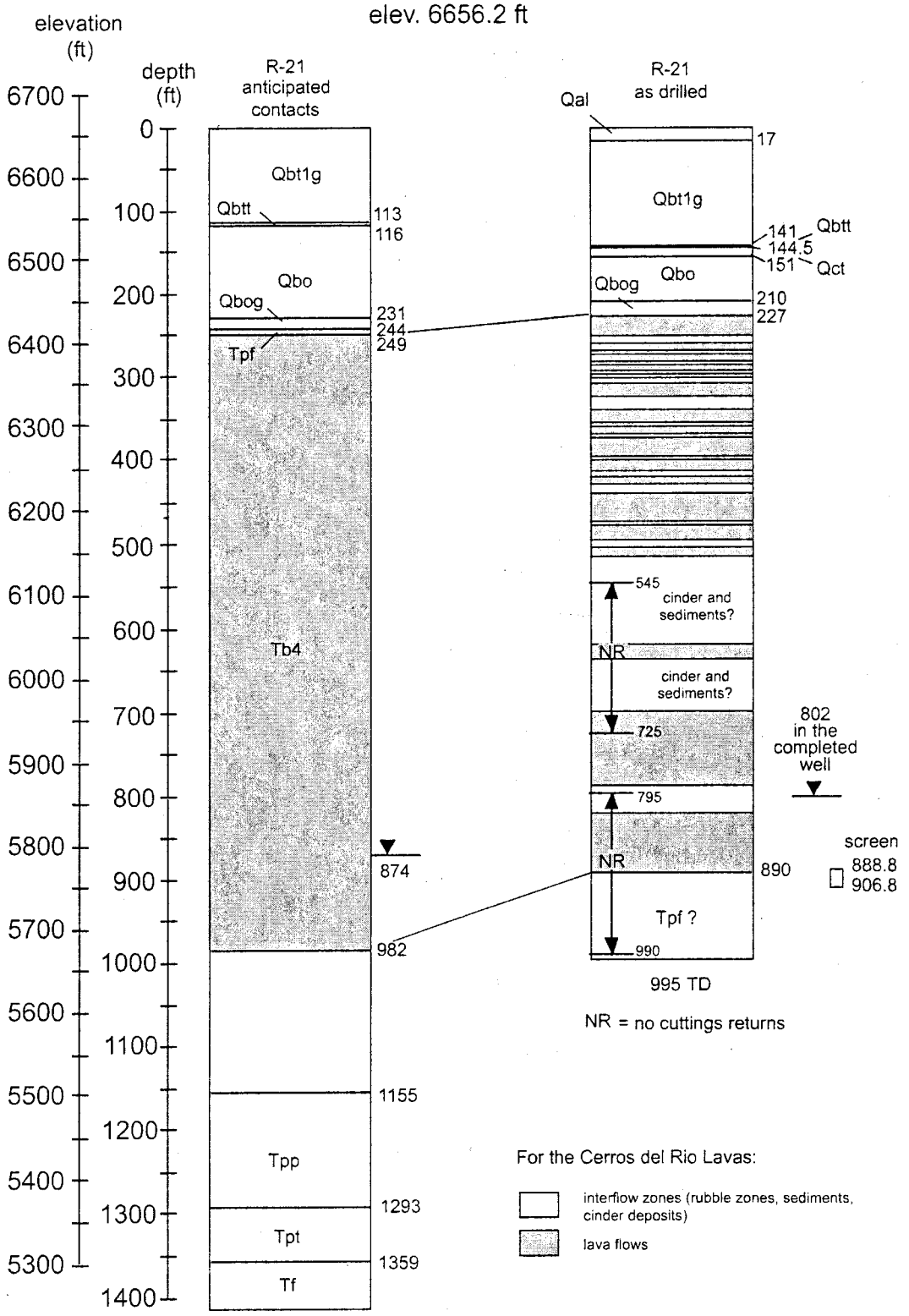
During the latter half of 2002, six new characterization wells were installed in the vicinity of Mortandad and Pajarito Canyons as part of the Hydrogeologic Workplan. The installed wells included R-14, R-16, R-20, R-21, R-23, and R-32. R-21 and R-23 were completed with a single screen. The remaining wells have two to four wells screens, and they contain the Westbay sampling system.

The six wells were installed in boreholes ranging in depth from 935 to 1365 ft. Geologic data collected during drilling operations include moisture and anion profile samples, borehole video logs, geophysical logs, and lithologic logs. Additional samples of core and cuttings were collected to characterize rock chemistry and mineralogy. Water level data for the regional groundwater system were collected in the boreholes and in the completed wells.

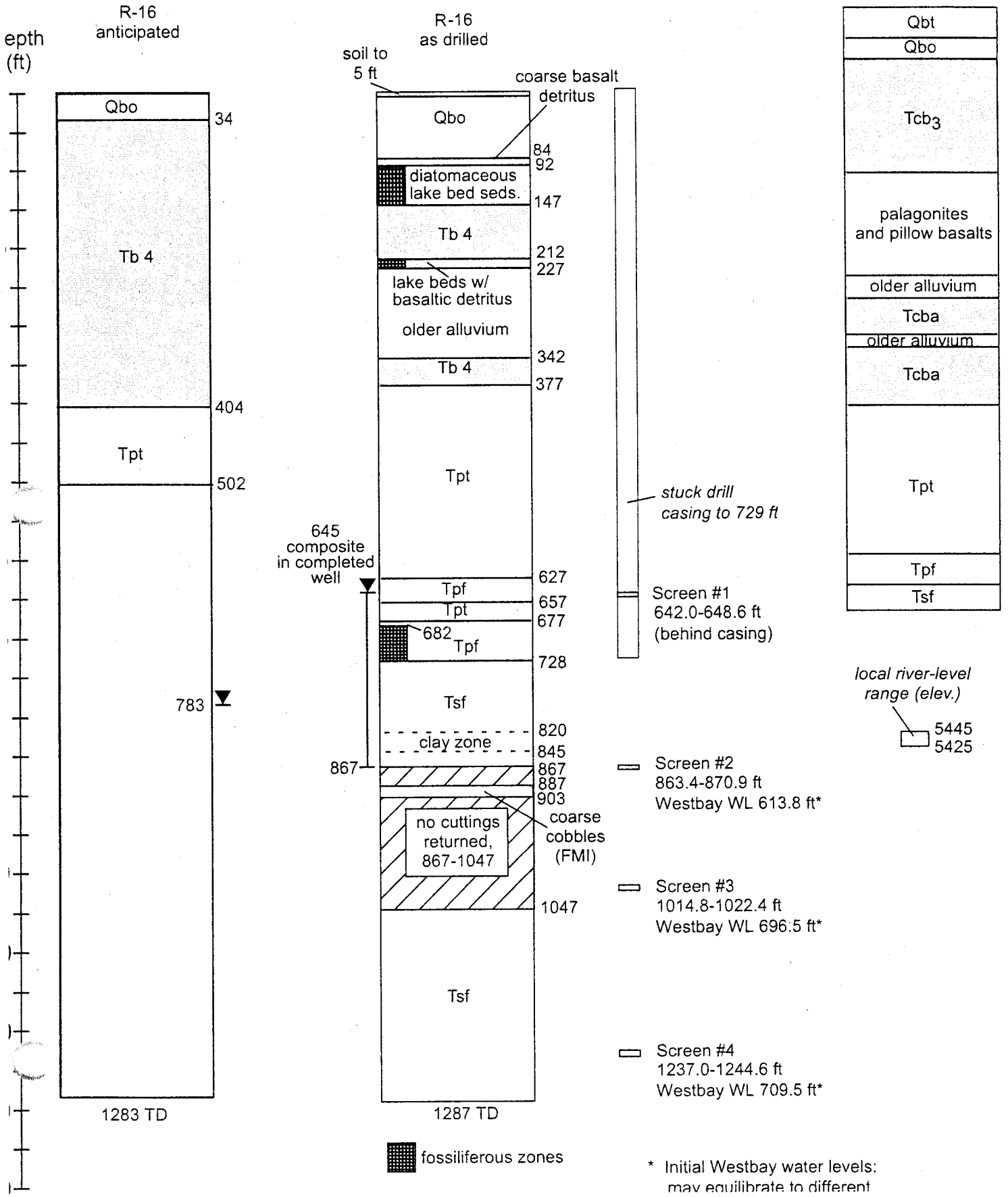
The geologic units encountered during drilling were generally similar to those predicted by the site-wide geologic model prior to drilling . The most significant differences occurred in R-23 where the thickness of the Cerros del Rio basalt was somewhat less than expected and the top of the Santa Fe Group was higher than predicted. Correlation of subsurface geologic units and occurrences of groundwater beneath Mortandad and Pajarito Canyons are presented on geologic cross sections .

R-21

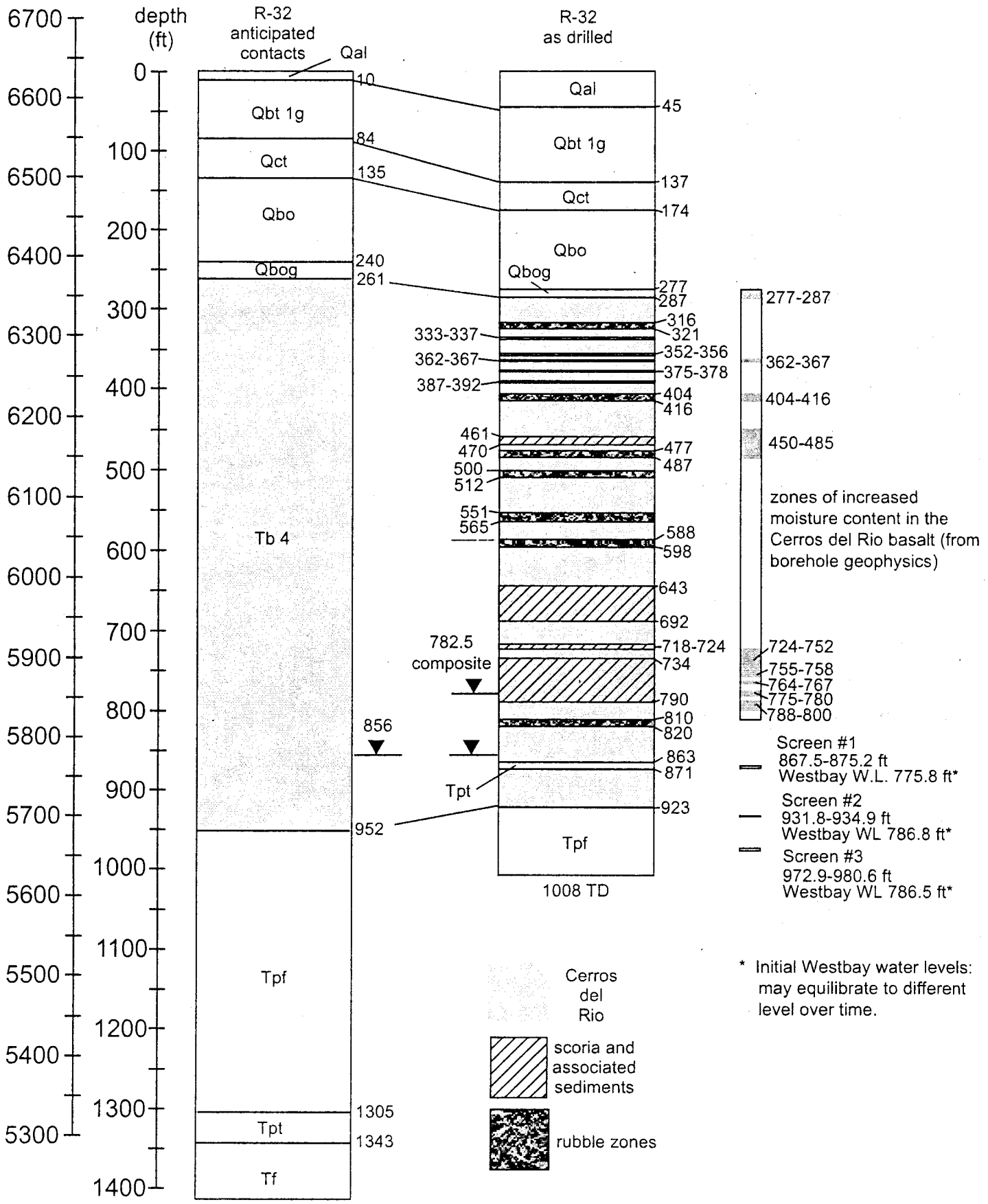
elev. 6656.2 ft



R-16


epth
(ft)
R-16
anticipated
Qbo
34
Tb 4
404
Tpt
502
783
1283 TD
R-16
as drilled
soil to
5 ft
coarse basalt
detritus
Qbo
84
92
diatomaceous
lake bed seds.
147
Tb 4
212
227
lake beds w/
basaltic detritus
older alluvium
342
Tb 4
377
Tpt
645
composite
in completed
well
627
Tpf
657
Tpt
677
682
Tpf
728
Tsf
820
clay zone
845
867
867
887
903
no cuttings
returned,
867-1047
coarse
cobbles
(FMI)
1047
Tsf
1287 TD
stuck drill
casing to 729 ft
Screen #1
642.0-648.6 ft
(behind casing)
Screen #2
863.4-870.9 ft
Westbay WL 613.8 ft*
Screen #3
1014.8-1022.4 ft
Westbay WL 696.5 ft*
Screen #4
1237.0-1244.6 ft
Westbay WL 709.5 ft*
fossiliferous zones
* Initial Westbay water levels:
may equilibrate to different
Dethier (1997)
Section D
Qbt
Qbo
Tcb3
palagonites
and pillow basalts
older alluvium
Tcba
older alluvium
Tcba
Tpt
Tpf
Tsf
local river-level
range (elev.)
5445
5425

R-32


elevation (ft)
depth (ft)
R-32 anticipated contacts
R-32 as drilled
Qal
Qbt 1g
Qct
Qbo
Qbog
Tb 4
Tpf
Tpt
Tf
10
84
135
240
261
952
1305
1343
856
6700
6600
6500
6400
6300
6200
6100
6000
5900
5800
5700
5600
5500
5400
5300
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
45
137
174
277
287
316
321
333-337
352-356
362-367
375-378
387-392
404
416
461
470
477
487
500
512
551
565
588
598
643
692
718-724
734
782.5 composite
790
810
820
863
871
923
1008 TD
277-287
362-367
404-416
450-485
zones of increased moisture content in the Cerros del Rio basalt (from borehole geophysics)
724-752
755-758
764-767
775-780
788-800
Screen #1
867.5-875.2 ft
Westbay W.L. 775.8 ft*
Screen #2
931.8-934.9 ft
Westbay WL 786.8 ft*
Screen #3
972.9-980.6 ft
Westbay WL 786.5 ft*
Cerros del Rio
scoria and associated sediments
rubble zones
* Initial Westbay water levels: may equilibrate to different level over time.

# R-21 Geologic Data Collection
TD = 995 ft

- Core from 0 to 250 ft:
  - anion profle samples
  - moisture profile samples

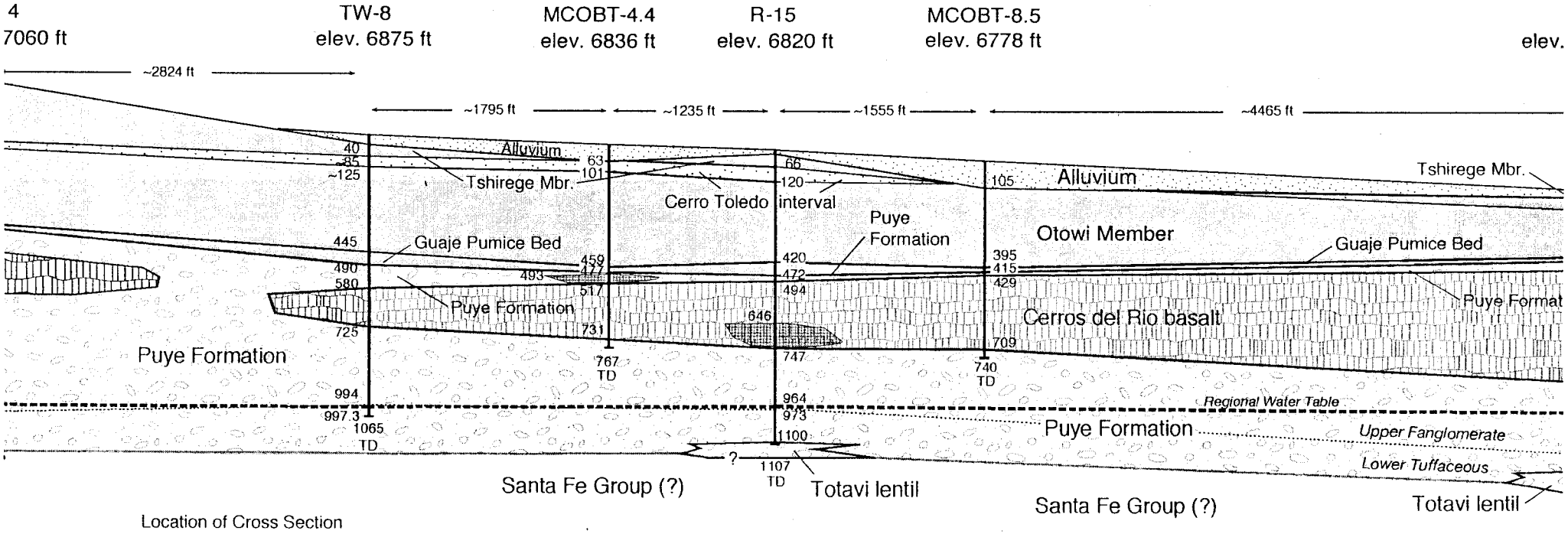
- Borehole Video (0-528 ft, open hole)

- Lithologic Log from 0 to 995 ft depth (core/cuttings/geophysics)

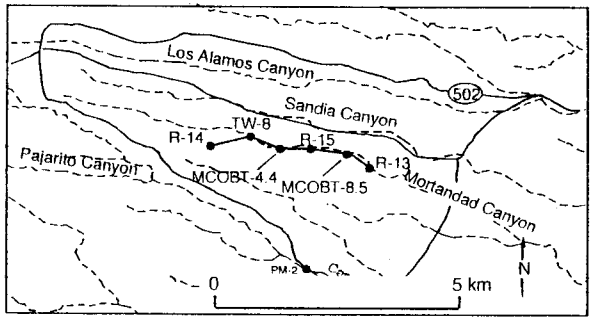
- Geologic Chararacterization Samples (10)

- Schlumberger Geophysical Logs (all open hole; depth from surface to 930 to 986 ft depth because of bore-hole sloughing):
  - caliper
  - natural gamma (total and spectral)
  - array induction
  - combinable magnetic resonance
  - elemental capture
  - thermal/epithermal neutron
  - lithodensity
  - Formation microimager

Cross Section Showing Stratigraphy and Occurrence of Intermediate Perched Groundwater in Mortandad Canyon



Location of Cross Section

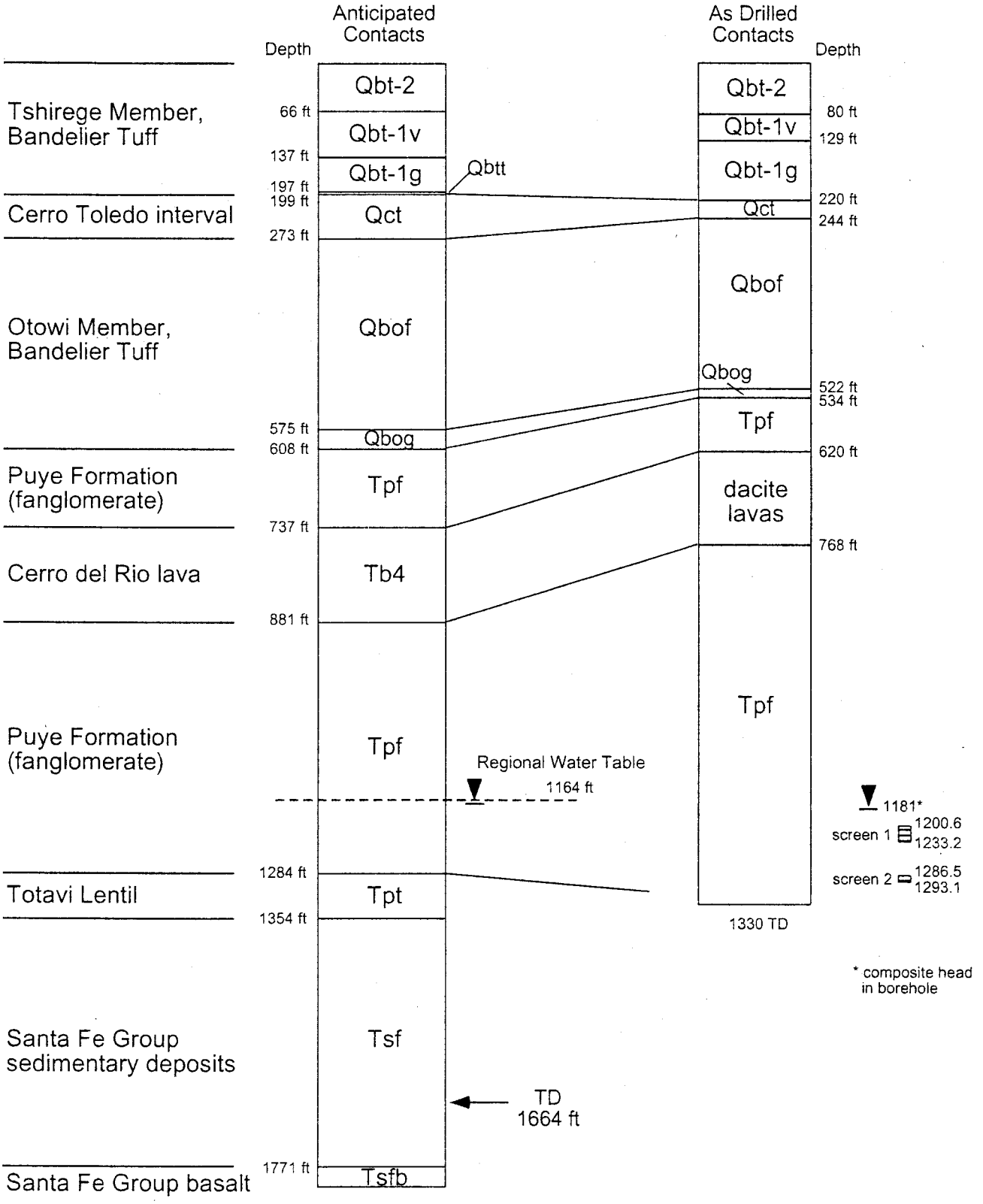


Vertical Exaggeration = 2X
All footages in feet.

Intermediate-de
perched ground

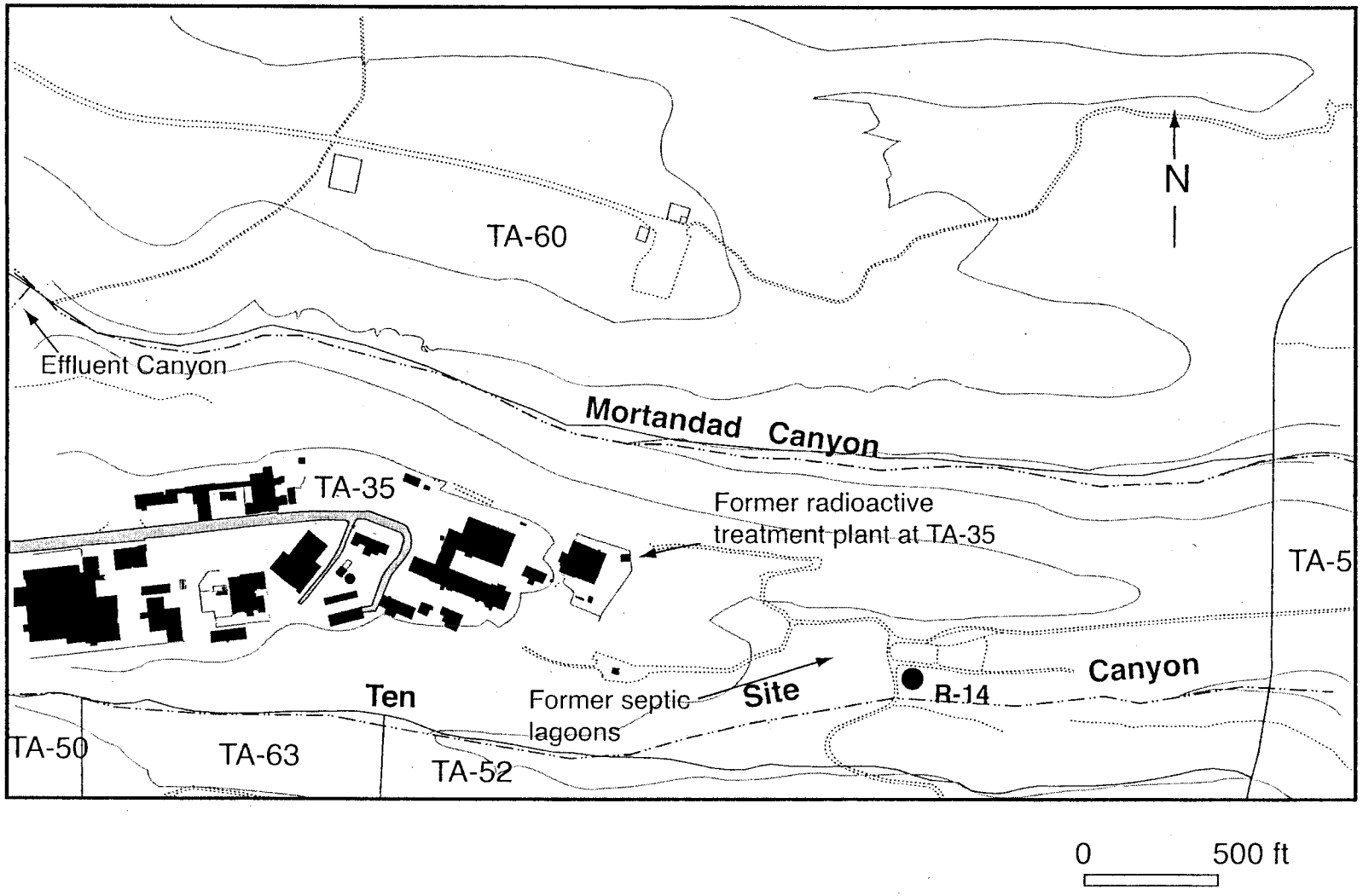
R-14

(surface elev. 7062.1 ft)



From FY99A site-wide model

R-14 Location Map



# R-20 Data Collection
TD = 1365 ft

- Core from 0 to 436 ft:
  - anion profle samples (13)
  - moisture profile samples (13)

- Natural Gamma Log (LANL) (0 to 785 ft depth, cased to 80.3 ft; 0 to 1365 ft, cased to 729 ft)

- Lithologic Log from Core/Cuttings

- Geologic Chararacterization Samples (12)

- Borehole Video (82 ft to 785 ft depth)

- Schlumberger Geophysical Log #1 (cased 0 to 80.3 ft; open hole 80.3 to 781 ft depth):
  - caliper
  - natural gamma (total and spectral)
  - array induction
  - combinable magnetic resonance
  - elemental capture
  - thermal/epithermal neutron
  - lithodensity

- Schlumberger Geophysical Log #2 (cased 0 to 729 ft; open hole 729 to 1365 ft depth):
  - same as above plus sonic and formation microimager (FMI)

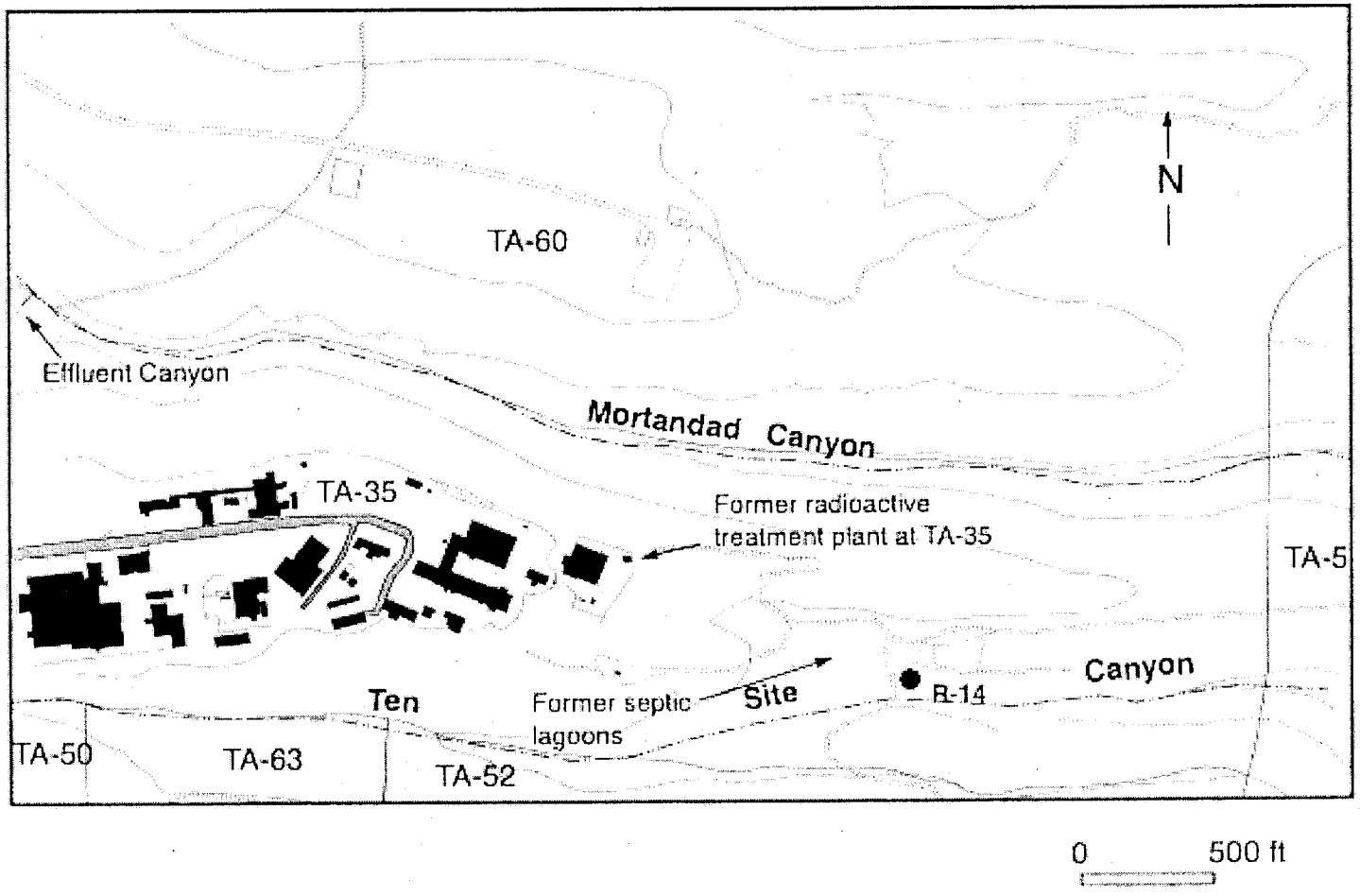
Los Alamos Groundwater Protection Program Geology Subcommittee Report:

Data Collection and New Results from Drilling Activities in the Latter Part of FY-02

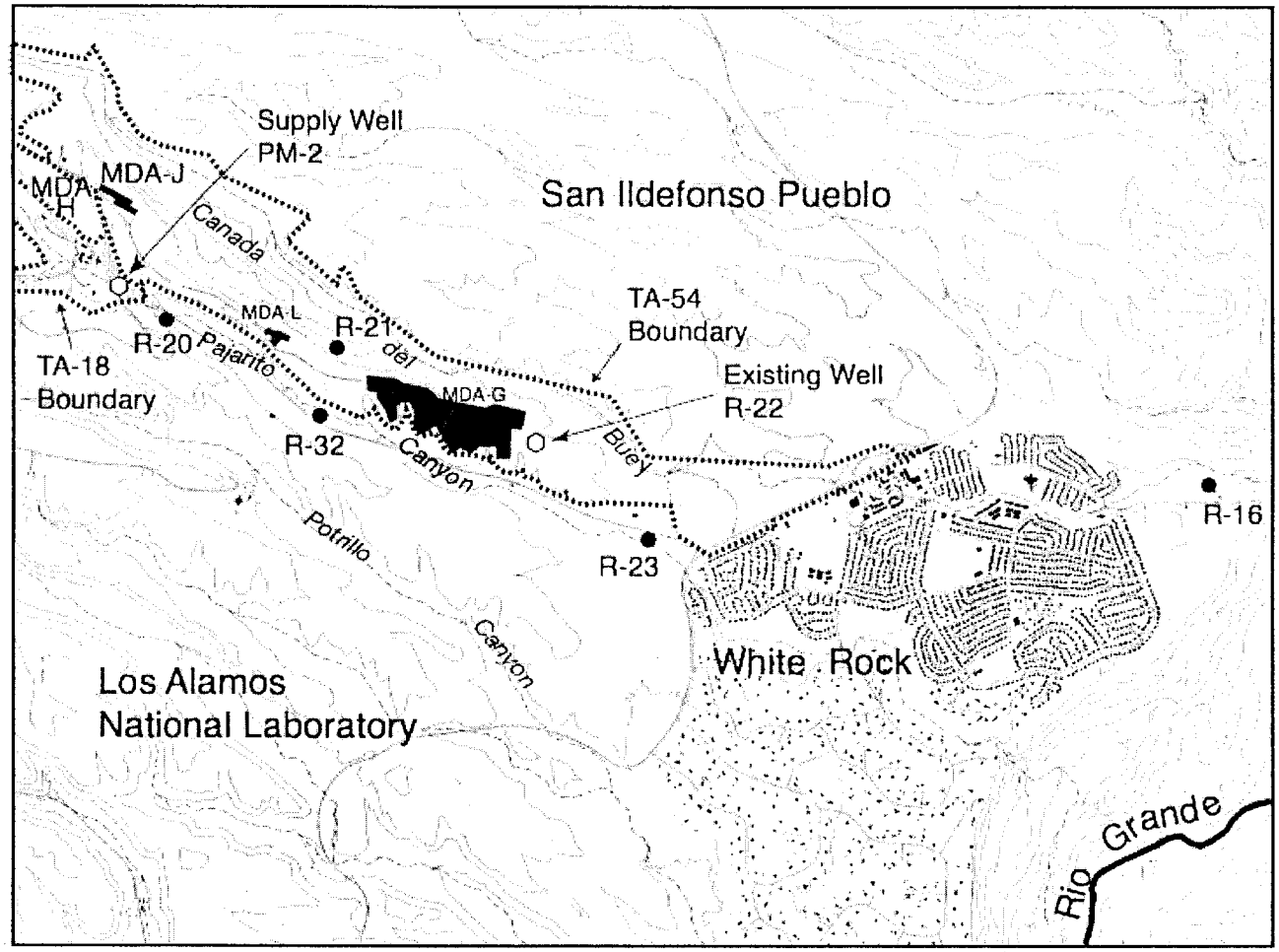
D. Broxton
D. Vaniman
R. Lawerence
G. Cole
B. Carey

GIT Annual Meeting, March 18, 2003

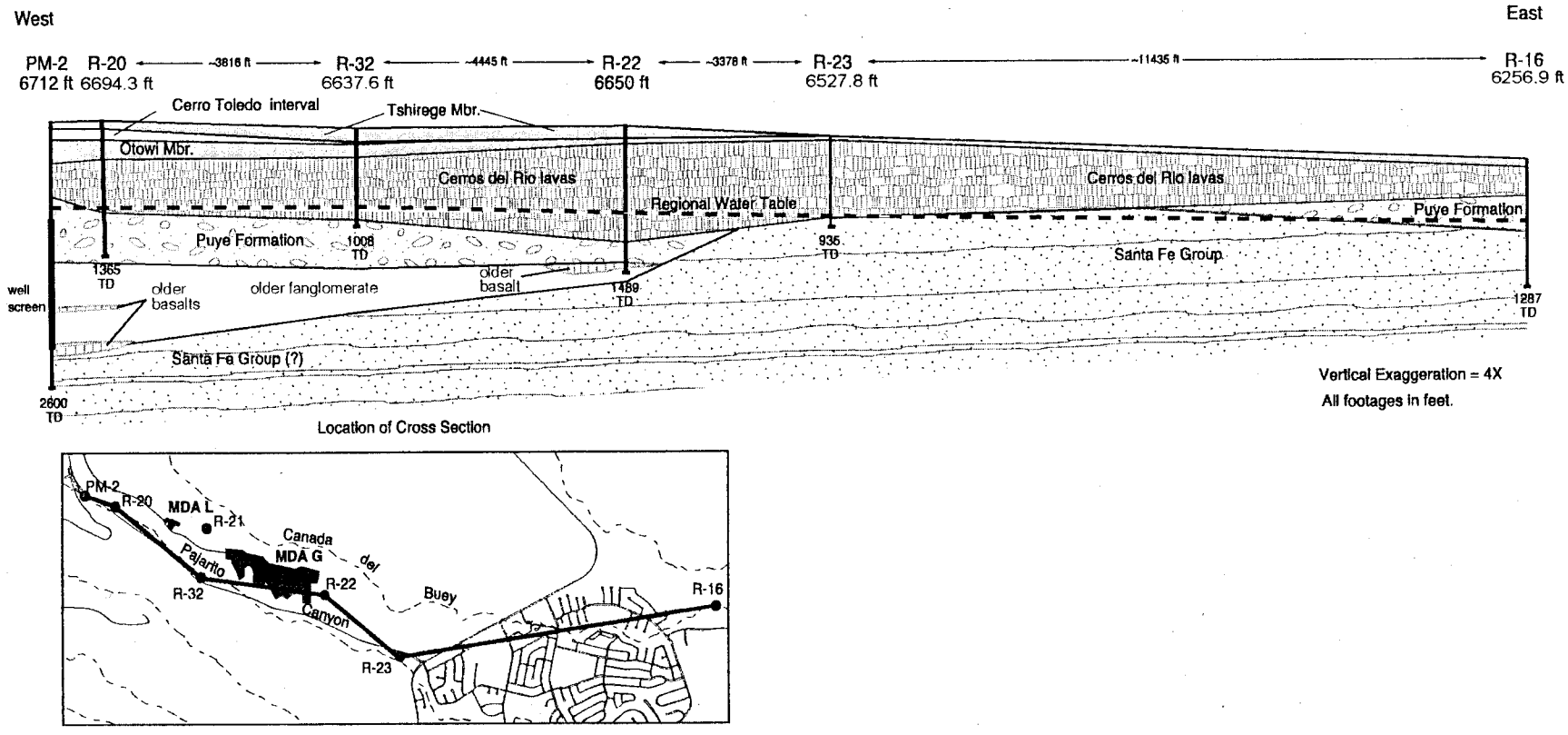
R-14 Location



Pajarito Canyon Wells



Cross Section Showing Stratigraphy in Pajarito Canyon

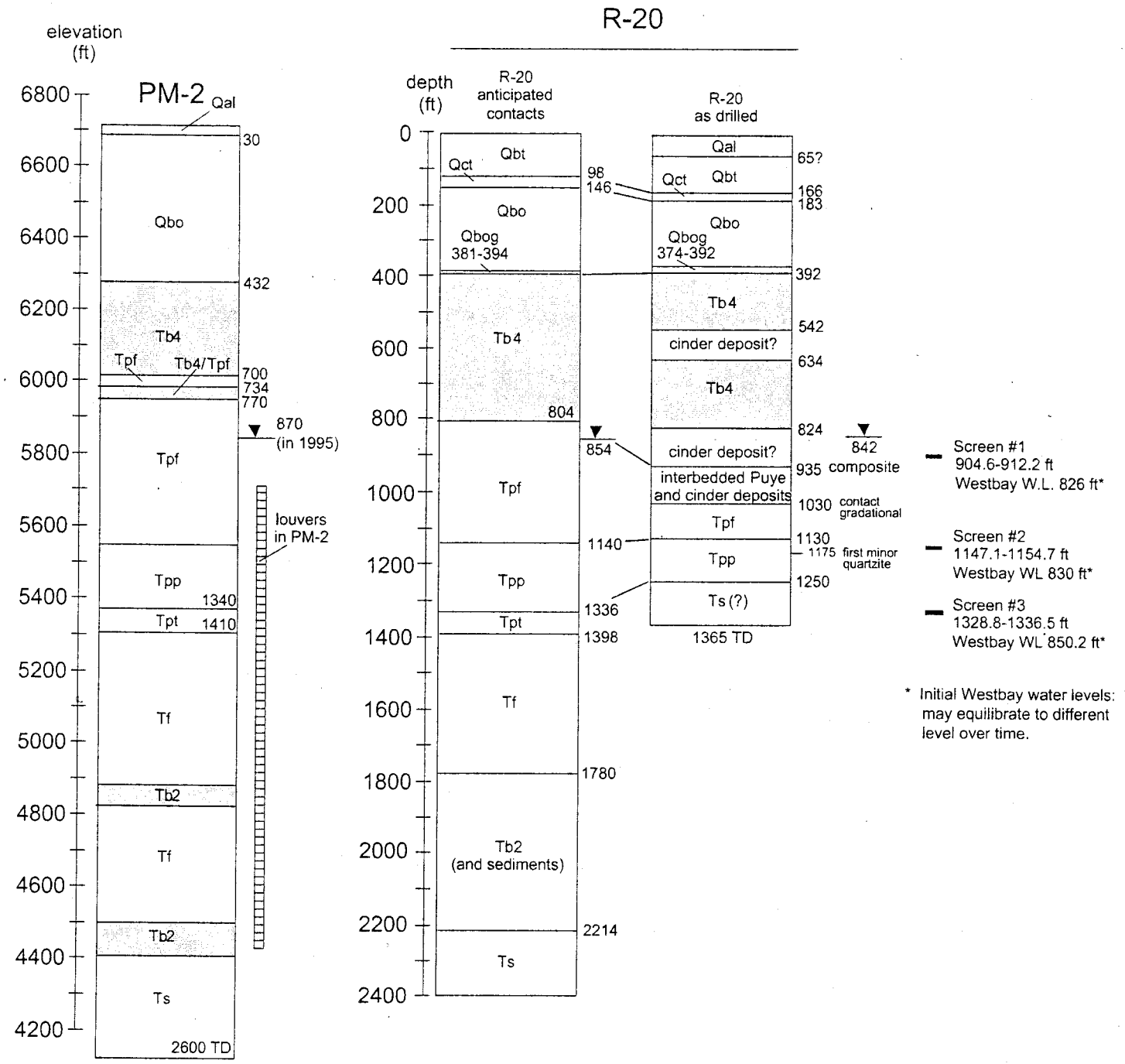


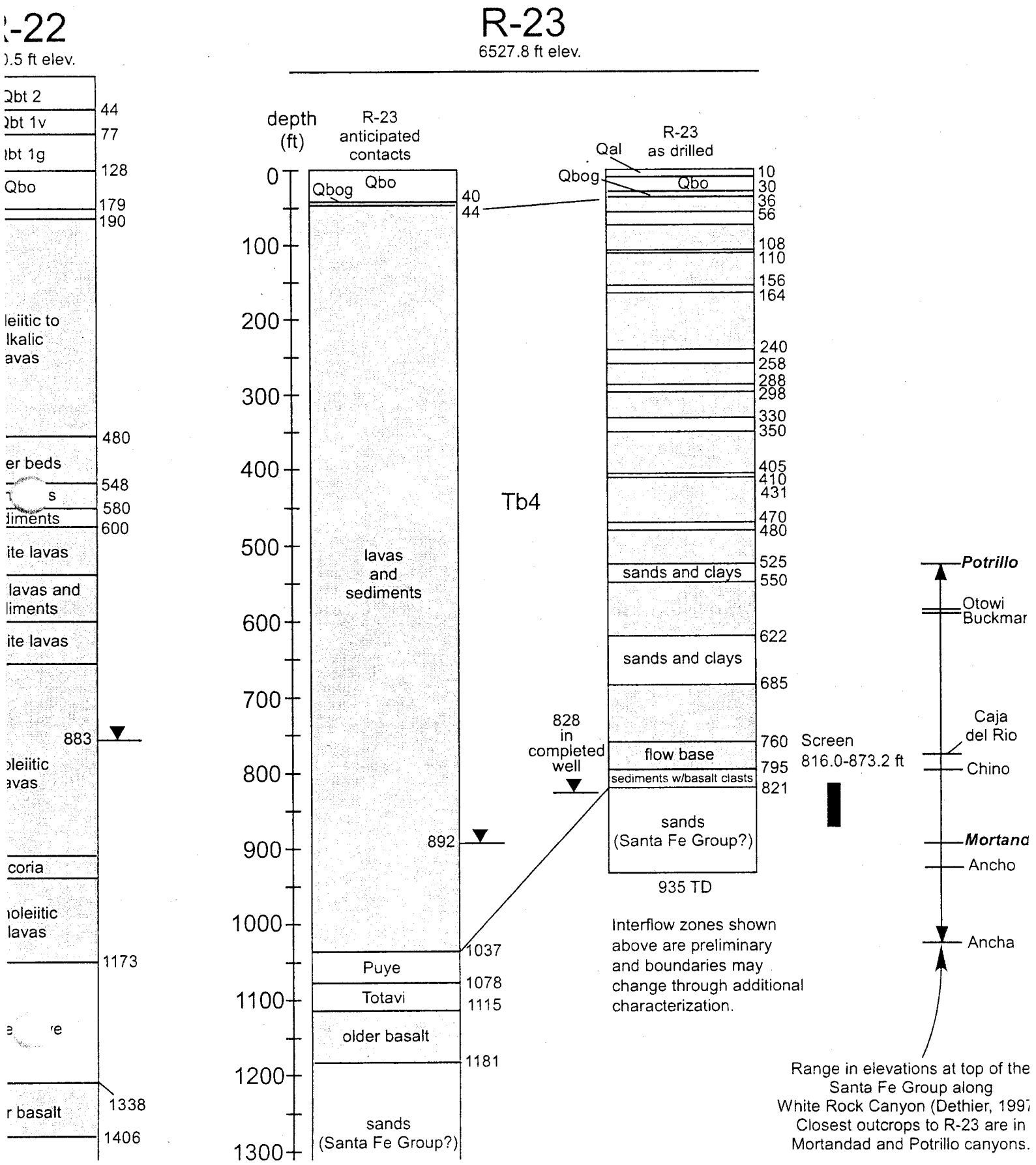
# R-23 Geologic Data Collection
TD = 935 ft

- No Core
- Natural Gamma Log (LANL) (0 to 842 ft depth, cased to 599 ft)
- Caliper (LANL) (0 to 887 ft, cased to 599 ft)
- Borehole Video (0-827 ft, cased to 599 ft)
- Lithologic Log from 0 to 935 ft depth (cuttings)
- Geologic Chararacterization Samples
- Schlumberger Geophysical Log (cased 0 to 599 ft; open hole 599 to 828 ft depth):
    - caliper
    - natural gamma (total and spectral)
    - array induction
    - combinable magnetic resonance
    - elemental capture
    - thermal/epithermal neutron
    - lithodensity

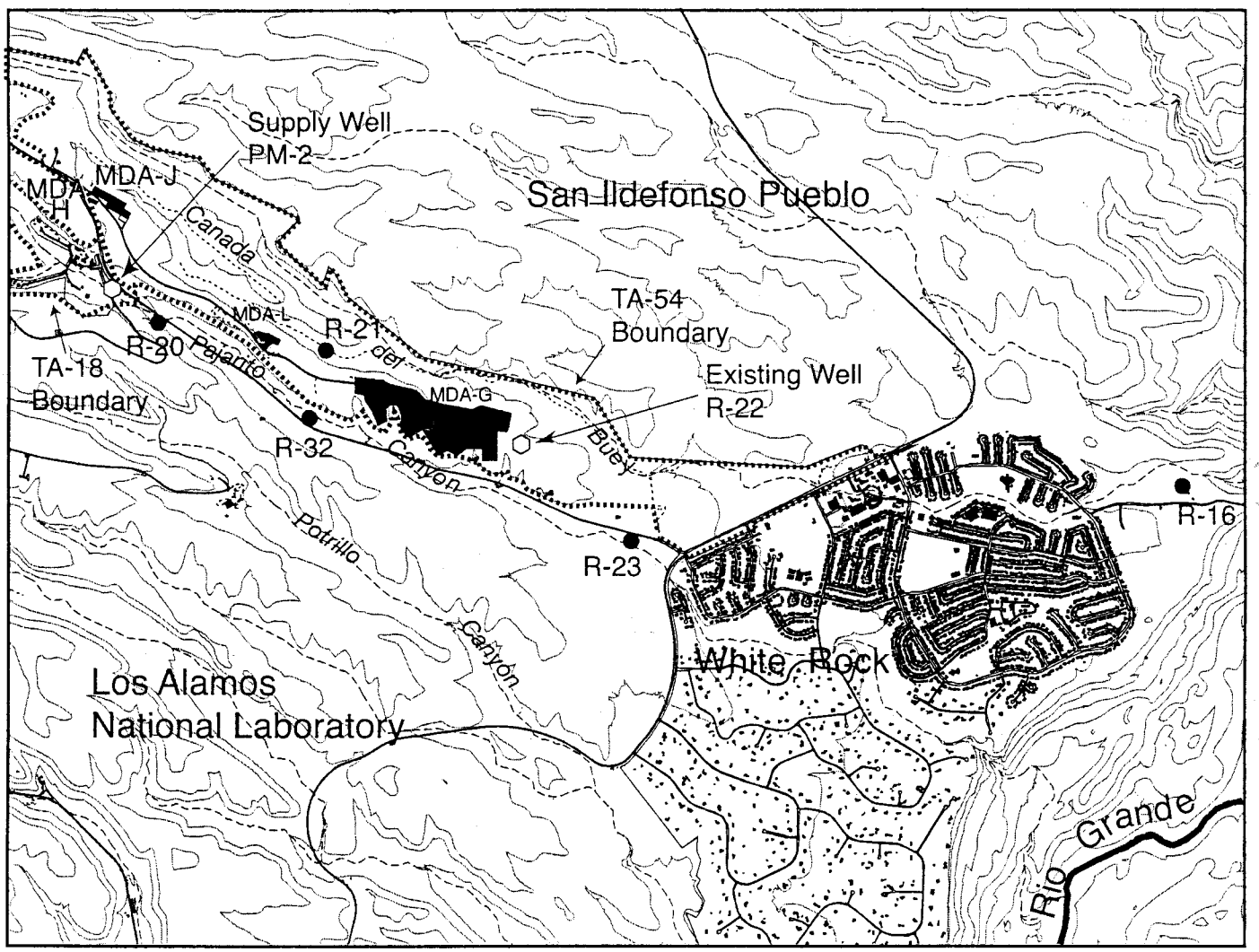
# R-32 Geologic Data Collection
TD = 1008 ft

- Core from 0 to 318 ft:
  - anion profile samples (13)
  - moisture profile samples (13)
- Natural Gamma and Induction Logs (LANL) (0 to 795 ft depth, cased above 54 ft; and 0 to 1008 ft, cased above 798 ft)
- Borehole Video (53 ft to 720 ft depth)
- Lithologic Log from Core/Cuttings
- Geologic Chararacterization Samples (7)
- Schlumberger Geophysical Logs (Open Hole 53 ft to 808 ft):
  - caliper
  - natural gamma (total and spectral)
  - array induction
  - combinable magnetic resonance
  - elemental capture
  - thermal/epithermal neutron
  - lithodensity


R-20
elevation (ft)
PM-2
Qal
30
Qbo
432
Tb4
Tpf
Tb4/Tpf
700
734
770
870 (in 1995)
Tpf
louvers in PM-2
Tpp
1340
Tpt
1410
Tf
Tb2
Tf
Tb2
Ts
2600 TD
6800
6600
6400
6200
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
depth (ft)
R-20 anticipated contacts
Qbt
Qct
98
146
Qbo
Qbog 381-394
Tb4
804
854
Tpf
1140
Tpp
1336
Tpt
1398
Tf
1780
Tb2 (and sediments)
2214
Ts
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
R-20 as drilled
Qal
65?
Qct
Qbt
166
183
Qbo
Qbog 374-392
392
Tb4
542
cinder deposit?
634
Tb4
824
842 composite
cinder deposit?
935
interbedded Puye and cinder deposits
1030 contact gradational
Tpf
1130
1175 first minor quartzite
Tpp
1250
Ts (?)
1365 TD
Screen #1
904.6-912.2 ft
Westbay W.L. 826 ft*
Screen #2
1147.1-1154.7 ft
Westbay WL 830 ft*
Screen #3
1328.8-1336.5 ft
Westbay WL 850.2 ft*
* Initial Westbay water levels: may equilibrate to different level over time.


R-22
).5 ft elev.
Qbt 2
Qbt 1v
Qbt 1g
Qbo
44
77
128
179
190
leiitic to
lkalic
avas
480
er beds
548
580
600
ite lavas
lavas and
liments
ite lavas
883
leiitic
avas
coria
oleiitic
lavas
1173
r basalt
1338
1406
R-23
6527.8 ft elev.
depth
(ft)
R-23
anticipated
contacts
Qbog
Qbo
40
44
lavas
and
sediments
892
Puye
1037
Totavi
1078
1115
older basalt
1181
sands
(Santa Fe Group?)
Tb4
R-23
as drilled
Qal
Qbog
Qbo
10
30
36
56
108
110
156
164
240
258
288
298
330
350
405
410
431
470
480
525
550
sands and clays
622
sands and clays
685
828
in
completed
well
760
flow base
795
sediments w/basalt clasts
821
sands
(Santa Fe Group?)
935 TD
Screen
816.0-873.2 ft
Interflow zones shown
above are preliminary
and boundaries may
change through additional
characterization.
Potrillo
Otowi
Buckmar
Caja
del Rio
Chino
Mortand
Ancho
Ancha
Range in elevations at top of the
Santa Fe Group along
White Rock Canyon (Dethier, 1997
Closest outcrops to R-23 are in
Mortandad and Potrillo canyons.

TA-54 Well Locations



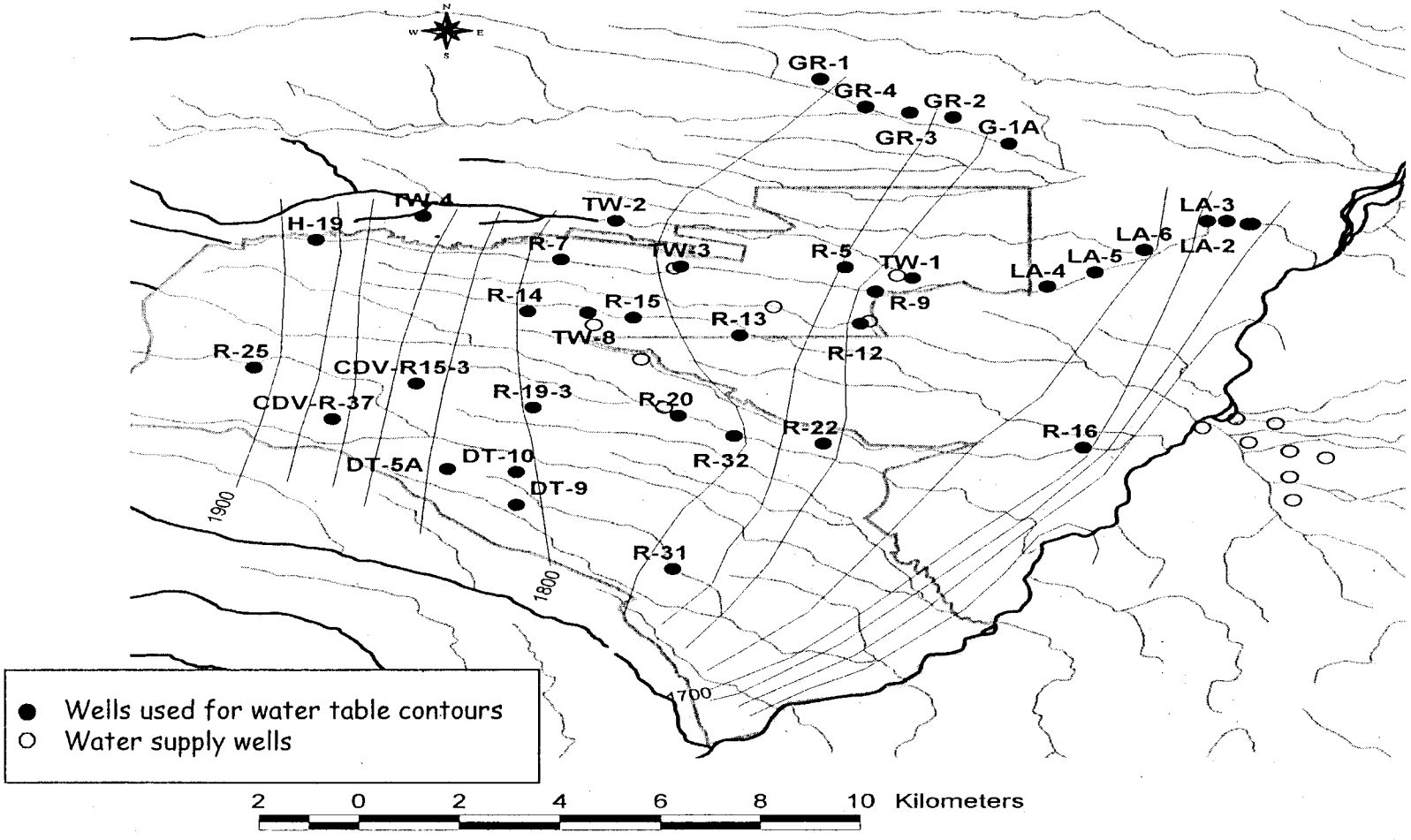
# R-14 Geologic Data Collection
TD = 1330 ft

- Core from 0 to 306 ft:
  - anion profile samples (24)
  - moisture profile samples (24)
- Natural Gamma Log (LANL) (0 to 1068 ft and 1046 to 1325 ft depth)
- Borehole Video (12 ft to 945 ft depth)
- Lithologic Log from Core/Cuttings
- Geologic Chararacterization Samples (12)
- Schlumberger Geophysical Logs (Open Hole 12 ft to 1068 ft):
  - caliper
  - natural gamma (total and spectral)
  - array induction
  - combinable magnetic resonance
  - elemental capture
  - thermal/epithermal neutron
  - lithodensity

# R-16 Geologic Data Collection
TD = 1287 ft

- Natural Gamma Log (LANL) (0 to 1287 ft depth, cased to 729 ft)
- Lithologic Log from 0 to 1287 ft depth (cuttings)
- Geologic Chararacterization Samples (12)
- Schlumberger Geophysical Log (cased 0 to 729 ft; open hole 729 to 1287 ft depth):
  - caliper
  - natural gamma (total and spectral)
  - array induction
  - combinable magnetic resonance
  - elemental capture
  - thermal/epithermal neutron
  - lithodensity
  - sonic
  - formation micro-imager

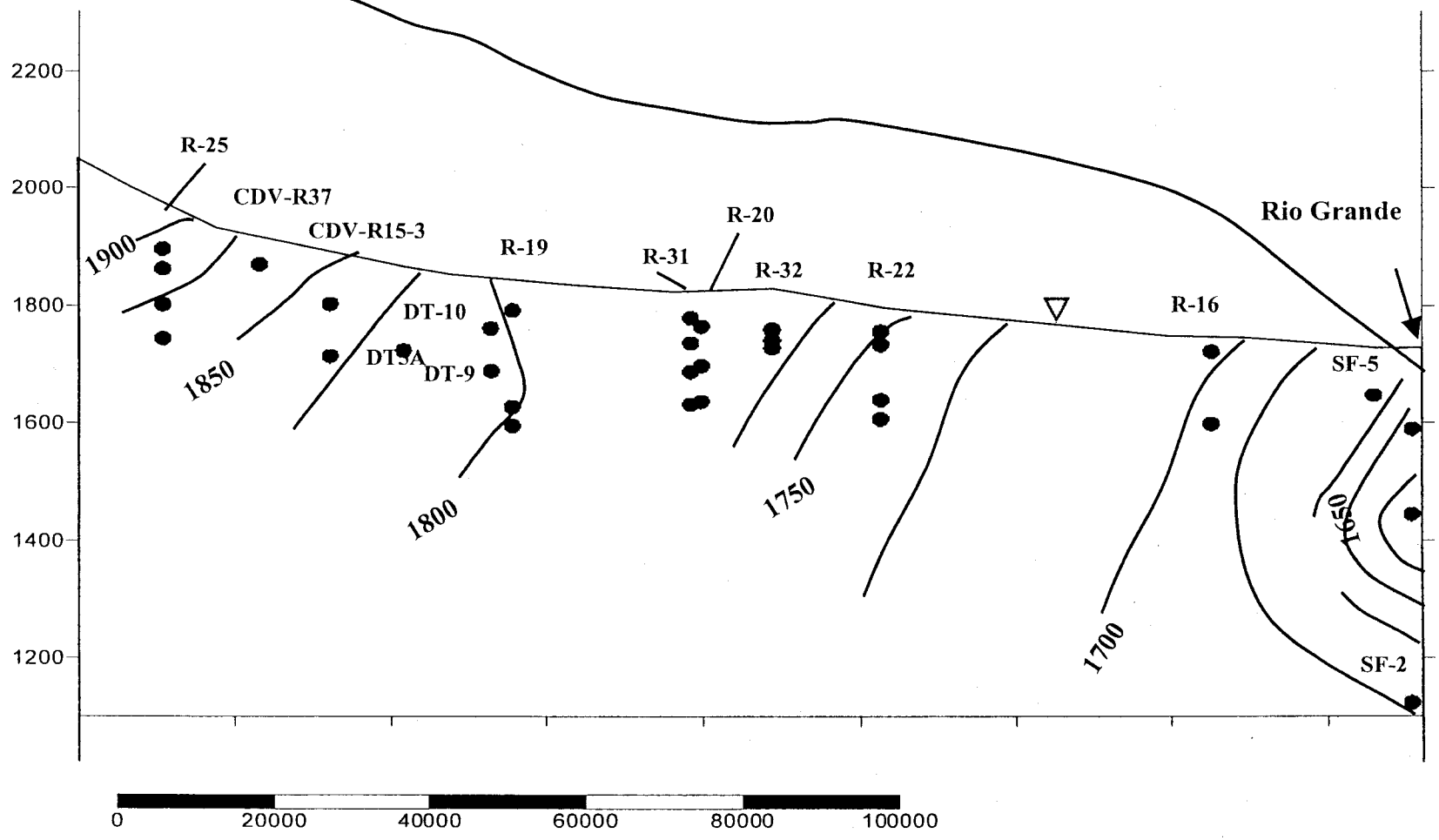
Water table map, using primarily data from wells with relatively short screens at or near the water table. Contour interval = 20m. Data are presented in accompanying table.



W

East-west cross-section of head data from the regional aquifer, using wells in the southern portion of LANL. Contour interval is 25m.

E



Water table elevations beneath LANL					
Well		Date	Head		Source
			feet	meters	
Water Supply	G-1A	2001	5654	1723	LA County (2001)
	GR-1	2001	5884	1793	LA County (2001)
	GR-2	2001	5770	1759	LA County (2001)
	GR-3	2001	5800	1768	LA County (2001)
	GR-4	2000	5819	1774	LA County (2000)
	LA-1	1990	5537	1688	1995 Water Supply Report
	LA-1B	1996	5646	1721	1995 Water Supply Report
	LA-2	1991	5525	1684	1995 Water Supply Report
	LA-3	1991	5560	1695	1995 Water Supply Report
	LA-4	1987	5706	1739	1995 Water Supply Report
	LA-5	1987	5671	1729	1995 Water Supply Report
	LA-6	1985	5678	1731	1995 Water Supply Report
Characterization well	CDV-R15-3-5	2001	6014	1833	Well completion report
	CDV-R-37-2	2001	6133	1869	Broxton
	R-12-3	2001	5697	1736	RRES-WQDB
	R-13	2001	5826	1776	Stone-fact sheet
	R-15	2000	5856	1785	Well completion report
	R-19-3	2000	5882	1793	Well completion report
	R-22-1	2000	5767	1758	Well completion report
	R-25-5	2001	6234	1900	RRES-WQDB
	R-31-2	2000	5833	1778	Well completion report
	R-5-3	2001	5788	1764	Stone - fact sheet
	R-7-3	2002	5882	1793	RRES-WQDB
	R-9	1998	5695	1736	Well completion report
	R-20-1	2003	5868	1789	Westbay (Larssen)
	R-14-1	2002	5885	1794	Westbay (Larssen)
	R-16-2	2002	5643	1720	Westbay (Larssen)
	R-32-1	2002	5860	1786	Westbay (Larssen)
Monitoring Well	DT-10	1998	5922	1806	RRES-WQDB
	DT-5A	1996	5961	1817	RRES-WQDB
	DT-9	1998	5920	1805	RRES-WQDB
	TW-1	1998	5840	1781	RRES-WQDB
	TW-2	1996	5850	1784	RRES-WQDB
	TW-3	1997	5813	1772	RRES-WQDB
	TW-4	1996	6068	1850	RRES-WQDB
	TW-8	1997	5883	1794	RRES-WQDB
Other	H-19	1949	6228	1898	1

MCOBT-4.4: What We Know and What Decisions Need to Be Made

MCOBT-4.4: What We Know

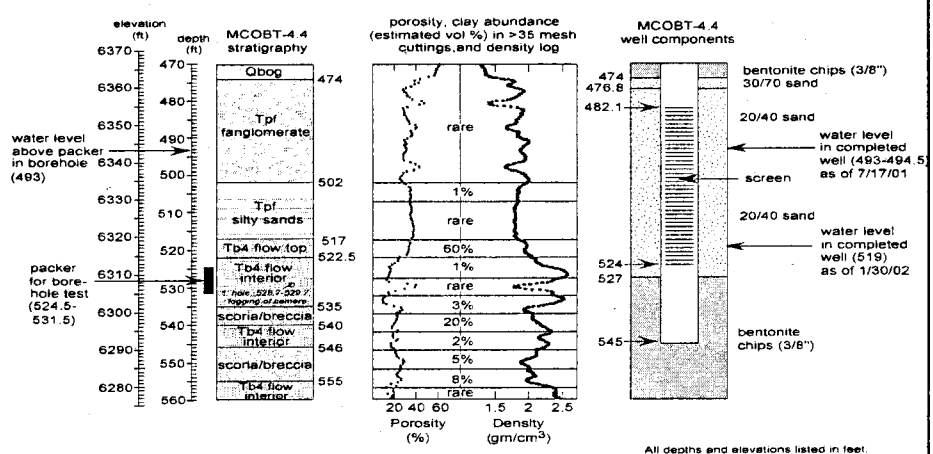
- Drilled to total depth of 767 ft
- Completed with a single screen between 482 and 524 ft
- Intermediate perched water was first detected at a depth 493 ft in the upper Puye Formation
- The well is screened across stratigraphic boundary of the Puye and Cerros del Rio

MCOBT-4.4: What We Know (cont.)

- The thickness of the intermediate perched zone is uncertain, but is above a depth of 524 ft, where a packer was set to evaluate the zone
- The water beneath the packer was evacuated by air lifting to see if the water in the borehole was from the Puye below the Cerros del Rio –the water level below the packer did not recover and the water level above the packer remained at a steady 493 ft.

MCOBT-4.4: Hydrogeologic Setting

Hydrogeologic Setting of the MCOBT-4.4 Well Screen



MCOBT-4.4: What We Know (cont.)

- Following well development, there was an unexplained decline in static water level to 519 ft
- Borehole video shows water entering the well at a depth of 497 ft

MCOBT-4.4: What We Know (cont.)

- The water in the intermediate perched zone is contaminated with:
  - Tritium: 14,900 ± 768 pCi/L (3 σ)
  - Perchlorate: 178 µg/L
  - Nitrate: 12.5 mg/L
- No drilling fluid residuals are present at MCOBT-4.4

MCOBT-4.4: What We Suspect

- The bottom of the screen was too close to the perching interval, so that the well development activities opened up previously closed fractures
- The perched intermediate water was drained through the freshly opened fractures

MCOBT-4.4: Decisions to be Made

- Whether to plug and abandon MCOBT-4.4
- Where to locate a replacement well
- How to target the perched intermediate zone without getting too close to the perching horizon

Hydrogeologic Work Plan Data Overview

Field Activity Reports

- Well Completion Reports
  - 12 have been completed
  - 7 remaining will be completed by March 31
- Hydrologic Testing
  - Report available today on pumping tests in earlier wells
  - Future reports on a well-by-well basis (poster session)
  - PM-2 (poster session)

Interpretive Reports

- Geology
  - 3-D geologic model (poster session)
- Hydrology
  - Regional Aquifer Modeling FY02 Milestone report (June 2003)
  - Regional Aquifer Modeling FY03 Milestone report (October 2003) (poster session)
  - Groundwater Pathways Assessment Report
  - Pajarito Plateau Infiltration Report (poster session)
  - Vadose Zone Anion Profiles (poster session)
- Geochemistry
  - R-25
  - Baseline Groundwater Report (poster session)

WATER-QUALITY RESULTS,

LOS ALAMOS CANYON LOW-HEAD WEIR

William J. Stone
Los Alamos National Laboratory
EES-6

OUTLINE

Background (Weir Site, Sampling)

General Constituents

Fire-Related Constituents

Surface to Groundwater Flux Rate (Tracer test)

SAMPLING AT THE WEIR

Purpose	***Frequency***
Pond	
General water quality	When it exists
LAWS-01	
General water quality	Irregular (R-9i nearby)
Background chemistry for tracer test (KBr)	Pre-Test only
Arrival of tracer	Weekly

GENERAL WATER QUALITY

Ag, Al, Alk (lab), As

B, Ba, Be, Br

TIC, TOC, Ca, Cd, Cl, ClO3, ClO_4, Co, CO_3, Cr, Cs, Cu

F, Fe

Hardness, HCO_3, Hg

K

Li

Mg, Mn, Mo

Na, NH_4, Ni, NO_2, NO_3

Oxalate

Pb, PO_4

Rb

Sb, Se, Si, SiO_2, SO_4, Sn, Sr

TDS, Th, Ti

U

V

Zn

DATA

Date	*Source*	*Results (ppm)* *Cs*	*Sr (total)*
5 April 01	LAWS-01 #2 (163')	<0.001	0.16
	#4 (275')	<0.001	0.20
6 April 01	Pond	<0.001	0.11
17 Dec 01	LAWS-01 #2	<0.001	0.25
	#3 (193')	<0.001	0.24
	#4	<0.001	0.25

RADIOGENIC CONSTITUENTS

Less than detection for

Am-241

Cs-137

Pu-238, 239/240

Sr-90

< 200 pCi/L for tritium

FIRE-RELATED CONSTITUENTS

LAWS-01

Elevated levels of

TOC (330 ppm; background ~3 ppm)

Alkalinity (bicarbonate)

Ca

Na (fire or road salt?)

From draining of reservoir as storms not in burned area

R-9i

Some evidence of fire impact as above

Not as much as at weir (ponding)

SURFACE TO GROUNDWATER FLUX

APPROACH

- Addressed by *tracer test* (April 02)
- 16,000 ppm KBr solution applied to dry pond floor
- Runoff/ponding mobilized tracer
- Arrivals of moisture & tracer in well/boreholes gives flux
- Wire-pair data give wetting events (vadose zone)

RESULTS

- Three ponding events in 2002: June, Aug, Oct
- First runoff (*June*) caused *3 ft of ponding*
- *Wetting at 89 ft in 3 days*: 30 ft/d (vadose zone)
- Water level rose in vertical well (perched zone)
- *Bromide increased in well within 10 days*: 12-18 ft/d
- Flux rate greater as fractures not vertical (so longer)
- Results of subsequent events consistent with first one

Hydrogeologic Characterization Annual Meeting

Well Construction Subcommittee Report

March 18, 2003

John McCann

Overview

- Drilling Accomplishments
- Well Development Challenges
- Sampling Activities
- Reporting Activities

Drilling Accomplishments

- R-14 - Mortandad (Ten Site), 1327 ft, 2 screens
- R-16 - Mortandad (White Rock), 1287 ft, 4 screens
- R-20 - Pajarito, 1365 ft, 3 screens
- R-21 - DOE Well, Cañada del Buey, 995 ft, 1 screen
- R-23 - Pajarito, 935 ft, 1 screen
- R-32 - Pajarito, 1008 ft, 3 screens

Well Development Challenges

- Faced several challenges in the well development area:
  - Removal of drilling fluids from the wells
  - Increasing the yield of the wells
  - Logistics related to developing 5 wells at the same time
- These problems required the use of chemical additives to support development

Well Development Challenges

- R-14 - removed 205,010 gallons
- R-16 - removed 100,120 gallons
- R-23 - removed 25,900 gallons
- R-20 - removed 113,070 gallons
- R-32 - removed 144,670 gallons

Status of Sampling Activity

Accomplished sampling includes:

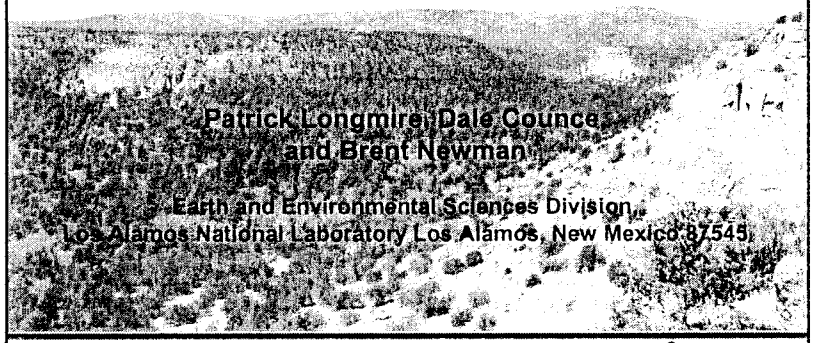
- R-13 - 1st screening and 3 quarters of sampling
- MCOBT-4.4 - 1st screening and 3 quarters of sampling
- One round of sampling at wells with 4 quarters complete - R-7, -9, -9i, -12, -15, -19, -22, and -25
- Quarterly sampling at the two CdV wells

Status of Reporting Activity

Accomplishments in reporting include:

- Fact Sheets - R-14, R-16, R-20, R-23 and R-32
- Geochemistry Reports - R-7, -12, 19, and -22
- Well Completion Reports - MCOBT-4.4, R-7
- Balance of Well Completion Reports expected by the end of March - R-5, -8, -13, -14, -16, -20, -23, and -32

Hydrochemistry of Selected Characterization Wells, Los Alamos, New Mexico



Patrick Longmire, Dale Counce, and Brent Newman

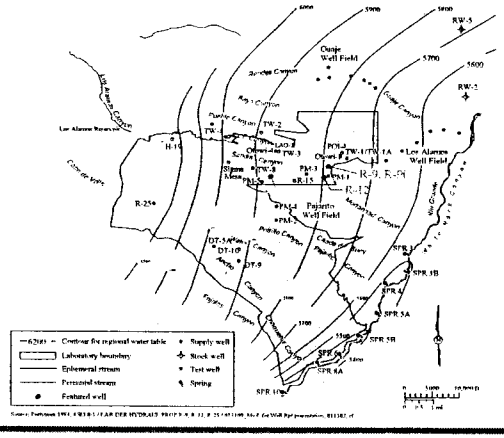
Earth and Environmental Sciences Division, Los Alamos National Laboratory Los Alamos, New Mexico 87545

Objective of Presentation

Evaluate the hydrochemistry of wells R-9i, R-12, and MCOBT-4.4 during characterization sampling conducted from February 2000 through August 2002 at Los Alamos National Laboratory.

These wells were installed as part of the hydrogeologic characterization of the Pajarito Plateau, Los Alamos, New Mexico.

Locations of Characterization Wells



Topics of Interest

- Inorganic solutes
- Distributions of tritium
- Stable isotopes of hydrogen, nitrogen, and oxygen
- Geochemical calculations

Analytical Methods EPA SW846

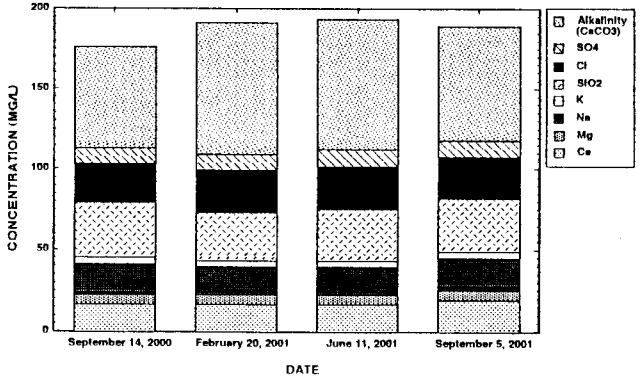
- Metals- Inductively Coupled Plasma Optical Emission Spectroscopy and Inductively Coupled Plasma Mass Spectrometry
- Anions- Ion Chromatography and Titration (alkalinity)
- Organic Compounds- Gas Chromatography and
- Gas Chromatography-Mass Spectrometry
- High-Explosive Compounds- High Pressure Liquid Chromatography and Diode Array Detector
- Radionuclides- Alpha Spectrometry, Gas Proportional Counting, Gamma Spectroscopy, Liquid Scintillation, Direct Counting, and Electrolytic Enrichment
- Stable Isotopes- Isotope Ratio Mass Spectrometry

Field-Measured Parameters for Ground Water Samples Collected at Well R-12, Screen #1

Geologic Unit	Cerros del Rio Lavas	Cerros del Rio Lavas	Cerros del Rio Lavas	Cerros del Rio Lavas
Depth (ft)	468.0	468.0	468.0	468.0
Date Sampled (mo/d/yr)	09/18/00	03/14/01	06/13/01	09/07/01
pH (standard units)	8.01	6.91	8.63	8.94
Temperature (°C)	21.8	13.2	19.9	21.3
Specific conductance (µS/cm[a])	280	254	175	122
Turbidity (NTU[b])	3.3	4.4	5.3	6.5

[a]µS/cm = microsiemens per centimeter.
[b]NTU = nephelometric turbidity unit.

Major Ion Chemistry for Well R-9i (Upper Perched Zone), Upper Los Alamos Canyon



Hydrochemistry of Perched Ground Water at MCOBT-4.4 (Filtered)

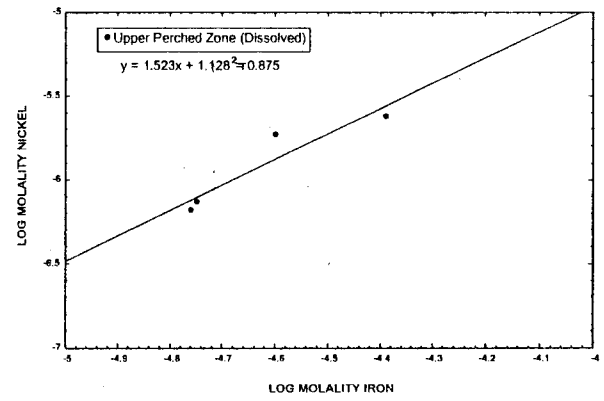
Depth (ft)	524
Geologic Unit	Puye Formation/Cerros del Rio Lavas
Date Sampled	06/28/02
Alkalinity (Lab) (mg $CaCO_3$/L)	49.3
Ca (mg/L)	32.7
ClO_4 (µg/L)	178
Cl (mg/L)	17.0
F (mg/L)	0.44
Mg (mg/L)	5.36
$NO_3 + NO_2$ (as N) (mg/L)	12.5
K (mg/L)	0.62
Na (mg/L)	21.3
SO_4 (mg/L)	25.4
TDS (mg/L)	175
Tritium (pCi/L)	14,900

Summary of Trace Solutes and Nitrogen Isotopes at Wells R-9i, R-12, and MCOBT-4.4

Well	R-9i (upper zone)	R-9i (lower zone)	R-12	MCOBT-4.4
NH_4 (mg/L)	Not detected	Not detected	2.23	Not detected
Fe (mg/L)	1.42	1.07	0.36	Not detected
Mn (mg/L)	0.83	0.53	0.46	0.003
Ni (mg/L)	0.083	0.065	0.003	0.003
$NO_3 + NO_2$ (as N) (mg/L)	Not detected	≤ 0.02	0.13	13.2
ClO_4 (μg/L)	Not detected	Not detected	Not detected	142
TOC (mg/L)	3.6	2.9	9.7	0.8
U (μg/L)	0.487	0.043	0.340	0.281
$\delta^{15}N$-NH_3 (‰)	ISV	ISV	-1.9	ISV
$\delta^{15}N$-NO_3 (‰)	ISV	ISV	ISV	-2.9

Note: detection limits for NH_4, Fe, $NO_3 + NO_2$ (as N), and ClO_4 are 0.02, 0.020, 0.02, and 0.004 mg/L, respectively. ISV means insufficient sample volume

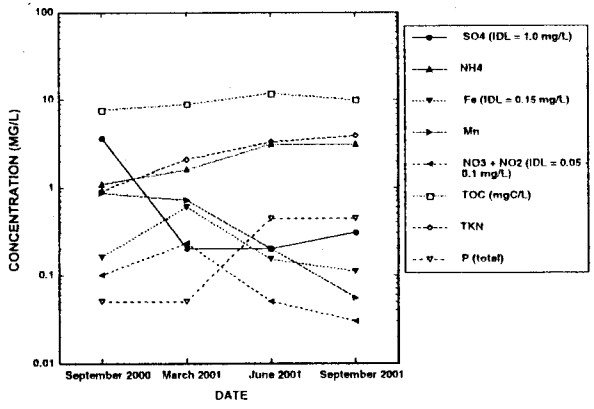
Log Molality Iron Versus Log Molality Nickel at Well R-9i, Upper Los Alamos Canyon



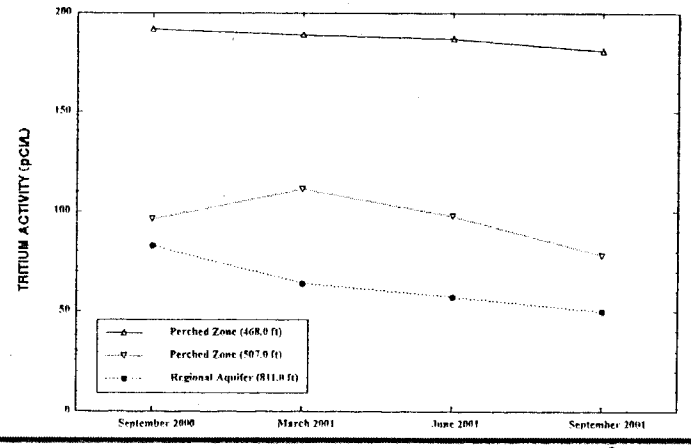
Results of Adsorption Calculations Using MINTEQA2 for Well R-9i, Upper Los Alamos Canyon

Parameter	Value	Surface Complex
Concentration of HFO (g/L)	0.0014	Not applicable
Specific surface area (m^2/g)	600	Not applicable
Ionic strength	0.003 molal	Not applicable
pH	8.04	Not applicable
Concentration of Ni molal (mg/L)	2.045E-06 (0.120)	Not applicable
Percentage Ni dissolved	97.8	Not applicable
Molality (mg/L)	1.999E-06 (0.118)	Not applicable
Percentage Ni adsorbed	2.2	Not applicable
Molality (mg/L)	4.563E-08 (0.002)	Not applicable
Percentage Ni adsorbed to strong binding site	1.0	$\equiv Fe_^{s}OHNi^{2+}$
Molality of adsorbed complex (mg/L)	2.074E-08 (0.001)	$\equiv Fe_^{s}OHNi^{2+}$
Percentage Ni adsorbed to weak binding site	1.2	$\equiv Fe_^{w}ONi^{+}$
Molality of adsorbed complex (mg/L)	2.489E-08 (0.001)	$\equiv Fe_^{w}ONi^{+}$
Speciation of dissolved and adsorbed Ni (%)	Ni^{2+} (3.0), $NiCO_3^0$ (93.2), $Ni(CO_3)_2^{2-}$ (1.1), $\equiv Fe_^{s}OHNi^{2+}$ (1.0), $\equiv Fe_^{w}ONi^{+}$ (1.2)	Not applicable

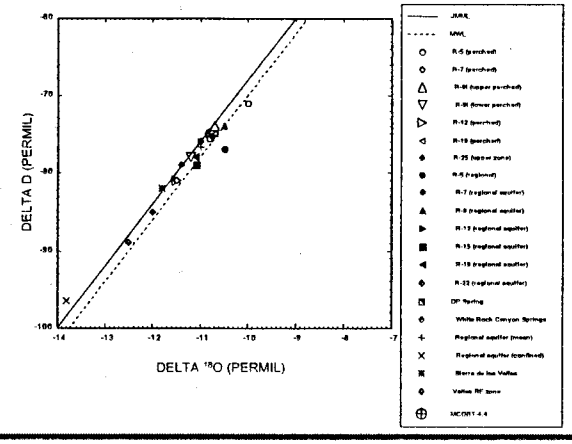
Distribution of Selected Solutes at Well R-12



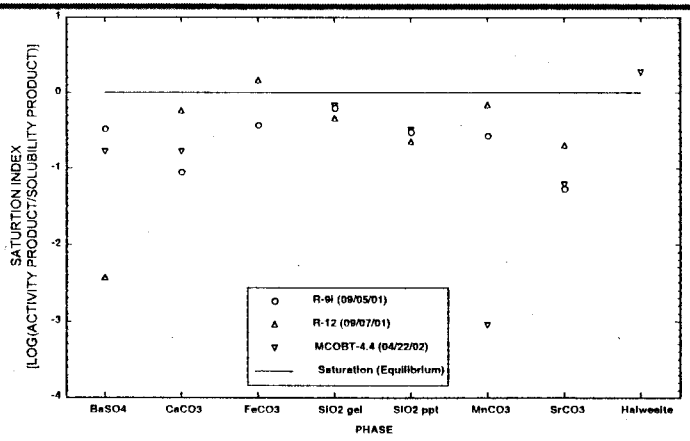
Distribution of Tritium in Well R-12 During Characterization Sampling



Average Stable Isotope Results for Wells and Springs



Results of Saturation Index Calculations Using MINTEQA2 for Wells R-9i, R-12, and MCOBT-4.4

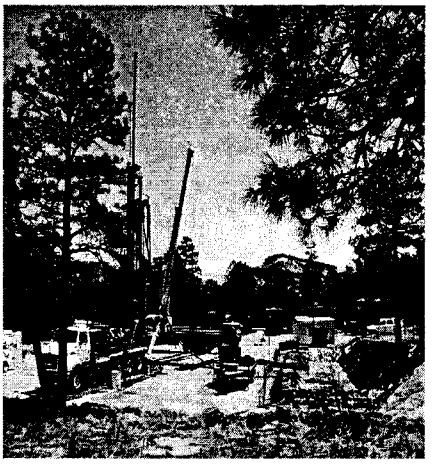


Conclusions

- Aqueous chemistry of perched ground water and the regional aquifer varies.
- Characterization sampling provides decisions for monitoring (trends, contaminants, levels).
- Perchlorate, nitrate, and tritium were observed in MCOBT-4.4. Tritium was observed in R-9i, R-9, and R-12.
- Breakdown of drilling fluid results in release of natural nickel from ferric hydroxide in R-9i.
- Geochemical calculations using the computer program MINTEQA2 were performed to evaluate speciation, adsorption/desorption, and mineral equilibrium.

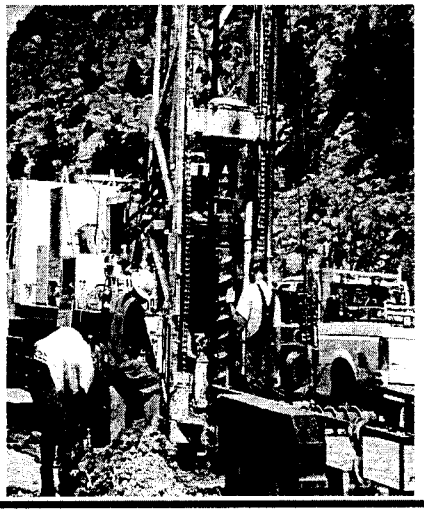
FY03 Proposed Work

Proposed FY03 Field Activities



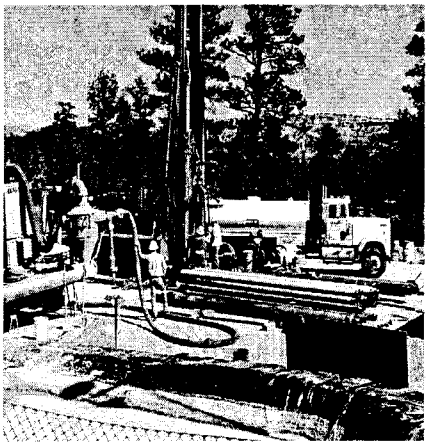
- If additional budget is available; install:
  - NWT: R-2, R-6, R-11, & R-26
  - ER: R-4 & R-18
- Characterization sampling and analysis
- Hydrologic testing

R-2



- Subsurface distribution of contaminants in an area expected to contain the maximum groundwater contamination from Acid Canyon.
- Open borehole, using air with minimal fluids.
- Core the upper portion of the boring
- Single screen just below the regional aquifer water table
- Total depth of about 100 ft below the regional aquifer table.
- DQOs approved by NMED February 27 2003

R-4

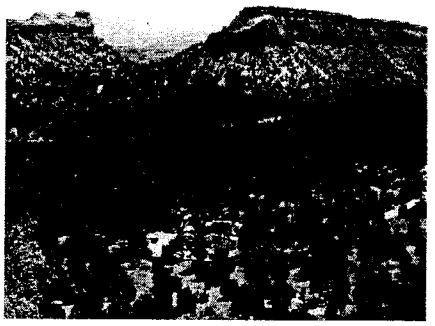


- Subsurface distribution of contaminants in an area down gradient of releases in Pueblo Canyon and upgradient of the treatment plant effluent.
- Open borehole, using air with minimal fluids.
- Core the upper portion of the boring
- Completion be determined after analysis of R-5 data and particle-tracking simulation to determine how deep contaminants from Pueblo Canyon might be expected.
- DQOs approved by NMED on 2/27/03

R-6

- Water quality in an area up gradient of all releases in from Laboratory operations.
- Drilling method TBD by driller
- Two screened intervals in the regional aquifer, approximately matching the two upper regional aquifer screens in R-25.
- Total depth penetrate about 300 feet into the regional aquifer.
- DQOs still under discussion with NMED

R-11

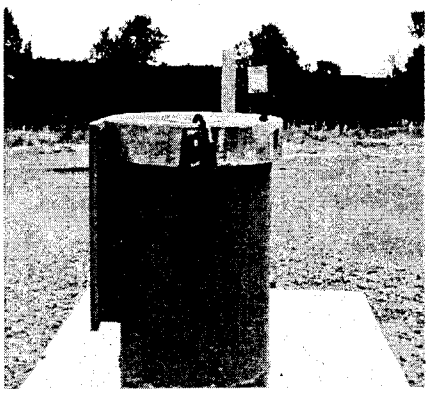


- Perched zones are anticipated to occur as a result of infiltration of surface water; opportunity to assess pathways
- Open borehole using air with minimal fluids
- Core the upper portion of the borehole, to auger refusal or 250 ft max.
- One screened interval in the regional aquifer.
- DQOs approved by NMED 2/27/03

R-18

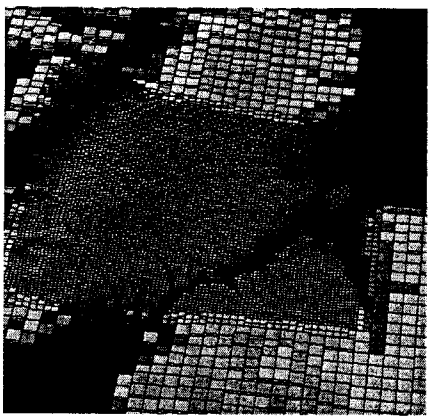
- Propose relocation to Potrillo Canyon, where R-23 was originally planned.
- Drill an open borehole, using air with minimal fluids to 500 feet below the top of the regional aquifer
- Complete with up to 4 screens in the regional aquifer, placed in different geologic units
- DQOs still under discussion with NMED

R-26



- Water quality in an area up gradient of all releases from Laboratory operations and effect of the Pajarito fault on groundwater flow Air with minimal fluids
- Core the upper 200-foot portion of the borehole
- Two screened intervals: one in the perched zone (if present) and one in the regional aquifer.
- Total depth will be about 1500 ft and will penetrate about 100 feet into the regional aquifer.
- DQOs under discussion with NMED

FY03 Non-Field Activities



- Information Management
- Groundwater Pathways Assessment
- Regional aquifer modeling
- Geologic Model
- Quarterly and Annual Meetings
- Annual Report

Hydrogeologic Characterization Program – March 18, 2003 Annual Meeting

Posters:

"Water Quality Database Website"
Ann Lee and Sue Kinkead
LA-UR-03-1721

"Geological Characterization of the Pajarito Plateau"
D. Vaniman, D. Broxton, B. Carey, G. Cole, E. Keating
LA-UR-03-1908

"Drilling Team"
John McCann

"Pajarito Plateau Vadose Zone Characterization Using Pore Water Anions and Stable Isotopes"
Brent Newman, Kay Birdsell, Deb Bergfeld, and Pat Longmire.

"Infiltration Scenario for the Los Alamos Regional Infiltration Study Area"
Edward Kwicklis, Marc S. Witkowski, Douglas Walther
LA-UR-03-1889

"Preliminary Analysis of the PM-2 Aquifer Test Conducted on 3-28 February 2003"
Stephen G. McLin, Velimir V. Vesselin, David E. Broxton, and William J. Stone

"Hydrologic Properties of the Regional Aquifer"
Bill Stone

"Environmental Chemistry of Perchlorate"
Pat Longmire, Dale Counce, Brent Newman

"Contaminant Pathways and Travel Times"
Bruce Robinson
LA-UR-03-2245

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Master Publication List

Revised 3/24/03

Primary Author	Co-Authors	Date	Title	Report Number	Publishing Information
Ball, T.T.		2001	Use of Modern Project Management Techniques for the Hydrological Characterization Project at Los Alamos National Laboratory	ER2001-0930 and LA-UR-01-6171	Department of Energy Technical Information Exchange Workshop, November 13, 2001 Albuquerque, New Mexico
Ball, T.	M. Everett, P. Longmire, D. Vaniman, W. Stone, D. Larssen, K. Greene, N. Clayton, S. McLin	2002	Characterization Well R-22 Completion Report	LA-13893-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	P. Longmire	2003	Groundwater Contamination in Mortandad Canyon, Los Alamos National Laboratory: a Summary of Ongoing Hydrogeologic Investigations	LAUR-02-5648	National Groundwater Association, Tucson, AZ, 2003
Broxton, D.E.	D. Vaniman, P. Longmire, B. Newman, W. Stone, A. Crowder, P. Schuh, R. Lawrence, M. Everett, R. Warren, N. Clayton, D. Counce, E. Kluk, D. Bergfeld	2002	Characterization Well MCOBT-4.4 and Borehole MCOBT-8.5 Completion Report	ER2002-0715 and LA-13993-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	R. Gilkeson, P. Longmire, D. Vaniman, J. Marin, R. Warren, A. Crowder, B. Newman, B. Lowry, D. Rogers, W. Stone, S. McLin, G. WoldeGabriel, D. Daymon, D. Wycoff	20001	Characterization Well R-9 Completion Report	LA-13742-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.		2001	Geology of the Pajarito Plateau and Vicinity, North-Central New Mexico		P. Johnson, ed., Water, Watersheds, and Land Use in New Mexico, New Mexico Decision-Makers Field Guide No. 1, New Mexico Bureau Mines and Min Res.
Broxton, D.E.	R. E. Lewis	2001	Use of Borehole Geophysics for Hydrogeological Characterization at Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	C. Nylander	2001	Groundwater Investigations to Support Environmental Decisions at Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	P. Longmire, D. Counce, B. Newman	2001	Hydrochemical Characterization at R-15, Mortandad Canyon, Los Alamos National Laboratory		US DOE 13th Technical Information Conference Abstracts, Albuquerque, New Mexico
Broxton, D.E.	R. Gilkeson, P. Longmire, D. Vaniman, J. Marin, R. Warren, A. Crowder, B. Newman, B. Lowry, D. Daymon, D. Wycoff	2001	Completion Report for Characterization Well R-9	ER2000-0218 and LA-UR-00-4120	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	R. Warren, D. Vaniman, B. Newman, A. Crowder, M. Everett, R. Gilkeson, P. Longmire, J. Marin, W.J. Stone, S. McLin, D. B. Rogers	2001	Characterization Well R-12 Completion Report	ER2000-0290 and LA-UR-00-3785	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	D. Vaniman, W. Stone, S. McLin, M. Everett, A. Crowder	2001	Characterization Well R-9i Completion Report	ER2000-0446 and LA-UR-00-4255	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	D. Vaniman, W. Stone, S. McLin, J. Marin, R. Koch, R. Warren, P. Longmire, D. Rogers, N. Tapia	2001	Characterization Well R-19 Completion Report	ER2000-0398 and LA-UR-00-4085	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	R. Warren , P. Longmire, R. Gilkeson, S. Johnson, D. Rogers, W. Stone, B. Newman, M. Everett, D. Vaniman, S. McLin, J. Skalski, D. Larssen	2002	Characterization Well R-25 Completion Report	ER 2001-0697 and LA-13909-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Broxton, D.E.	C. Nylander, R. Gilkeson, P. Longmire, W. Stone, D. Rogers	1999	Groundwater Issues on the Pajarito Plateau		EOS, American Geophysical Union Transactions, 79
Broxton, D.E.	S. L. Reneau	1996	Buried early Pleistocene landscapes beneath the Pajarito Plateau, northern New Mexico		Goff, F., Kues, B. S., Rogers, M. A., McFadden, L. D., and Gardner, J. N., eds,The Jemez Mountains Region: New Mexico Geological Society 47th Field Conference Guidebook

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Master Publication List

Revised 3/24/03

Primary Author	Co-Authors	Date	Title	Report Number	Publishing Information
External Advisory Group		2002	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, June 2002
External Advisory Group		2001	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, June 2001
External Advisory Group		2001	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, December 2001
External Advisory Group		2000	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, June 26, 2000
External Advisory Group		2000	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, December 5, 2000
External Advisory Group		1999	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, July 20, 1999
External Advisory Group		1999	Semi-Annual Report to the Groundwater Integration Team of the Los Alamos National Laboratory		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, December 23 1999
External Evaluation Group		1998	Semi-Annual Report, Groundwater Integration Team		Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, October 31, 2000
Hickmott, D.		2000	Progress Report for Plume-Chasing and Characterization Well Canon de Valle R-15-3	LA-UR-00-4527	Los Alamos National Laboratory, Los Alamos, New Mexico
Keating, E.H.	E. Kwicklis, K. Manley	2002	Overview of the Hydrogeology of the Espanola Basin		Hydrogeology Journal., in review
Keating, E.H.	V.V. Vesselinov, E. Kwicklis, Z. Lu	2002	Coupling Basin- and Local-Scale Inverse Models of the Espanola Basin		Groundwater Journal
Keating, E.H.	E. Kwicklis, V. Vesselinov, A. Idar, Z. Lu, G. Zyvoloski, M. Witkowski	2000	A Regional Flow Model and Transport Model for Groundwater at Los Alamos National Laboratory. Progress Report		Progress Report submitted to Hydrogeologic Characterization Program, Los Alamos National Laboratory, October 31, 2000
Keating, E.H.	E. Kwicklis, M. Witkowski, T. Ballantine	1999	A Regional Flow Model for the Regional Aquifer beneath the Pajarito Plateau. Progress Report	LA-UR-00-1029	Los Alamos National Laboratory, Los Alamos, New Mexico
Keating, E.H.	G. Zyvoloski, C. Gable, M. Witkowski, K. Bower, K. Manley	1998	A Steady-State Regional Flow Model for the Saturated Zone in the Espanola Basin		Los Alamos National Laboratory, Los Alamos, New Mexico
Koch, R.J.	P. Longmire, D.B. Rogers, K. Mullen	1999	Report of Testing and Sampling Municipal Supply Well PM-4	LA-13648	Los Alamos National Laboratory, Los Alamos, New Mexico
LANL	Groundwater Integration Team	2002	Action Plan for External Advisory Group June 2002 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, September 2002
LANL	Groundwater Integration Team	2002	Action Plan for External Advisory Group December 2001 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, April 2002
LANL	Groundwater Integration Team	2001	Action Plan for External Advisory Group June 2001 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, September 2001
LANL	Groundwater Integration Team	2001	Action Plan for External Advisory Group December 2000 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, March 15, 2001
LANL	Groundwater Integration Team	2000	Action Plan for External Advisory Group December 1999 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, March 2000

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Master Publication List

Revised 3/24/03

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LANL	Groundwater Integration Team	2000	Action Plan for External Advisory Group June 2000 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, September 2000
LANL	Groundwater Integration Team	1999	Action Plan for External Advisory Group July 1999 Recommendations		Report for Hydrogeologic Characterization Program, Los Alamos National Laboratory, November 30, 1999
LANL		1998	Hydrogeologic Workplan		Los Alamos National Laboratory, Los Alamos, New Mexico
LANL		1998	Field Implementation Plan for Drilling and Testing of LANL Regional Characterization Well R-25		Hydrogeologic Characterization Program Plan, Los Alamos National Laboratory, March 1998
LANL		1997	Conceptual Design Report Monitoring Well Installation Project, 100% Conceptual Design Report		Los Alamos National Laboratory, Los Alamos, New Mexico
LANL		1997	Field Implementation Plan for Drilling and Testing of LANL Regional Characterization Well R-9		Hydrogeologic Characterization Program Plan, Los Alamos National Laboratory, March 1998
LANL		1996	Groundwater Protection Management Program Plan		Los Alamos National Laboratory, Los Alamos, New Mexico
Longmire, P.		2002	Characterization Well R-15 Geochemistry Report	LA-13896-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Longmire, P.		2002	Characterization Wells R-9 and R9i Geochemistry Report	LA-13927-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Longmire, P.	D. E. Broxton, W. Stone, B. Newman, R. Gilkeson, J. Marin, D. Vaniman, D. Counce, D. Rogers, R. Hull, S. McLin, R. Warren	2000	Characterization Well R-15 Completion Report	ER2000-0308 and LA UR-00-4139	Los Alamos National Laboratory, Los Alamos, New Mexico
Newman, B.D.	R.H. Gilkeson, B.M. Gallaher	1997	Vadose Zone Water Movement at TA-49, Los Alamos National Laboratory: Interpretations based on Chloride and Stable Isotope Profiles	LA-UR-97-3924	Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.	T. T. Ball, K.A. Bitner, K. Henning, E.H. Keating, P. Longmire, B. Robinson, D.B. Rogers, W.J. Stone, D. Vaniman	2002	Groundwater Annual Status Report for Fiscal Year 2001	LA-13931-SR	Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.	K.A. Bitner, D.E. Broxton, K. Henning, R. Hull, A.S. Johnson, E.H. Keating, P. Longmire, B.D. Newman, B. Robinson, D.B. Rogers, W.J. Stone, D. Vaniman	2001	Groundwater Annual Status Report for Fiscal Year 2000	LA-138-SR	Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.	K.A. Bitner, D.E. Broxton, K. Henning, A.S. Johnson, E.H. Keating, P. Longmire, B.D. Newman, B. Robinson, D.B. Rogers, W.J. Stone, D. Vaniman	2000	Groundwater Annual Status Report for Fiscal Year 1999	LA-13710-SR	Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.	K.A. Bitner, D.E. Broxton, G.L. Cole, B.M. Gallaher, A.S. Johnson, D. Katzman, E.H. Keating, P. Longmire, S.G. McLin, K.I. Mullen, B.D. Newman, D.B. Rogers, A.K. Stoker, W.J. Stone	1999	Groundwater Annual Status Report for Fiscal Year 1998	LA-13598-SR	Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.	K.A. Bitner, D.E. Broxton, B.M. Gallaher, P. Longmire, McLin, S.G, B.D. Newman, D.B. Rogers	1998	Groundwater Annual Status Summary Report FY97		Hydrogeologic Characterization Program, Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.		2002	Los National Laboratory Groundwater Integration Team Action Plan for External Evaluation Group		Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.		2001	Los National Laboratory Groundwater Integration Team Action Plan for External Evaluation Group		Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.		2000	Los National Laboratory Groundwater Integration Team Action Plan for External Evaluation Group		Los Alamos National Laboratory, Los Alamos, New Mexico
Nylander, C.L.		1999	Los National Laboratory Groundwater Integration Team Action Plan for External Evaluation Group		Los Alamos National Laboratory, Los Alamos, New Mexico

Los Alamos National Laboratory
Hydrogeologic Characterization Program
Master Publication List

Revised 3/24/03

Primary Author	Co-Authors	Date	Title	Report Number	Publishing Information
Stauffer, P.	K. Birdsell, M. Witkowski, T. Cherry, J. Hopkins	2000	Subsurface Vapor-Phase Transport of TCA at MDA L: Model Predictions	LA-UR-00-2080	Los Alamos National Laboratory, Los Alamos, New Mexico
Stimac, J.A.	D. E. Broxton, E.C. Kluk, S.J. Chipera, J.R. Budahn	2002	Stratigraphy of Tuffs from Borehole 49-2-700-1 at Technical Area 49, Los Alamos National Laboratory, NM	LA-13969	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	S. McLin	2003	Hydrologic Tests at Characterization Wells R-9i, R-13, R-19, R-22, and R-31	LA-13987-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	D. L. Newell	2002	Installation of the Monitoring Site at the Los Alamos Canyon Low-Head Weir	LA-13970	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	P. Longmire, D. Newell, D. Leavitt	2002	Impact of the Cerro Grande Fire on Intermediate-Depth Perched Water Quality - Preliminary Results from the Low-Head Weir, Los Alamos National Laboratory		New Mexico Water Research Symposium, New Mexico Water Resources Research Institute, New Mexico Tech, Socorro, New Mexico
Stone, W. J.	D. Vaniman, P. Longmire, D. Broxton, M. Everett, R. Lawrence, D. Larssen	2002	Characterization Well R-7 Completion Report	LA-13932-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	S. McLin, D. Vaniman	2001	Hydraulic Conductivity vs Geology in New Los Alamos Wells: Abstract to New Mexico Geological Society 2001 Spring Meeting	ER-70090	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	G. Cole, W. Carey, M. Jones	2001	Los Alamos National Laboratory Expanded Hydrogeologic Atlas	LA-UR-01-70	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.		2000	Laboratory-derived hydraulic properties of selected materials from wells R-9, R-12, and R-25	LA-UR-00-3587	Los Alamos National Laboratory, Los Alamos, New Mexico
Stone, W. J.	G. Cole, M. Jones	1999	Preliminary Hydrogeologic Atlas for Los Alamos National Laboratory	LA-UR-99-4619	Los Alamos National Laboratory, Los Alamos, New Mexico
Vaniman, D.	J. Marin, W. Stone, B. Newman, P. Longmire, N. Clayton, R. Lewis, R. Koch, S. McLin, G. WoldeGabriel, D. Counce, D. Rogers, R. Warren, E. Kluk, S. Chipera, D. Larssen, W. Kopp	2002	Characterization Well R-31 Completion Report	LA-13910-MS	Los Alamos National Laboratory, Los Alamos, New Mexico
Vaniman, D.	G. Cole, D. Broxton	2001	From Drill Hole Data to 3-D Geologic Models	LA-UR-01-6201	Los Alamos National Laboratory, Los Alamos, New Mexico
Vesselinov, V.V.	E. Keating, G.A. Zyvoloski	2002	Analysis of model sensitivity and predictive uncertainty of capture zones in the Espanola Basin regional aquifer, Northern New Mexico		ModelCare2002 Calibration and reliability in groundwater modeling: A few steps closer to reality, Prague, Czech Republic, pp. 496-500
WoldeGabriel. G	R.G. Warren, D.E. Broxton, D.T. Vaniman, M.T. Heizler, E.C. Kluk, L. Peter	2001	Episodic volcanism, petrology, and lithostratigraphy of the Pajarito Plateau and adjacent areas of the Espanola Basin and the Jemez Mountains		in L.S. Crumpler and S.G. Lucas, eds, Volcanology in New Mexico, New Mexico Museum of Natural History and Science Bulletin 18, pp. 97-129.